Statistical literacy level of mathematics education students: Challenges and recommendations for competency improvement

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Abstract:
An essential part of statistical literacy is a person's fundamental ability to read, understand, interpret, compile, represent, process, and critically evaluate statistical information. In addition, the ability to interpret and communicate the data that has been obtained is also part of statistical literacy. This study aims to analyze students' statistical literacy level and the challenges faced in statistical literacy and provide recommendations for improving competence. The study used a quantitative approach with an online survey involving mathematics education students. Data collection used a researcher-developed survey instrument, which was used consisting of 15 items covering essential, intermediate, and upper competencies. The population was students of the Mathematics Education study program. The sample was selected using a purposive sampling technique based on the criteria of students who have taken statistics courses. The survey was administered online. The results showed that the students' statistical literacy level was in the low category. Students have difficulty understanding the basic concepts of statistics in essential competencies, interpreting data in intermediate competencies, and communicating statistically in upper competencies. This challenge is influenced by low motivation and interest in learning. These findings suggest several strategies to improve statistical literacy competencies, including developing a more effective curriculum, increasing learning motivation, and strengthening basic math skills. Implementing these recommendations is expected to enhance the quality of statistics learning in the Mathematics Education study program and produce mathematics educators who are competent in statistical literacy.

Keywords: Literacy Skills; Mathematics Education; Statistical Literacy.

Introduction

Education in Indonesia, from elementary school to university, introduces and studies statistics as one of the subjects in mathematics. (Elfitra & Siregar, 2020; Hariyanti, 2020; Karimah, 2017; Setiawan, 2021). The subject matter taught at the elementary school level starts from direct and indirect data collection, introducing

tables, diagrams and graphs, and data structure (average, mode, and median) of a data group. Students learn different data types, presentation, entry, and distribution methods at the secondary school level. The next level corresponds to what is taught at the previous level. While at the university level, the development and implementation of data or information itself. It shows the importance of learning statistics in solving problems in everyday life (Chick & Pierce, 2013). it is in accordance with (Habibie & Hidayat, 2022; Schield, 2004). The teaching curriculum should be based on situational data to motivate students to learn statistics based on their daily situations.

Students' statistical literacy is an important aspect that needs to be considered in mathematics education (Serrano & Inzunza, 2022; Yusof et al., 2021). Statistical literacy is understanding, criticizing, and interpreting statistical information daily (Gieg et al., 2023; Henderson & Corry, 2021). Good mastery of statistical literacy can help students understand and analyze data, make the right decisions, and solve statistics-related problems (Carmichael et al., 2009). However, several studies have shown that students still face challenges developing their statistical literacy skills (Serrano & Inzunza, 2022; Yusof et al., 2021). Students often experience difficulties in understanding statistical concepts, interpreting data analysis results, and applying statistical knowledge in real-life contexts (Çakıroğlu & Güler, 2021; Yusof et al., 2021). it can be caused by various factors, such as a lack of basic understanding of mathematics, difficulty reading and understanding statistical texts, and a lack of motivation and interest in learning statistics (Yusof et al., 2021).

Therefore, it is essential to conduct research and analyze the level of statistical literacy of mathematics education students. This research can identify the challenges students face in developing their statistical literacy skills and provide recommendations to improve students' statistical literacy competencies (Çakıroğlu & Güler, 2021; Yusof et al., 2021). The results of this study are expected to help mathematics education study programs design more effective curriculum and learning strategies to improve students' statistical literacy (Carmichael et al., 2009; Prince & Frith, 2017; Setio & Baiduri, 2023). One of the main challenges students face is the lack of a deep understanding of statistical concepts and their applications. Research by Zhang shows that attitudes toward statistics and confidence in using statistics are essential for improving statistical literacy (Zhang & Han, 2024). It aligns with findings from Zimprich, who revealed that negative attitudes towards statistics are often caused by a lack of math skills and gender differences, which can affect students' confidence in learning statistics (Zimprich, 2012). Thus, it is essential to identify the factors influencing statistical literacy to formulate effective strategies to improve students' competence in this area.

