



Statistical Literacy: Students' Performance in Solving Numeracy-Based Statistic Questions

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Abstract. Literacy is essential in preparing for 21st-century life and the big data era. At the very least, people need the ability to process, analyse, read, and use the data they collected to make decisions. This ability is known as statistical literacy. The level of students' statistical literacy needs to be appropriately diagnosed for learning improvement. This study aims to determine students' statistical literacy using numeracy-based statistic question known as AKM (*Asesmen Kompetensi Minimum* - Minimum Competence Assessment) problems. The respondents are 187 students from six different schools with different ability and status (state and private school). The data is students' work on solving four AKM problems, and analyzed using a score rubric designed by author. The results obtained: the students' statistical literacy in solving AKM problems is spread to several scores depend on question type. Overall, more than a half of students gain score 5, a few of them able to gain score 6, several of them gain score 4, even there are students still gain score 3 and 2. Therefore, it is necessary to do further research to find know the causal factor and how fix it.

Keywords: statistical literacy · numeracy · AKM

1 Introduction

The COVID-19 pandemic has changed the way people interact socially. The effects of the pandemic are also expected to affect the psychology of society, the economy, and education both in the short and long term [1]. As a result, many activities have shifted to online mode, for example, communicating, transacting, educating, editing, actualizing, and socializing [2]. This causes society, including our students, to come into contact with data spread out in cyberspace.

Data, nowadays known as big data, has the following characteristics: volume (data size), velocity (data access speed), variety (data diversity), veracity (incomplete and not always reliable), and value (information contained) [3]. At least two main competencies are required for those data characteristics. The first competency is the ability to use programs/applications on a computer or mobile device. The second is the ability to process, analyze, read, and use the data to make conclusions and appropriate actions [4]. Good knowledge of data or data literacy is part of statistical literacy [5].

The importance of including statistics in school curriculum rests on two arguments. First, schools need to prepare the students for more advanced statistics in higher stages of education. Second, schools also have a role in preparing the students to be future citizen who are capable at quality, data-based decision-making. The latter is known as statistical literacy.

Over the years, several definitions of statistical literacy have emerged in literature. One of the earliest and frequently cited is defined statistical literacy as the ability to understand and critically evaluate statistical information found in everyday life, as well as appreciating the role of statistical thinking in better decision-making [6]. Statistical literacy goes beyond critical evaluation of statistical information, but also the ability to appropriately use that information in discussion or argument [7]. Statistical literacy also means the ability to organise data, construct tables, and work with various Table representations [8]. Statistical literacy is important for students because it helps them become informed society members and intelligent consumers who can criticize and make the right decisions based on the statistical information they obtain [9]. Statistical literacy is also necessary for students to understand, interpret, evaluate, and communicate data critically [10].

Studies by Watson and Callingham [11] reveals that statistical literacy is a hierarchical construct which can be mapped along six levels, as summarized in Table 1. At the lowest level, students' responses are often personal, intuitive, and non-statistical in nature, involving only basic mathematics skills. As the level increases, more sophistication is shown in the students' use of statistical procedure, greater appreciation of variation and uncertainty, and ability to transfer statistical knowledge to the context. Students at the highest level are generally able to critically question the context, take uncertainty in making predictions, as well as use proportional reasoning. The notion of statistical literacy as a hierarchical construct is important for teacher because designing effective tasks must consider "where students start and how they progress" [9].

Assessing the students' statistical literacy can be done at four levels by having students do several activities, namely evaluating the use of statistics in a news story, estimating a quantity or making a decision in an open-ended situation, describing and comparing statistics presented in graphs or Tables, and answering multiple-choice questions on specific aspects of statistical literacy [12].

In Indonesia, no attempt has been made by the government in terms of official assessment of the students' statistical literacy. However, the current AKM (*Asesmen Kompetensi Minimum* - Minimum Competence Assessment) is an indication of the government's awareness of the importance of literacy. AKM is an assessment in the field of numeracy and literacy administered to grade 5, grade 8, and grade 11 students. The problems in AKM do not center on contents, but more on how it is applied in everyday life. Instead of assessing and ranking the students, AKM focuses on mapping the numeracy and literacy levels of the students to inform stakeholders and policy makers.

