Statistical literacy of undergraduate students in Indonesia: survey studies

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Abstract. Nowadays, statistics based information is widely used by various institutions and social media, therefore statistical literacy as an essential knowledge has been recognized by various modern countries is something that must be owned by every citizen in recent information-based society. Students need statistical knowledge and skills so that they will be able to apply it in their studies and daily life. This study aims to assess the level of statistical literacy and variables that influence the improvement of undergraduate students’ literacy in Indonesia. The statistical literacy model used is the model proposed by Gal, which are the knowledge component consisting of five cognitive elements: literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions and disposition components consisting of two elements: attitude critical; beliefs and attitudes. A survey was given to 114 of students, which are from both mathematics study program and mathematics education study program who either have studied basic statistics or have not. The results showed that the level of students’ statistical literacy for all components was sufficient, both for the component of good knowledge and the low disposition component. The average statistical literacy score of students who have studied basic statistics is higher than those who have not studied basic statistics. There are four factors that influence students’ statistical literacy, namely mathematical ability (logical and critical thinking), general knowledge, literacy skills (language), and statistical knowledge.

1. Introduction
Some researchers differed in their opinions about the definition of statistical literacy, but they agree that it is needed to be improved in our future statistical education. These changes must be based on the understanding, purpose, and basic framework of statistical education in elementary, secondary and tertiary schools. Therefore, it is important to define statistical literacy, its components, and what changes must be made in statistical literacy, reasoning, and statistical thinking. Some definitions of statistical literacy are: basic skills and important for understanding statistical information both from social media or from research results [1]; the ability to collect data, interpret, and create statistical information in the form of numbers (average, median, etc.), tables, and graphs, where the process goes through four stages: collection or calculation of data, summary data, products for journalism, and making headlines [2]; a person's ability to interpret and evaluate statistical information critically [3]; the ability to critically understand and evaluate statistical results that penetrate our daily lives - paired with abilities to appreciate the contribution that statistical thinking can make in public and private professions, and personal decisions [4]; the ability to read and interpret provide data: the ability to use...
statistics as evidence in arguments, the ability to think critically about statistics [5]. Based on the definition of statistical literacy mentioned before, the definition of statistical literacy can be summarized as follows, statistical literacy is a basic ability consisting of the ability to collect data, read, and interprets statistics (tables, graphs, averages, standard deviation, etc.) of statistical information and interpreting and criticizing statistically-based arguments.

A survey conducted by Milo Schieldin [6], to measure student statistical literacy at Augsburg College shows that the instruments in the study are not suitable for use at the institution, so there needs to be an improvement. Meanwhile, according to [7], four social media services include non-linearity, interaction, contextual design, and openness of service repositories, showing justification for the implementation of long-term national statistical literacy development strategies. Gundlach et al. [8] survey results offer recommendations for developing improved statistical literacy using statistical information through social media. The expansion of the concept of statistical literacy needed is the ability to read and interpret statistics that are relevant to consumers and decision makers [9].

Students have a high level of literacy skill and mathematical knowledge, moderate level of statistical knowledge and critical questions, but have a low level of context knowledge [5]. Whereas M A Jenny et al. [10] reported that medical students and medical education lacked the basic concepts of medical statistics. To produce students who are statistically literate with minimal misunderstanding, statistical modules must be carefully designed at the university level before learning is carried out [11].

2. Methods

This study used a survey method with respondents as many as 114 college students in Bandung and its surroundings. The sampling technique used snowball techniques, and the instruments used validated questions. Statistical analysis was done on the average score of statistical literacy. Indicators of statistical literacy were adapted from the Gal statistical literacy model [12] which consists of two components such as knowledge components and components of disposition. The component of knowledge consists of 5 elements such as literacy skill, statistical knowledge, mathematical knowledge, and content knowledge. The disposition component consists of 2 elements, which are beliefs attitudes and critical questions.

3. Result and Discussion

The results of the statistical analysis showed that there were significant differences ($\alpha = 0.05$) between the average statistical literacy score of students who had studied basic statistics and those who had not (Sig. $= 0.045$), nor were they all the same score for each element of statistical literacy (Sig. $= 0.000$). With a significant level of $\alpha = 0.05$, the average score of each element is different except for elements of literacy skill with no different mathematical knowledge (Table 1 and Table 2).