In addition, research by Setio shows that many students have a low level of statistical literacy, indicating the need for improvements in teaching methods and teaching materials (Setio & Baiduri, 2023). It reflects the gap between school teaching practices and the statistical literacy demands required in higher education, as expressed by Prince and Frith (Prince & Frith, 2017). Most statistical literacy competencies have been included in the 2013 Curriculum mathematics textbooks at the elementary, junior, and senior high school levels. Some changes can still be made to increase the breadth and depth of statistical literacy (Setiawan, 2019). Therefore, this study aims to explore the challenges faced by mathematics education students in statistical literacy and provide recommendations to improve their competence.

Recommendations for improving statistical literacy could include developing a more integrated and practice-based curriculum, as proposed by Schwab-Mccoy, who

emphasized the importance of relevant and applicable learning experiences in statistics (Schwab-McCoy, 2016). In addition, a more interactive and collaborative approach to teaching statistics can help students understand and apply statistical concepts effectively (Budgett & Rose, 2017; Hui, 2024). Thus, this study contributes to understanding statistical literacy among mathematics education students and provides insights for developing better teaching strategies.

Permendikbud No. 24 of 2016, the basic skills of statistics are: a) analyzing data, mean, median, and mode values, as well as data distribution to draw conclusions, make decisions, and make predictions; b) presenting and solving problems related to data distribution, mean, median, mode and data distribution to draw conclusions, make decisions and make predictions. Statistical knowledge can be developed by studying statistics in mathematics (Batanero et al., 2011; Risqi & Ekawati, 2020). Starting from the level of understanding statistics by collecting and drawing conclusions based on data processing results (Fardillah et al., 2019). Even NCTM recommends that secondary school students have experience organizing, representing, and interpreting data through statistics. In addition, statistical knowledge is also essential in making decisions based on information or data obtained during the consumption program (Hafiyusholeh, 2015). The existing mathematics curriculum in New Zealand has three program components in learning statistics, namely statistical questions, interpretation of statistical reports, and analysis of practical problems (Callingham & Watson, 2023; Ridgway et al., 2011).

Thus, statistical literacy is essential in our education. Still, it is not in line with students' understanding, even at the university level, as not many students understand this statistical learning. Research conducted by (Andriatna et al., 2021; Andriatna & Kurniawati, 2021; Azis, 2020), namely the analysis of basic statistical abilities in students at the beginning of the statistics course, shows that the level of their basic statistical skills at the start of the statistics course is at a low level, the statistical literacy level of prospective mathematics teachers is mainly at a *consistent non-critical* level, and the achievement of statistical literacy skills of prospective mathematics teachers is uneven for each indicator, The indicator of reasoning about data and statistical results is at the multi structural level, the indicator of reasoning about basic concepts and statistical terms is at the uni structural level, the indicator of reasoning about collecting and processing data descriptively is at the relational level, and the indicator of interpreting data is at the uni structural level.

Several previous studies have examined issues related to students' statistical literacy. (Yusof et al., 2021) surveyed to assess the level of statistical literacy of postgraduate students in Malaysia. The results showed that although students understood descriptive and inferential statistics well, they still had difficulties interpreting inferential data. (Serrano & Inzunza, 2022). It also found that students at the end of senior secondary education still have a superficial understanding of the concept of hypothesis testing.
In addition, (Çakıroğlu & Güler, 2021) conducted an experiment to improve college students' statistical literacy through real-life activities enriched with gamification elements. The results showed that this approach can enhance statistical knowledge and motivate students to learn statistics. (Carmichael et al., 2009) also emphasized the importance of developing students' interest in statistical literacy from a young age, as interest is a significant predictor of later achievement. Another relevant study is that of (Connell et al., 2022), who conducted a literature review on health literacy education programs for healthcare professionals. The review showed that the main focus of such

programs is on the functional dimensions of health literacy (reading, writing, and numeracy). However, there is an increasing emphasis on the interactive and critical domains.