This study investigated the performance of junior high school students from different schools in Batu, Indonesia, in solving AKM numeracy test problems in the domain of statistics. The result hopefully will help map the students' ability to apply statistical

Table 1. The hierarchy of statistical literacy construct Watson & Callingham

Level	Name	Characteristics of level
1	Critical-mathematical	The ability to analyze and understand the context in a critical and inquisitive manner, especially when dealing with media or situations involving chance, demonstrating a grasp of proportional reasoning, recognizing the importance of uncertainty in making predictions, and comprehending the nuanced aspects of language.
2	Critical	This refers to the ability to analyze and question situations in both familiar and unfamiliar contexts. It does not necessarily involve proportional reasoning, but it does require using terminology correctly, interpreting chance in a qualitative way, and understanding the significance of variation.
3	Consistent-non-critical	The ability to engage with context in a suitable manner, but not critically. Can use terminology in various aspect, recognize and appreciate variation in chance settings, and possess statistical skills related to mean, basic probabilities, and graph characteristics.
4	Inconsistent	Selectively engaging with the context in a supportive manner, acknowledging conclusions without providing justification, and utilizing statistical ideas in a qualitative rather than quantitative way.
5	Informal	Understanding contexts in a way that is intuitive and reflect non-statistical beliefs, using simple terminology and settings, and performing basic calculations involving Tables, graphs, and probability.
6	Idiosyncratic	Understanding contexts in idiosyncratic ways, repeated use of terminology, involving only basic mathematical skills associated with one-to-one counting and reading cell values in tables.

knowledge and procedure in everyday life context, and shed light on the students' statistical literacy. The question this study attempts to answer is *how do students in different schools in Batu do in a literacy-based statistics test?*

2 Methods

This study is qualitative research with a quantitative descriptive approach, by describing the meaning of the research data obtained [13]. It is not generalized, and the research subjects were selected using a non-probability purposive sampling method. This research procedure was carried out according to the steps presented by Yusuf [14], summarized in four stages: preparation, implementation, data processing/analysis, and reporting.

The participants in this study are 187 students, who come from six different schools (roughly 30 students from each school). Among these schools, two are categorized as

high ability schools (namely school A1 and A2), two are medium (school B1 and B2), and two are low (school C1 and C2), and each category consist of one state school and one private school. The schools are categorized based on the result of 2019 national examination (which no longer take place), in the topic of data and uncertainty.

The instruments used to collect data in this study were numeracy questions in the AKM question simulation compiled by Pusmenjar (*Pusat Asesmen dan Pembelajaran – The Centre of Assessment and Learning*) [15]. The questions used are 4th-level numeracy questions on the data and uncertainty topic, with indicator questions about using mean, median, and mode. The chosen questions descriptors are shown in Table 2 below.

The questions are described in more detail as follow. Question 1 is in the topic of data presentation, and student must agree or disagree with the statement and explain their reason (Fig. 1).

Since January 2020, a type of virus has caused a commotion in China's Wuhan Province. Then it spread to many countries. The diagram on the side is data on patients who have recovered from the Covid-19 outbreak in several ASEAN countries. Is it accurate to describe the number of Covid-19 sufferers in several ASEAN countries using a mean concept? Explain.

Question 2 is also the topic of data presentation, student must choose which statements are true based on data presented. The question 2 as follows (Fig. 2).

The diagram above shows the state of Indonesia's workforce from August 2015 to August 2019. According to the Central Bureau of Statistics, what is meant by open unemployment is the workforce that simply does not have a job. According to the 2003

Table 2. Question grid

Question Number	Question Indicator	Question Type
1	Presented with a bar chart of data on patients with COVID-19 in early January 2020, students can evaluate the use of the average to describe the number of COVID-19 sufferers in ASEAN.	Essay
2	Presented bar charts and line charts regarding the state of employment in Indonesia in August 2019, students can determine whether the statements are true or false based on the diagrams.	Complex multiple-choice
3	Presented table about the weight development of the fetus and pregnant women during pregnancy. Based on the diagram, students can determine whether the statements are true or false.	Complex multiple-choice
4	Presented data on several parks and the nature of some tree species transpiration, students can decide which park to choose if they want a fresh garden and sufficient sunlight.	Multiple-choice

