The Statistical Literacy of Mathematics Education Students: An Investigation on Understanding the Margin of Error

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***Abstract* – Understanding the margin of error (MoE) as a part of statistical literacy which is useful for the public to select credible information from various surveys and polls. The study aims to reveal the levels of statistical literacy of mathematics education students, especially in understanding MoE, and compare them based on four variables: gender, enrollment in a statistics course, year in the program, and type of university. The online survey research involved undergraduate students of the mathematics education study program from 21 universities in Indonesia's western, central, and eastern regions as the sample (*n* = 970). Descriptive statistics was used to describe the literacy levels and inferential statistics (*t*-test and *F*-test) to compare them based on the four variables. The results of the study reveal that: (1) student literacy in understanding the MoE concept is dominant at the non-literate level; and (2) there are significant differences in students' literacy levels in terms of gender, enrollment in a statistics course, year in the program, and type of university. The study indicates that the literacy of mathematics education students is still low, so the statistics course is expected to focus more on developing statistical literacy.**

***Keywords* – Statistical literacy, margin of error, statistics education, mathematics education, higher education.**

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1. Introduction

Statistical literacy has become a necessity for society in the modern era. In a data-driven technology society, the need to understand and apply statistical literacy is crucial for all elements of society [1], [2], [3], [4]. Most information and research reports that often appear in mass media used for decision-making are usually presented in statistics [3], [5], [6]. For instance, people without statistical literacy may be unable to identify credible information [1], [7]. They will find interpreting, evaluating, and communicating this information challenging [1], [3], [7]. Therefore, statistical literacy is crucial to improve the quality of decision-making by individuals, communities, and governments.

The importance of statistics in everyday life and the workplace has increased attention to statistical literacy in the mathematics curriculum [3]. In the digital era, statistical literacy is crucial because students are continuously presented with statistics from many sources [3]. Statistical literacy has also been described as an essential learning outcome in teaching basic or introductory statistics in universities [8], [9]. In fact, the importance of statistical literacy has encouraged the Statistics Education Research Journal to publish a special issue (May 2017) dedicated to the topic of statistical literacy [9]. The guest editor of the special issue concluded that statistics educators should take time to directly promote statistical literacy [9].

Although attention to statistical literacy is continuously increasing in education today, there is little consensus on the definition of statistical literacy [9], [10], [11]. One of the first published definitions of statistical literacy was put forward by Walker [12], who suggests that statistical literacy is the ability to communicate statistical information. Several statistics educators have described statistical literacy as understanding and using basic statistical terminology [3], [8], [9], [13], [14], [15], applying it to the real world [15], [16], and reasoning with the information presented in statistical data [17]. On the other hand, statistical literacy has been defined as high-level skills such as communicating, interpreting, and being critical of statistical information [3], [9], [16], [18], [19], as well as questioning conclusions and statistical results [15]. Based on the definitions put forward, this study defines statistical literacy as a skill to understand statistics, apply it in various contexts (research and the real world), interpret it, and be critical of statistical information.

One part of statistical literacy is interpreting a margin of error (hereafter MoE) [20]. MoE is a signature index of sampling variability in surveys or polls that appear in non-technical publications such as newspapers and magazines [21]. Franklin *et al.* [22] stated that statistically literate citizens should be able to understand the behavior of 'random' samples and interpret the 'margin of sampling error.' Awareness of MoE is crucial for data communicators and consumers [20]. However, MoE is also one of the least understood statistical concepts by the public [21]. There is still much confusion about the MoE for both the laymen and the educated [23]. Budgett and Rose [20] reveal that journalists also often ignore MoE in estimating poll or survey results. This indicates that the MoE concept is not yet a significant concern even among data communicators.

The mass media and pollsters often mention MoE in reporting the results of polls or surveys, however, people are generally unaware of its function and meaning [20]. Furthermore, Budgett and Pfannkuch [24] emphasize that there have been just a few research studies on people's understanding of MoE concepts, what it means, and when to use it. Therefore, more research related to the understanding of MoE is needed, both in general and specific contexts in the field of education. This present research bridges the gap by investigating MoE understanding in the educational context, focusing on aspects of the assessment so that the results can be helpful in mapping students' statistical literacy levels.