In majors other than mathematics education (Apriani, 2018; Saparwadi, 2023; Syarief et al., 2023; Wahyuningrum, 2021; Yuniarti, 2022), namely the mistakes of public administration study program students in solving descriptive statistics and inferential statistics questions that from the test results and interviews the most errors found were process errors with a large percentage of 92%, namely in hypothesis testing material. Factors that cause high conceptual errors are found in hypothesis testing material because they do not memorize the formula, are not accustomed to reading the price of the table, have errors in determining the criteria for acceptance/rejection of the hypothesis, and have interpretation errors. Six mistakes were committed by students in the biology education study program when attempting to solve inferential statistics issues. Students make mistakes in forming hypotheses, understanding symbols, concepts, and skills, and using procedures and formulas. These errors are often made in determining the hypothesis, especially in presenting the hypothesis in its mathematical form, and procedural errors, especially in the steps in deciding what test to use. More than 50% of students can fulfill statistical literacy competencies such as understanding statistical concepts, numeracy, interpretation, and communication skills. The competency of insight into applying statistical concepts and the ability to visualize students did not meet the competencies because less than 50%.

In learning statistics at university, teachers must provide space for students to develop their statistical literacy skills in the learning process and assist in the development of their mathematical knowledge in various contexts of everyday life, which is related to the activities of understanding, managing, analyzing information presented in the form of tables, graphs, and diagrams and interpreting the results of data analysis. According to (Schield, 1999), statistics is the ability to think critically about statistical matters. Learning statistics is a fundamental and essential tool for understanding statistical information or research results, including organizing data, constructing and presenting tables, and carrying out various forms of data representation (Ben-Zvi & Garfield, 2004).

More broadly, the learning of statistics in the classroom is related to two interconnected components, namely (1) the ability to interpret and critically evaluate statistical information, data-related responses, or random events that occur in various relevant contexts and (2) the ability to discuss or communicate reactions to data or information obtained, such as understanding information, the impact of information, or agreement with conclusions given based on data (Gal, 2002; Weldon, 2002; Yolcu, 2014). There are several countries, for example, in the United States, Australia, New Zealand, and Malaysia, several professional organizations of teachers in mathematics subjects mention that they provide critical support for learning statistics (Callingham & Watson, 2023; Sharma, 2017; Yusof et al., 2021).

Although some previous studies have examined students' statistical literacy issues, some gaps remain. Most of the earlier studies focused on graduate or high school students, while research on the statistical literacy of mathematics education students is still limited (Serrano & Inzunza, 2022; Yusof et al., 2021). Mathematics education students are essential in developing statistical literacy among future students (Yusof et al., 2021). In addition, previous studies tend to focus on the functional aspects of statistical literacy, such as concept understanding and computational ability, but pay

less attention to the critical and interpretative aspects (Çakıroğlu & Güler, 2021; Yusof et al., 2021). The ability to criticize and interpret statistical information is essential to statistical literacy (Gieg et al., 2023; Henderson & Corry, 2021).

This research will fill the gap by analyzing the statistical literacy level of mathematics education students. This research will evaluate students' ability to understand, critique, interpret statistical information, and identify challenges. In addition, this study will also provide recommendations to improve the statistical literacy competencies of mathematics education students. This research will use a comprehensive approach, covering functional, interactive, and critical aspects of statistical literacy (Gieg et al., 2023; Henderson & Corry, 2021). In addition, this study will also consider factors that affect students' statistical literacy, such as basic understanding of mathematics, ability to read and understand statistical texts, and motivation and interest in learning statistics (Yusof et al., 2021).

Statistical literacy is one of the competencies that students must also have in learning statistics at university, especially for students who will face the research process in their final project. In the learning process, students hesitate to ask the teacher how to solve statistical problems even though they do not understand the lesson. Thus, the purpose of this study is not only to describe the condition of students' statistical literacy but also to provide recommendations that can help Mathematics Education study programs improve the quality of statistics learning. Implementing these recommendations is expected to produce mathematics educators who are competent in developing statistical literacy skills among their students in the future.