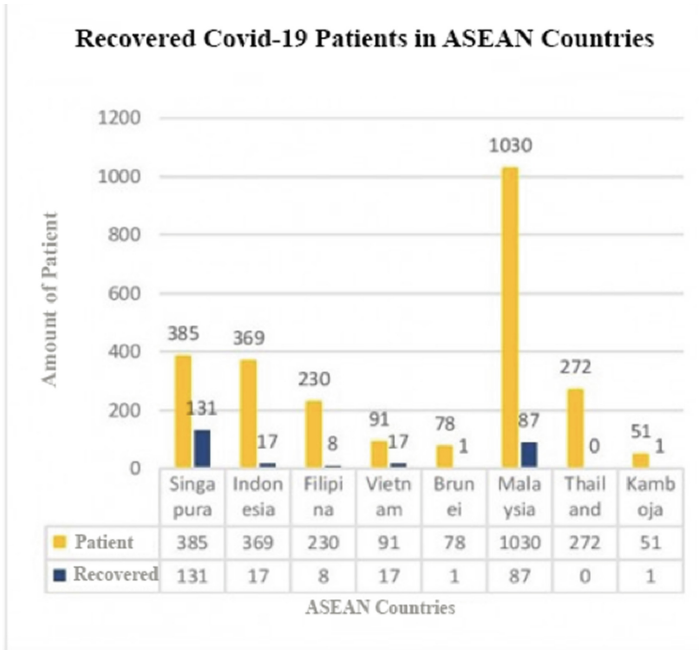


Fig. 1. Question 1 on Covid-19 penetrating ASEAN

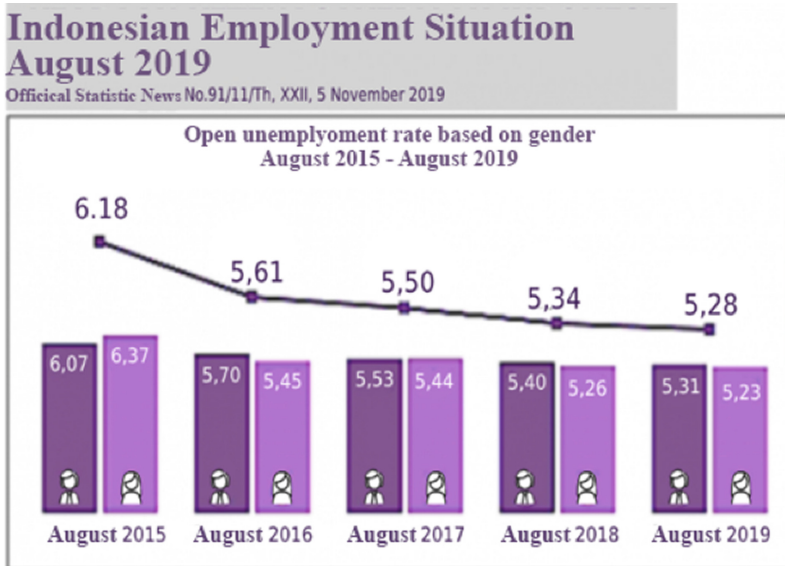


Fig. 2. Picture 2. Workforce

Workforce Law, the workforce is between 15 and 64 years old. The line chart shows the average male and female open unemployment rates from August 2015 to August 2019.

By looking at the diagram above, put a check mark on the following statements that are appropriate and there may be more than one answer.

<input type="checkbox"/>	The workforce in the following year will increase so that unemployment will decrease.
<input type="checkbox"/>	Unemployment will tend to decrease for both men and women in the following year.
<input type="checkbox"/>	Home industry businesses opened new branches and mushroomed everywhere the following year.
<input type="checkbox"/>	The open unemployment rate for women has decreased as more men have worked in the following year.

Question 3 is also the topic of data presentation; student must choose which statements are true based on data presented. The question 3 as follows (Fig. 3).

A pregnant woman checks herself at the Public Health Centre. On January 5, 2020, the pregnant woman’s weight is 45 kg with a pregnancy of 11–12 weeks. On March 19, he weighed 45 kg. By looking at the Table of fetal and pregnant mother’s weight development during the pregnancy, which of the following statements is appropriate?

(put a check mark on the appropriate statement, and more than one answer is allowed).