Meanwhile, the percentage of students’ statistical literacy on the component of knowledge and the result is quite high at 63.9% (result not shown), especially on the elements of statistical knowledge and context knowledge, this is because many students have studied basic statistics, but the disposition component is still low, 37.1%, this is due to the low attitudes and beliefs of students towards statistical information from social media, as well as the lack of student responses to statistical information, especially information from unbelievable social media, ignoring statistical information from scientific sources such as accredited scientific journals [7], mathematical and language skills also affect students’ statistical literacy [13]. In addition, computers can assist students in producing and interpreting statistical information. Therefore, the ability of computers can affect student statistical literacy [14]. Based on the results of the questionnaire and interviews with several respondents (see Table 3), it is obtained that there are 4 factors and 14 indicators needed to improve statistical literacy in higher education, which is describes as follows.
Table 1. Indicator of Gal’s statistical literacy model: literacy skill, statistical knowledge, mathematical knowledge, context knowledge, critical question, beliefs & attitudes, critical stance.

| Indicator             | Definition                                                                 | Measure                                      |
|-----------------------|---------------------------------------------------------------------------|----------------------------------------------|
| **Literacy skill**    | The ability to read various non-prose texts, for example, graphics, tables, and symbols | Adapted from Gal (2004)                      |
| **Statistical knowledge** | The ability to understand why data is needed and how data can be generated | Adapted from Gal (2004) and Wade (2009)      |
| **Mathematical knowledge** | Ability to understand algebraic operations, such as percent, average, standard deviation, etc. | Adapted from Gal (2004) and Wade (2009)      |
| **Context knowledge** | The ability to convey statistical messages in context.                     | Adapted from Gal (2004) and Wade (2009)      |
| **Critical question** | Ability to ask critically the results of research publications           | Adapted from Gal (2004) and Wade (2009)      |
| **Beliefs & Attitudes** | Individual perceptions of how they respond to statistical messages on social media | Adapted from Wade (2009)                    |
| **Critical stance**   | Individual attitudes toward statistics like or dislikes statistics        | Adapted from Gal (2004)                      |

Table 2. Test results for the similarity of the average score of the statistical literacy component with categories A and B.

Dependent Variable: All Component Score

| Source                  | Type III Sum of Squares | df | Mean Square | F     | Sig  |
|-------------------------|-------------------------|----|-------------|-------|------|
| Corrected Model         | 577,941                 | 7  | 82,563      | 131.034 | .000 |
| Intercept               | 185.877                 | 1  | 185.877     | 295.022 | .000 |
| Category_Component      | 2.547                   | 1  | 2.547       | 4.043  | .045 |
| Statistical_Literacy    | 575.393                 | 6  | 95.999      | 152.280 | .000 |
| Error                   | 497.769                 | 768 | .630       |       |      |
| Total                   | 3600.000                | 768 |            |       |      |
| Corrected Total         | 1075.709                | 767 |            |       |      |

a. R Squared = .537 (Adjusted R Squared = .533)

Table 3. Average score equity test results element of statistical literacy

| (I) Statistical_Literacy | (II) Statistical_Literacy | Mean Difference | Std Error | Sig  | 95% Confidence Interval |
|--------------------------|----------------------------|-----------------|-----------|------|-------------------------|
| Literacy_skill           | Statistical_knowledge      | -.104           | .000      | .136 | -.73                    |
|                          | Mathematical_knowledge     | .04             | .000      | .36  | .27                     |
|                          | Context_knowledge          | .32             | .000      | .01  | .64                     |
|                          | Critical_Question          | -.138           | .000      | .164 | .92                     |
|                          | Beliefs_Attitudes          | 1.11            | .000      | .80  | 1.43                    |
|                          | Critical_stance            | .91             | .000      | .60  | 1.22                    |
3.1 Knowledge factors
- Knowledge of valid data.
- The knowledge that is insightful to strengthen the interpretation of statistical information.
- The knowledge that is needed for daily needs, for example, business needs.
- The knowledge that is in nature to strengthen understanding of statistical information.

3.2 Mathematical capability factors
- Ability to overcome mathematical, logical, variable, etc.
- Numeracy skills such as percentage, difficulty, ratio, average, variance, etc.
- The ability to read data and interpret both in the form of tables and diagrams, and graphs of functions.
- Mathematical literacy.

3.3 Language ability factors
- The ability to understand the text and interpret the reading text.
- The ability to connect the components contained in the text.
- The ability to interpret ideas contained in the text.
- The ability to write ideas in easily understood texts.
- The ability to use and reflect text or reading for the purpose and content of information produced.

3.4 Confidence factors
- Confidence in the ability to understand data and facts.
- The ability to respond to statistical information based on opportunity theory and statistical estimation.
- The ability to understand sources of information that can be trusted, so that they are not easily deceived.

4. Conclusion
Statistical literacy is needed by all students in higher education. They will do their final assignment that the statistical literacy is needed [2]. Students must have scientific arguments for the results of their research and it will be strengthened by reliable statistical analysis. Statistical literacy will help students in statistical analysis, representing and arguing scientifically the results of their research correctly [15].

The mathematical disposition also influences the beliefs attitudes and critical question elements [16]. The attitude of trust in mathematical ability also affects the attitude of confidence in the ability to analyze statistics and critical of statistical information. Students who lack confidence in their mathematical tendencies tend to have weak critical skills.

Students who are familiar with mathematical problem solving tend to have no difficulty in understanding the text and context [17,18,19] so that their knowledge component is high on average [20]. Problem-based learning can improve mathematical literacy [21] which also has an effect on increasing statistical literacy.

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