Currently, there is a need to design new assessments to help researchers and educators explore students' statistical literacy [9]. Ziegler and Garfield [9] added that in developing statistical literacy assessments, a clear framework is needed to guide the development of these assessments. However, several recent studies have not focused on the context of statistical literacy assessment. For example, Gonulal [25] researched to investigate predictors of statistical literacy in the context of Second Language Acquisition (SLA) involving doctoral students. This study seeks to reveal the factors that contribute significantly to statistical literacy, not to assess statistical literacy skills on a broader scale. Auliya [26] investigated the effects of mathematics and statistics perceptions on the statistical literacy of informatics students. Like Gonulal, the study focused on the factors that contribute to statistical literacy, not assessing the level of statistical literacy. Setiawan and Sukoco [27] explore the statistical literacy of first-year students in the statistics study program. The focus of the study was to investigate students' abilities in using simple descriptive statistics and data visualization that had been studied at the senior high school level. Study findings also have not been able to capture statistical literacy on a broader scale.

A study on statistical literacy with a more specific topic was conducted by Budgett and Rose [20]. This study investigates appropriate teaching approaches to understanding the MoE concept for New Zealand grade 13 students (ages 17–18). This study produced a learning trajectory of several vital components, including media reports as motivational and conceptual development tools. This study only focuses on improving the quality of learning on the topic of MoE but like the aforementioned studies not on the assessment. Therefore, a study regarding statistical literacy in the context of assessment is worth conducting, including capturing the extent of students' understanding of the MoE concept from various levels of education.

Learning improvement cannot be separated from the assessment. Efforts to increase statistical literacy must begin with an initial mapping related to students' statistical literacy level, including in university. At the university level, statistical literacy is the result of learning from introductory statistics courses [8]. Information about statistical literacy on a broad scale will be invaluable for designing improvement of a statistics course in the future. However, it is still difficult to find a survey study that explicitly captures the levels of students' statistical literacy on a broad scale. Existing surveys in several countries only involve samples on a limited scale. For example, Hassan *et al.* [28] conducted a statistical literacy survey of 360 undergraduate students in Pakistan. Ismail and Chan [29] surveyed 412 respondents, but the respondents were not from the university level. In Indonesia, Khaerunnisa and Pamungkas [30] reveal the statistical literacy profile of mathematics education students, involving students only from one of the universities in Indonesia, with a total sample of 107.

Therefore, a survey to capture students' statistical literacy levels on a national scale still needs to be carried out.

Information related to the extent to which students understand, apply, and critically evaluate statistical concepts in various contexts, both in the context of research and in everyday life, is useful for educators to design appropriate statistics courses. This information can be used by researchers to map research potential in the future, both in the context of improving the learning process and its assessment. Also, the survey's results can be used to evaluate the suitability of the statistics education curriculum to the needs of education in the modern era. Within the framework of statistical literacy, many researchers have suggested several essential aspects that can be considered in curriculum improvements, such as gender, enrollment in statistics, year in the program [31], and types of educational institutions (state vs. private) [32]. Therefore, this study aims to investigate the levels of statistical literacy of mathematics education students in terms of their understanding of the MoE concept and compare them based on gender, enrollment in a statistics course, year in the program, and type of university.

2. Methods

This survey study [33] focused on revealing the levels of statistical literacy of mathematics education students in terms of their understanding of the MoE concept and comparing them based on three aspects of demography and type of university. The literacy levels of students are classified based on their ability to answer questions about the use of MoE in reporting the results of surveys. The demographic aspects: gender, year in the program, and enrollment in a statistics course, as well as type of university were linked to differences in literacy levels.

2.1. Survey Instrument

The survey instrument was developed by adapting instruments from previous studies. Some demographic aspects such as gender, major program, enrollment in a statistics course, and year in the program were adapted from Gonulal *et al.* [31]. Aspects of disposition and source of knowledge to understand the MoE concept was adapted from Gonulal *et al.* [31] and Lazaraton *et al.* [34]. Cognitive aspects related to understanding the MoE concept were developed based on research by Budgett and Rose [20]. Finally, this survey consisted of ten questions: four questions about the respondent's identity (gender, university name, education degree, and semester); one question related to students' experience of taking a statistics course; two questions regarding familiarity with the term MoE; one question about the respondent's belief in understanding the MoE concept; and two questions that measure students' understanding of MoE applications in various contexts.