Research Methods

This survey research (Cohen et al., 2017; Creswell & Creswell, 2018; Fraenkel & Wallen, 2008) focuses on revealing the statistical literacy skills of mathematics education students. The level of statistical literacy ability of these students is classified based on low, medium, and high ability in reporting survey results (Henderson & Corry, 2021; Serrano & Inzunza, 2022; Yusof et al., 2021).

Data were collected using a survey instrument developed by the researcher based on the competencies required in future aspects of research for university students (Nikiforidou et al., 2010; Risqi & Ekawati, 2020). The instrument consists of 15 items covering three competencies: basic, intermediate, and upper (Gieg et al., 2023; Henderson & Corry, 2021). The basic competency in question is how students solve statistical problems, from finding references to interpreting data. Intermediate competence is how students carry out appropriate analysis to the conclusion of the analysis results. Meanwhile, the upper competency is how students are directed to interpret and regularize the data analysis results. In this upper competency, students will also be asked how they think about good research results related to plagiarism. The validity and reliability of the instrument will be tested before use.

The population in this study is students in the Mathematics Education study program. The sample will be selected using a purposive sampling technique with the criteria that students have taken statistics courses (Çakıroğlu & Güler, 2021; Serrano & Inzunza, 2022; Yusof et al., 2021). The survey was conducted online for one week using Google Forms. Students were given free rein with no time limit to complete the study, although ideally, they should only take 5-10 minutes. Each student was only allowed to complete the survey once and could do so via computer, laptop, or mobile device. This

research specifically focused on the survey results from the Mathematics Education study program students. In this survey, only mathematics education students who have not taken the thesis examination and have taken mathematical statistics courses. The survey is voluntary, so there are no special requirements. Sampling was done using the convenience sampling technique (Edgar & Manz, 2017). The reason for using convenience sampling is that this technique is relatively cheap, does not take much time, and is simple (Stratton, 2021).

Data will be analyzed descriptively to determine the students' statistical literacy level. Data related to students' statistical understanding is scored 2 if the answer is correct and the reason is relevant, 1 if the answer is accurate but not relevant, and zero if the answer is wrong. The level of statistical literacy ability of mathematics education students is identified through students' statistical understanding asked in the survey divided into three categories, namely high ($x \geq 80$), medium ($65 \leq x < 80$), low ($x < 65$), and classical categorization was made.

The flow of research to be carried out: (1) Literature Study: Reviewing literature related to student statistical literacy, measurement methods, and data analysis; (2) Instrument Development: Designing statistical literacy test instruments that include functional, interactive, and critical aspects; (3) Validity and Reliability Test: Conduct validity and reliability tests of research instruments; (4) Data Collection: Collecting data through statistical literacy tests to Mathematics Education study program students; (5) Data Analysis: Conduct descriptive data analysis to determine the level of statistical literacy of students; (6) Interpretation of Results: Interpreting the results of data analysis and concluding; and (7) Reporting: Compile a research report and publish it.

Research Results

Student Statistical Literacy Level

The number of respondents who accessed and filled out this survey was 13 students. These 13 respondents consisted of 3 (23.08%) 6th-semester students who had taken mathematical statistics courses, 8 (61.54%) 8th-semester students who had also taken mathematical statistics courses but had not yet taken their thesis exams, and 2 (15.38%) 10th-semester students who had also taken mathematical statistics courses but had not yet taken their thesis exams. The level of statistical literacy ability of mathematics education students based on their answers to the questions in the survey is shown in Table 1.

Table 1 shows that all respondents who filled out the online questionnaire scored 2 if the answer was correct and the reason was relevant, 1 if the answer was correct but not relevant, and 0 if the answer was wrong. The description of their ability level can be seen in Table 2 below.