Fetal and maternal weight development during pregnancy			
Weeks of pregnancy	Average fetal weight	Average fetal height	Average maternal weight gain
8-9 weeks	1gr	4 cm	0,5kg
9-10 weeks	4gr	4 cm	0,7kg
10-11 weeks	10gr	6,5cm	0,9kg
11-12 weeks	15gr	6,5cm	1,1kg
12-13 weeks	20gr	9cm	1,4kg
13-14 weeks	50gr	9cm	1,7kg
14-15 weeks	85gr	12,5cm	2,0kg
15-16 weeks	100gr	12,5cm	2,3kg
16-17 weeks	110gr	16cm	2,7kg
17-18 weeks	180gr	16cm	3,0kg
18-19 weeks	210gr	20,5cm	3,4kg
19-20 weeks	300gr	20,5cm	3,8kg
20-21 weeks	325gr	25cm	4,3kg
21-22 weeks	400gr	25cm	4,7kg
22-23 weeks	485gr	27,5cm	5,1kg
23-24 weeks	500gr	27,5cm	5,5kg

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Fig. 3. Picture 3. Fetal Weight

	<i>The weight of pregnant women on March 19 2020 is less than the ideal body weight for pregnant women.</i>
	<i>On March 19, 2020, the minimum weight of pregnant women is 50 kg and the minimum weight of the fetus is 485 g.</i>
	<i>On March 19, 2020, the fetus's weight increased by 310 g and the fetus's height increased by 18.5 cm.</i>
	<i>The fetal height on March 19, 2020 has increased by 14 cm and the fetal weight has increased by 195 g.</i>

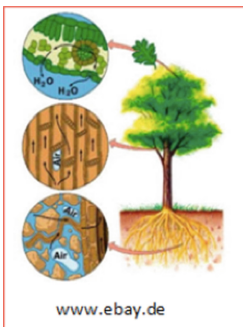
Question 4 is still about data presentation topic, student must student decide which the right option based on statement. The question 4 as follows.

Trees release water through their leaves, which is called transpiration. Climatic facts that affect transpiration are the intensity of sunlight, the water vapor pressure in the air, temperature, and wind speed. Transpiration from plant bodies during the day will exceed evaporation from the water surface or soil surface, whereas at night there will be less or no transpiration. The following Table shows the average velocity of water escaping from tree leaves in a suburban park. Also, pay attention to the available tree images (Fig. 4).

Mr. Jaya wants to take his family on a picnic to a fresh park and plenty of sunlight. According to the data and pictures, which park will priority be chosen by Mr. Jaya?

- a. *A garden with lots of Grindelia trees because their leaves release the least amount of water.*
- b. *A garden with lots of Bottlebrush trees because it generates a lot of wind.*
- c. *A garden with lots of oak trees because their leaves release the most water.*
- d. *Parks with lots of sycamore trees because transpiration and evaporation occur in their leaves.*

Since no literature existed that analyses AKM tasks using Watson and Callingham's [11] statistical literacy category, this study did not analyze the students' response using said category. Instead, the students' responses are scored using rubric generated by the authors, as depicted in Table 3.



Trees	Average rate of water released per day in milligrams per square centimeter
<i>Grindelia</i>	29
<i>Bottlebrush</i>	33
<i>Oak</i>	42
<i>Sycamore</i>	38

Fig. 4. Picture 4. Trees Transpiration

Table 3. Scoring rubric for the students' response

Question Number	Students answer	Score
1	- No answer/response	1
	- There is an answer but not related	2
	- There is an answer but no explanation	3
	- There is an answer by giving an example	4
	- Answer "correct" and explain the reason	5
	- Answering "wrong/incorrect" and explain the reason	6
2	- Did not answer or did not vote	1
	- Choose all the answer	2
	- Choose one answer, but it's still wrong	3
	- Choose more than one answer but all wrong	4
	- Choose at least one correct answer	5
	- Choose two correct answers	6
3	- Did not answer or did not vote	1
	- Choose all the answer	2
	- Choose one answer, but it's still wrong	3
	- Choose more than one answer but all wrong	4
	- Choose at least one correct answer	5
	- Choose two correct answers	6
4	- No answer	1
	- Choose all answer	2
	- Choose more than one answer	3
	- Answer b or d	4
	- Answer a	5
	- Answer c	6

To check the data's validity, semi-structured interviews were conducted with several students representing high, medium, and low levels of the results of student answers in each school. Interviews were conducted to dig for deeper information as well as to complete the information that was not found in the test results. Furthermore, triangulation of interview results was also carried out to compare the data and check the validity of the data.

3 Result and Discussion

The results of the research for each question are as follows (Table 4) (Table 5) (Table 6) (Table 7).