The questions used to measure students' understanding of the MoE application consisted of context, stem, and two answer choices. The context used was a survey report by a particular institution, including the sampling technique, significance level, and MoE used in the survey. Then, respondents were asked to choose the answer options: "agree" or "disagree." If the respondent chose the "disagree" option, the respondent would be asked to write down the reasons. It was done to validate whether the respondent understands the MoE concept in the context of the questions, not just by guessing the answer choices. However, if the respondent chose the "agree" option, it means that the respondent did not understand the MoE concept in the context of the question, so we did not ask students to write down their reasons. Following is an example of a question used to measure respondents' understanding of the MoE concept (Figure 1).

A survey agency conducted a quick count for regional head elections in District X. Sampling was done randomly using a multistage random sampling technique. The quick count results reported that candidate A won 53.7% of the vote and candidate B won 46.3% with a margin of error of ± 3.75% (α = 5%).

Based on the quick count results, do you agree that candidate A's vote acquisition is claimed to be higher than candidate B's? (*Note: the election is assumed to be fair, honest, and without fraud*).

○ Agree
○ Disagree

Figure 1. Example of question used to measure understanding of the MoE concept

Note: When the respondent clicks on the "Disagree" option, the survey will bring up a dialog box to facilitate the respondent in writing the reason for choosing this option. Respondents could not cancel or continue the survey if they did not fill in the dialog box.

The initial version of the survey was sent to reviewers for feedback to guarantee the face and content validity of the survey. The reviewers were three experts in mathematics education who are familiar with statistics education: two lecturers who have experience teaching statistics and one graduate of the mathematics education master's degree who was experienced in statistical data analysis. Reviewers were asked to provide feedback regarding the structure and format of the survey, the substance and order of the questions, the duration for completing the survey, the clarity of the questions and answer choices, and other additional factors or aspects that the survey had not accommodated. Based on this feedback, the questions and answer choices were modified, and one question was added related to the respondent's university origin.

This question was needed to make it easier for researchers to map the distribution of respondents and identify the type of university (public vs. private). Then the survey was formatted in a Microsoft Form, and a survey link was sent to all reviewers for feedback. Their responses and feedback were used in adjusting the online formatting and functionality, making minor edits to make it easier to read and understand and establishing an estimated time to complete the survey.

2.2. Survey Administration and Respondent Recruitment

The survey was administered online via Microsoft Form for four weeks. There was no time limit for the respondents to complete the survey, but under normal conditions, it was estimated that they only needed 2–3 minutes to complete the survey. The respondents were only allowed to complete the survey once and could complete the survey via their computer/laptop or smartphone. For anonymity reasons, the survey did not ask for the respondents' name. However, the respondents were required to fill in the gender, semester, study program, degree, and university name. There are several department options: mathematics education, mathematics, statistics, and other options, but this paper only focuses on survey results for students from the mathematics education study program.

The respondents were recruited from various universities in various regions of Indonesia based on convenient and volunteer samples, so there were no special requirements for recruiting respondents. However, this survey prioritized respondents from universities that have mathematics education study programs, both public and private. First invitations were sent to mathematics education lecturers at various universities, who then asked for consent from their students at their universities. If the students agreed, two alternatives for administering the survey were provided: the lecturers asked the students to complete the survey in person during lectures, or they shared the survey link in online classes, WhatsApp Groups, or email. Through this method, the representation of respondents from three major regions in Indonesia, namely the western, central, and eastern regions was maintained.

2.3. Survey Respondents

This survey took undergraduate students in the mathematics education department in Indonesia as a population. The sampling of respondents was carried out using a convenience sampling technique [35]. The reason for using convenience sampling is that this technique is relatively inexpensive, does not take much time, and is simple [36].

Moreover, convenience sampling is also beneficial for developing potential hypotheses or study objectives for more rigorous research studies [36], which was relevant to the purpose of this study.

The number of respondents who accessed and completed the survey was 1111 from 21 universities spread across three regions of Indonesia: western (13 universities), central (5 universities), and eastern (3 universities). Geographically, the western region of Indonesia has a wide coverage area compared to the central and eastern regions, so the population of universities in the western region was much larger than the central and eastern regions. It caused researchers to recruit more respondents from universities in the western region. The distribution of respondents for the three regions is presented in Table 1 in the results section.