Based on Table 2 shows an overview of the students' statistical literacy skills level. The mean score and the standard deviation of all respondents' answers were calculated. The survey results show that students' statistical literacy skills are classically in the low category (Mean = 58.97, Standard Deviation = 12.87, Minimum Score = 36.67, Maximum Score = 76.67). Based on 13 people, there are 8 people with a low level of statistical literacy skills, 5 people with a moderate level of statistical literacy skills, and no students with a high level of statistical literacy skills.

Table 1. Statistical literacy ability questionnaire for mathematics education students

Name	IPS	IPK	Item															Value
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Res 1	3.90	3.75	1	0	2	0	1	0	0	0	0	1	2	1	1	1	1	36.67
Res 2	3.90	3.74	2	0	2	2	1	2	2	1	2	2	2	1	1	1	1	73.33
Res 3	3.90	3.72	2	1	2	2	1	1	0	1	0	0	2	2	2	2	1	63.33
Res 4	3.90	3.90	2	0	2	1	1	2	2	1	2	0	2	1	1	1	1	63.33
Res 5	3.67	3.77	2	0	2	1	2	2	2	0	0	0	2	1	1	1	0	53.33
Res 6	3.74	3.78	2	1	2	2	2	2	2	1	0	1	2	1	1	1	1	70.00
Res 7	3.94	3.72	2	2	2	1	2	2	1	1	2	1	2	2	2	0	1	76.67
Res 8	3.80	3.63	1	2	2	1	2	2	2	1	0	1	2	0	2	1	1	66.67
Res 9	4.00	3.86	0	1	2	1	1	2	1	1	0	1	2	0	2	0	1	50.00
Res 10	3.49	3.54	0	0	2	2	1	2	1	1	0	1	2	0	2	0	1	50.00
Res 11	4.00	3.91	2	2	2	2	1	2	1	1	2	0	2	0	1	1	1	66.67
Res 12	4.00	3.90	2	1	2	1	1	2	2	1	0	0	2	1	2	0	1	60.00
Res 13	3.83	3.,83	2	2	2	1	1	0	0	0	0	0	2	0	0	0	1	36.67

Table 2. Description of Mathematics Education Students' Statistical Literacy Abilities

N		Mean	Std. Error of Mean	Median	Mode	Std. Deviation	Range	Min	Max	Sum
Valid	Missing									
13	0	58,9746	3,56814	63,3300	36,67[a]	12,86511	40,00	36,67	76,67	766,67

a. Multiple modes exist. The smallest value is shown

Table 3. List of statistical literacy categories

Name	Value	Category
Res 1	36.67	Low
Res 2	73.33	Medium
Res 3	63.33	Low
Res 4	63.33	Low
Res 5	53.33	Low
Res 6	70.00	Medium
Res 7	76.67	Medium
Res 8	66.67	Medium
Res 9	50.00	Low
Res 10	50.00	Low
Res 11	66.67	Medium
Res 12	60.00	Low
Res 13	36.67	Low

Based on the data presented in Table 3 above, a percentage can be calculated as shown in Table 4 below.

Table 4. Percentage of statistical literacy skills

Category	Number of Students	Percentage (%)
High	0	0.00
Medium	5	38.46
Low	8	61.54

The analysis showed that out of 13 students, 61.54% had statistical literacy in the low category, 38.46% in the medium category, and 0% in the high category. Based on these findings, it can be concluded that the statistical literacy of mathematics education students is still low.

Challenges in Statistical Literacy

Based on the analysis of students' answers to the test instrument, several challenges faced by students in developing statistical literacy skills were found. One of the main challenges is understanding basic statistical concepts. Students still have difficulties understanding basic statistical concepts, such as concentration measures, dispersion, and probability. In addition, students also struggle with interpreting statistical data, especially in the context of hypothesis testing and statistical inference. The ability to analyze statistical data is an essential component of statistical literacy, yet research findings show that students still face challenges in this area. Another challenge identified is statistical communication skills. Students are still less skilled in communicating statistical information effectively, orally and in writing. Good statistical communication skills are needed so that students can convey statistical information clearly and be understood by others.