In general, students' statistical literacy scores in solving AKM questions are different depending on the question type. The worst performance can be observed on the essay question (question number 1), where 8.87 students obtained score 2, the overwhelming majority were from the low ability school (C1); 12.3% of students gain score 3; and 21.9% of students gain score 4. More than half of the students in each school scored 5, totaling to 55.3%; and only 1.56% of students able to gain score 6. Usually students have difficulties

Table 4. Students' responses for question 1

Schools	Statistical Literacy Score					
	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6
A1	0%	3.23%	6.45%	22.6%	67.7%	0%
A2	0%	0%	9.68%	3.23%	87.1%	0%
B1	0%	0%	16.1%	19.4%	64.5%	0%
B2	0%	9.38%	9.38%	28.1%	43.8%	9.38%
C1	0%	40.6%	15.6%	28.1%	15.6%	0%
C2	0%	0%	16.7%	30%	53.3%	0%

Table 5. Students' responses for question 2

Schools	Statistical Literacy Score					
	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6
A1	0%	0%	3.23%	0%	64.5%	32.3%
A2	0%	0%	0%	0%	93.5%	6.45%
B1	0%	0%	9.68%	0%	67.7%	22.6%
B2	0%	0%	3.13%	0%	50%	46.9%
C1	0%	0%	9.38%	6.25%	75%	9.38%
C2	0%	0%	10%	0%	73.3%	16.7%

Table 6. Students' responses for question 3

Schools	Statistical Literacy Score					
	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6
A1	0%	0%	0%	9.68%	87.1%	3.23%
A2	0%	0%	0%	0%	38.7%	61.3%
B1	0%	0%	9.68%	0%	90.3%	0%
B2	0%	0%	25%	9.38%	53.1%	12.5%
C1	0%	0%	3.13%	12.5%	75%	9.38%
C2	0%	0%	40%	0%	53.3%	6.67%

in solving mathematics essay problems because the difficulties of learning concepts, applying principles, and solving verbal problems, and to minimize it by developing critical thinking skills and students' mathematical literacy skills [16]. The other factors,

Table 7. Students' responses for question 4

Schools	Statistical Literacy Score					
	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6
A1	0%	0%	6.45%	29%	32.3%	32.3%
A2	0%	0%	0%	32.3%	0%	67.7%
B1	0%	0%	16.1%	32.3%	22.6%	29%
B2	0%	0%	3.13%	21.9%	37.5%	37.5%
C1	0%	9.38%	0%	31.3%	43.8%	15.6%
C2	0%	10%	0%	40%	46.7%	3.33%

students are not careful in observing the question given, and less understanding of concept related on the subject of statistics [17].

For complex multiple-choice question (question number 2 and 3) mostly students gain score 5, which is 60.8%; 13.6% of students are at score 4; and 8.54% of students are able to gain score 6. There are still 12.6% of students who are at score 3; even 4.44% gain score 2. This question type is relatively new for students, but because there was guidance how to answer it, more of them able to gain score 5, if there were difficulties, because they lack of understanding of the questions, lack of thoroughness in the process of working on the questions [18].

In multiple-choice question (question number 4), the percentage of students who gain score 4, 5, and 6 are almost the same. There are 31.1% of students gain score 4; 30.5% of students gain score 5; and 30.9% students able to gain score 6. But still there are 4.28% of students who are at score 3; and 3.23% students only gain score 2. This question type is the most familiar for students, and there are no fundamental difficulties in this question type, usually just reading errors, comprehension errors, processing errors, and encoding errors [19].

Those results, if related to statistical literacy theory by Watson [9], it can be concluded that the students are mostly able to reflect on their critical thinking skills in using mathematics skills (level 5 and level 6). Some students can also reflect on their ability to understand the context even though they are not yet critical of the content of the context, and sometimes they are still inconsistent (level 3 and level 4). However, some students cannot reflect on their abilities and struggle to understand a context (level 1 and level 2).

4 Conclusion

Based on the research results and discussion, the students' statistical literacy in solving numeracy-based statistic questions (AKM problems) is spread to several scores depend on question type. Overall, more than a half of students gain score 5, a few of them able to gain score 6, several of them gain score 4, even there are students still gain score 3 and 2. Therefore, it is necessary to improve students' statistical literacy by improving learning methods and teaching materials.

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