Of the 1111 respondents, 121 (10.89%) were not eligible because they were not mathematics education students, so the remaining 990 were. Of the 990 respondents, 20 (1.96%) were also excluded because they had studied for more than four years, leaving 970 respondents. Therefore, this survey involved 970 (87.31%) eligible respondents. The complete demographic data of 970 respondents are presented in Table 1 in the results section.

2.4. Data Analysis

The literacy levels of mathematics education students were identified through students' understanding of the MoE that was asked in the survey. Data related to students' understanding of the MoE application were given a score of 2 if the answer was correct and the reasons were relevant; 1 if the answer was correct, but the reasons were not relevant, and 0 if the answer was wrong. The maximum score obtained by students was 4, and the minimum was 0. The levels of literacy were categorized based on the levels of statistical literacy modified from the Tractenberg [37] model. The literacy levels developed by Tractenberg [37] consist of levels 1 to 6, where level 1 represents the level of literacy starting to emerge (pre-literate), and level 6 represents the expert/master in using statistics. However, in this study, the aspects of statistical literacy that were measured only focused on applying the MoE concept, so only three levels were used to categorize the literacy levels, as follows.

Literate : understand the meaning and application of the MoE concept in various contexts (score 4)

Pre-literate : start to understand the meaning of the MoE concept and its application only in specific contexts (score 1 – 3)

Non-literate : do not understand the meaning and use of the MoE concept (score 0)

To describe the levels of student literacy in terms of gender (male vs. female), enrollment in statistics course (ever vs. never), year in the program (1st-year; 2nd-year; 3rd-year; 4th-year), and type of university (public vs. private), the analysis was performed using a crosstab technique. The literacy level categories for each aspect are then presented as a percentage. Data on cognitive aspects related to an understanding of MoE were analyzed using descriptive statistics to obtain information regarding the mean, standard deviation, 95% confidence interval, minimum, and maximum value.

To test whether there were significant differences in student literacy levels by gender, enrollment in a statistics course, and type of university, raw scores of students' understanding of MoE were transformed into interval data so that the raw scores were transformed into *z*-scores [38]. After the scores were transformed, a *t*-test was performed to check the differences in statistical literacy levels regarding gender, enrollment in a statistics course, and type of university. One-way ANOVA was then performed to test the differences in statistical literacy levels in terms of the year in academics. Statistical testing was carried out at a significant level of 5%.

3. Results

In this section, we present the key findings of our study. First, we present the demographic information of the respondents. This information is useful to guide the reader to a comprehensive understanding of our findings. Second, we present the frequency distribution of respondents based on their statistical literacy level. Finally, we present the differences in respondents' statistical literacy in terms of gender, enrollment in statistics course, year in program, and type of university.

3.1. Respondent Demographics

The demographics of the respondents are presented in Table 1. Of the 970 respondents, the majority are female (79.90%). As many as 73.51% of respondents said they had taken statistics courses at their respective campuses. Even though 26.49% of respondents said they had never taken a statistics course, it was assumed that they could find information about MoE in other subjects, such as research methodology and sampling theory, or through scientific articles, statistics textbooks, and news from the mass media. The distribution of respondents is relatively equal in terms of years of study, but most respondents are studying in the second year (35.36%), followed by the third year (26.08%), and the percentages for the first and fourth year are the same.

Judging from the type of university, most of the respondents came from public universities (71.65%). Based on the geographical aspect, the distribution of respondents shows that most of the respondents came from universities located in the western region of Indonesia (82.99%), while those from universities located in the central and eastern regions of Indonesia are below 10%.

Table 1. Respondent demographics (n = 970)

Demographics aspect	*n* (%)
Gender:	
Male	195 (20.10%)
Female	775 (79.90%)
Enrollment in a statistics course:	
Ever	713 (73.51%)
Never	257 (26.49%)
Year in program:	
1st-year	187 (19.28%)
2nd-year	343 (35.36%)
3rd-year	253 (26.08%)
4th-year	187 (19.28%)
Type of university:	
Public	695 (71.65%)
Private	275 (28.35%)
Region:	
West	805 (82.99%)
Central	72 (7.42%)
East	93 (9.59%)

3.2. Statistical Literacy Levels of Mathematics Education Students

The statistical literacy levels of mathematics education students in understanding the MoE concept are described based on their responses in solving questions in the survey. Furthermore, the statistical literacy of students is categorized into three levels: literate, pre-literate, and non-literate. To obtain an overview regarding the levels of statistical literacy of the students, the mean score and standard deviation of the responses of all respondents were calculated. The survey results revealed that, in general, the literacy level of students in understanding the MoE concept was still low (M = 7.99, SD = 17.24, 95%CI [6.90, 9.07], Min. = 0, Max. = 100). Judging from the statistical literacy levels, most students (79.07%) were non-literate, 20.10% were pre-literate, and less than 1% were statistically literate (Table 2). Based on these findings, it can be concluded that the statistical literacy of mathematics education students in Indonesia is still low.

Table 2. Student literacy level in understanding the MoE concept

	Literate		Pre-literate		Non-literate	
	n	%	*n*	%	*n*	%
Overall	8	0.82%	195	20.10%	767	79.07%
Gender:						
Male	2	1.03%	52	26.67%	141	72.31%
Female	6	0.77%	143	18.45%	626	80.77%
Enrollment in a statistics course:						
Ever	6	0.84%	156	21.88%	551	77.28%
Never	2	0.78%	39	15.18%	216	84.05%
Year in program:						
1st-year	1	0.53%	28	14.97%	158	84.49%
2nd-year	3	0.87%	75	21.87%	265	77.26%
3rd-year	3	1.19%	61	24.11%	189	74.70%
4th-year	1	0.53%	31	16.58%	155	82.89%
Type of university:						
Public	7	1.01%	154	22.16%	534	76.83%
Private	1	0.36%	41	14.91%	233	84.73%

Table 2 also shows that in terms of gender, at literate and pre-literate levels, the percentage of males is higher than females. However, the percentage of females who are not statistically literate is much higher than males. The percentage of students who have taken statistics courses at the literate and pre-literate levels is higher than that of students who have never taken statistics courses. Nevertheless, the number of students at the non-literate level is dominated by students who have taken statistics courses. Students in the second and third years of lectures at the literate and pre-literate levels have a higher percentage than first and fourth-year students. Students who are not yet statistically literate are dominated by students in the first and fourth years of attending lectures. Furthermore, by type of university, students at public universities at the literate and pre-literate levels have a higher percentage than those from private universities. On the contrary, at the non-literate level, students at private universities dominate. The following section explains the significance of differences in student literacy levels regarding gender, enrollment in a statistics course, year in the program, and type of university.

3.3. Statistical Literacy Levels by Gender, Enrollment in Statistics Course, Year in Program, and Type of University

Student literacy levels are compared based on gender (male vs. female), enrollment in a statistics course (ever vs. never), year in the program (1st-year, 2nd-year, 3rd-year, and 4th-year), and type of university (public vs. private). The mean score for each category was calculated, and statistical analysis was used to examine the difference in means.

The results of descriptive and inferential statistics on students' ability to understand the MoE concept are presented in Table 3.

Table 3. Differences in literacy levels in understanding the MoE concept

	n	*M*	*SD*	95%CI
Overall	970	7.99	17.24	[6.90, 9.07]
Gender: t (968) = 3.11, p = 0.002)				
Male	195	11.41	20.18	[8.58, 14.24]
Female	775	7.13	16.32	[5.98, 8.28]
Enrollment in a statistics course: t (968) = 2.66, p = 0.008)				
Ever	713	8.87	18.20	[7.54, 10.21]
Never	257	5.54	14.01	[3.83, 7.26]
Year in program: F (3, 966) = 4.28, p = 0.005)				
1st-year	187	5.75	14.56	[3.66, 7.84]
2nd-year	343	8.16	16.96	[6.37, 9.96]
3rd-year	253	10.87	20.42	[8.35, 13.39]
4th-year	187	6.02	14.91	[3.88, 8.15]
Type of university: t (968) = 3.31, p = 0.001)				
Public	695	9.14	18.43	[7.77, 10.51]
Private	275	5.09	13.39	[3.51, 6.67]

In terms of gender, the mean difference in male and female literacy scores is significant, t (968) = 3.11, $p < 0.05$, where male score literacy (M = 11.41, SD = 20.18) is higher than female (M = 7.13, SD = 16.32). The mean score difference between students taking statistics courses and those not taking statistics courses is significant, t (968) = 2.66, $p < 0.05$. The mean literacy score of students who had taken statistics courses (M = 8.87, SD = 18.20) is higher than those who had never taken statistics courses (M = 5.54, SD = 14.01). Furthermore, the mean literacy scores of students from public and private universities also differ significantly, t (968) = 3.31, $p < 0.01$, where the mean literacy score of public university students (M = 9.14, SD = 18.43) is higher when compared with private university students (M = 5.09, SD = 13.39).

In terms of the year in the program, the analysis results show a significant difference in the mean literacy score of students, F (3, 966) = 4.28, $p < 0.05$. Post hoc analysis using the Tukey test revealed that the difference in mean literacy score of first-year students is not significantly different from second-year students, t (528) = –1.55, p = 0.41. The difference in mean literacy score of first-year students is not significantly different from fourth-year t (372) = –0.15, p = 0.99, but significantly different from third-year students t (438) = –3.10, $p < 0.05$. The mean literacy score of first-year students (M = 5.75, SD = 14.56) is lower than third-year students (M = 10.87, SD = 20.42). Furthermore, the mean literacy score of second-year students is not significantly different from third-year students, t (594) = –1.90, p = 0.23, and fourth-year, t (528) = 1.38, p = 0.51.

However, the mean literacy score of third-year students is significantly different from fourth-year students, t (438) = 2.93, $p < 0.05$, where the mean literacy score of third-year students (M = 10.87, SD = 20.42) is higher than fourth-year students (M = 6.02, SD = 14.91).

4. Discussion

In this section, we focus on providing a comprehensive discussion of the main findings of our study. Besides comparing our findings with those of previous studies, we also explain why they are important and their contribution to statistics education. Finally, we report on the limitations of our study and its implications for practice and future research.

4.1. The Statistical Literacy of Students in Terms of Understanding of the MoE

Interpreting MoE is one of the essential parts of statistical literacy [20]. Statistically, literate citizens must be able to interpret a MoE [22]. Therefore, understanding the application of the MoE concept in various contexts is one of the crucial parameters for describing the level of statistical literacy. The results of the study revealed that the ability of mathematics education students to understand the application of the MoE concept in various contexts was still deficient. It indicates that the statistical literacy of mathematics education students in general are not satisfying. This finding is consistent with previous research, e.g., [27], [28], [29], [30], [39]. The low ability of students to understand the concept of MoE is also consistent with the opinion of Thompson and Liu [21], who stated that MoE is a statistical concept not understood by laymen or educated people, even though MoE often appears in various statistical data in the mass media.

4.2. Statistical Literacy Differences by Groups of Respondents

Even though the literacy level of most mathematics education students is still low, the study findings reveal significant differences in literacy levels by gender, which is consistent with the findings of Mandap [40] but contradicts Edirisooriya and Lipscomb [41], which show no significant statistical difference in anxiety among college students. This study has not revealed the causes of this discrepancy, but the findings of previous studies are also inconsistent. Therefore, the issue of discrepancies in statistical literacy levels in terms of gender needs to be an important issue for further research.

Other findings show that students who have experience taking statistics courses have significantly better literacy levels than those who have never taken statistics courses. This finding is not surprising and is consistent with Loewen *et al.* [42] and Lukman and Wahyudin [43]. Additionally, Gonulal [25] reported that the number of statistics courses students took contributed positively to statistical literacy. Therefore, the more statistics courses taken by students, both those offered by departments and faculties as well as through independent courses, strongly indicate their contribution to strengthening the students' statistical literacy.

The study also revealed a trend of increasing the students' statistical literacy in terms of the year in the program. The statistical literacy of mathematics education students continues to increase from their first- to third-year study. However, what is interesting is that the statistical literacy of students in the fourth year has decreased. It supports Gonulal's findings [25] that year in the program does not significantly predict students' statistical literacy level. In the Indonesian context, mathematics education students are usually equipped with basic statistics, mathematical statistics, probability theory, and advanced statistics courses in the third year. So, it is not uncommon that students' statistical literacy is highest in the third year (compared to the first- and second-years). However, fourth-year students usually focus on field practices and final assignments (undergraduate thesis), making statistics is less of a focus for them, except for statistical concepts that will be used for data analysis in their final assignment. This reason is relevant to the findings of Thomas [44] and Gonulal [25], which emphasize that entering the final year of college, students tend not to deepen their statistical knowledge, except for those who are interested in specific statistics that are useful for completing their final assignment.

Another important finding is related to the gap in the literacy levels of mathematics education students in terms of university type. This research reveals that the literacy level of students at public universities is significantly higher than that of students at private universities. Literature still rarely investigates this aspect, but in the Indonesian context, these findings are essential for higher education stakeholders to adopt strategic policies to ensure equal access to education for students at public and private universities. Apart from that, this issue is interesting for academics in uncovering factors that cause these discrepancies and their impact on statistics education.

4.3. Implications of the Study Findings

Statistical literacy as a product of statistical education [8] can be used as a parameter to review the suitability of the statistics education curriculum to the needs of society in the modern era. Statistical education that has not focused on developing statistical literacy has an impact on students' low understanding of applying statistics in real contexts. Therefore, statistics education stakeholders should review the statistics education curriculum in various higher education institutions. Lipič and Ovsenik [45] state that the results of a survey on statistical literacy are helpful for educational institutions and other institutions involved in the statistical education process to strengthen the literacy of people from different generations. One of the crucial aspects that should be the focus of the statistics education curriculum is strengthening the understanding of the MoE concept.

The issues of gaps in literacy levels based on gender, enrollment in statistics courses, year in programs, and types of universities is important to consider in adjusting the statistics education curriculum in the mathematics education department. The statistics education curriculum is expected to focus on developing students' statistical skills in a research context. More than that, it should also develop students' skills in using statistics in everyday life, which are in line with the needs of society in the modern era. However, apart from being relevant to the needs of modern society, the development of a statistics education curriculum should also guarantee equal access to education for all students. The statistics education curriculum should not be gender biased and discriminate against differences in inputs and facilities of higher education institutions. Therefore, the expected statistics education curriculum is equitable for all students.

4.4. Limitations and its Implications

This survey study has several limitations. First, the survey respondents were not randomly selected due to the wide coverage area of the population and the limited cost, time, and resources of the research. The implication is that although the number of respondents participating in this survey is quite large, the findings of this study are potentially biased, so they cannot be generalized to the entire population, namely students of mathematics education in Indonesia. However, the research findings are meaningful and essential because they can be used to investigate other aspects of statistical literacy amidst the limited research on this topic.

In the future, other researchers need to follow up on the findings of this study through empirical studies based on various perspectives and using random sampling techniques.

At least two topics are urgent to investigate—first, the topic regarding what factors influence literacy levels. Second, substantial efforts to increase literacy through development, including curriculum, learning trajectories, media and lecture models, and statistical educational assessment models.

The second limitation is that this survey research captures literacy levels on only one statistical topic in higher education. On the other hand, the dimensions revealed by the respondents only focused on the cognitive dimension, while the dispositional dimensions had not been explored in the survey. Future surveys can be focused on measuring statistical literacy on broader statistical topics (e.g., probability and sampling, descriptive statistics, and inferential statistics). Aspects of disposition, such as confidence in statistical abilities, are also interesting to be surveyed. If these two topics can be examined simultaneously and their relationship is explored, powerful information will be obtained to map strategies for improving statistics education in today's modern era.

5. Conclusion

This study reveals that the statistical literacy level of most mathematics education students needs to be increased, especially in relation with understanding the use of the MoE concept in various contexts. Mathematics education students, who are considered more accessible to master statistics compared to other study programs, do not guarantee good statistical literacy either. It indicates that there is a need to reform the statistics education curriculum in the study program. The orientation of statistics education is expected to emphasize students' proficiency in using statistics in research and how to equip students to be proficient in using it in everyday life, both in their roles as students and citizens. Various issues related to the gap in literacy levels based on gender and type of university (public vs. private) also need to be considered in efforts to reform the statistics education curriculum. Substantial efforts are needed to provide equal access for students in statistics education. Therefore, future research is needed that seeks depth to reveal the factors causing low statistical literacy from various perspectives (e.g., demographic aspects, learning resources, facilities, infrastructure, and curriculum). Equally important are studies that address low statistical literacy, such as the development of learning trajectories, instructional media, learning models, and statistical education assessment models.

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