Furthermore, motivation and interest in learning are also challenging for some students. Some students are less motivated and less interested in learning statistics, thus having an impact on their mastery of statistical literacy. Low motivation and interest can hinder the learning process and the development of students' statistical literacy skills. These challenges need attention and appropriate handling efforts so that Mathematics Education study program students can develop adequate statistical literacy competencies. It is essential to consider their role as future mathematics educators.

Recommendations for Competency Improvement

Based on the research findings, several recommendations can be considered to improve the statistical literacy competence of Mathematics Education study program students. One of the key recommendations is to develop curricula and learning strategies that are more effective in teaching basic statistical concepts, data interpretation, and statistical communication. It is essential to ensure that students have a solid understanding of fundamental statistical concepts and adequate skills in interpreting data and communicating statistical information effectively. In addition, efforts must be made to increase students' motivation and interest in learning statistics. More contextualized and engaging learning approaches, such as the use of digital technologies, actual problem-based activities, and gamification elements, can help increase students' engagement and enthusiasm in learning statistics (Çakıroğlu & Güler, 2021; Yusof et al., 2021).

Furthermore, strengthening students' basic math skills is also an important recommendation. A strong understanding of basic math concepts is necessary for understanding statistical concepts (Carmichael et al., 2009; Yusof et al., 2021). Therefore, remedial or enrichment programs that focus on strengthening basic mathematical skills can be a helpful step. In addition, providing more intensive guidance and support for students who experience difficulties in statistical literacy should also be considered. It can be done through tutorials, consultations, or study groups that can help students overcome the challenges they face (Çakıroğlu & Güler, 2021; Yusof et al., 2021). Engaging students in activities that can improve statistical literacy skills, such as research, data analysis, and presentations, can also be a helpful recommendation. These activities can help students apply statistical knowledge in a more real-world context and improve their skills (Carmichael et al., 2009).

The challenges students face in completing their final project show that many students do not prepare well from the beginning and often only look for information near the end of the semester. It has the potential to result in stress and low-quality research. Research by Syomwene revealed that postgraduate students in Kenya often experience difficulties collecting and analyzing data, suggesting that this problem also occurs in other contexts (Syomwene, 2021). Time constraints and inadequate preparation frequently encourage students to take shortcuts, such as plagiarism, a serious academic problem (Syomwene, 2021).

Furthermore, many students do not understand the steps required before conducting research. They often do not realize the importance of careful planning, including selecting appropriate research methods and collecting relevant data. Research by Melawati et al. shows that understanding assessment instruments and methodologies can help improve students' critical thinking skills (Melawati et al., 2022). However, without an adequate understanding of data analysis and data collection techniques, students tend to struggle to produce quality research. Students often do not use appropriate sources to support their research. Research by Nermin and Kapucu showed that realistic mathematics education activities can improve students' problem-solving skills and mathematical literacy, indicating that the right approach in education can influence learning outcomes (Bal & Seckin Kapucu, 2022). However, if students are not well prepared, they may not be able to effectively apply the knowledge they have learned in their research.

This research highlights the need for better interventions in higher education to help students be better prepared to complete their final project. Recommendations for improving students' competencies include the development of a more structured curriculum and more excellent support from lecturers in understanding research methodology and data analysis (Syomwene, 2021). Thus, this study not only provides insights into the challenges that university students face but also offers solutions that can be implemented to improve the quality of research among university students. Implementing these recommendations is expected to help mathematics education study programs design more effective learning strategies to enhance students' statistical literacy competencies so that they can become competent mathematics educators and develop students' statistical literacy skills in the future.

Discussion

The absence of students' statistical literacy skills is one of the causes of students being unable to describe the research results they obtained (Apino et al., 2024). The

results revealed that the statistical literacy skills of mathematics education students in various contexts were still lacking. It indicates that students' statistical literacy in mathematics education is generally unsatisfactory. This finding is consistent with previous research, for example (Andriatna et al., 2021; Andriatna & Kurniawati, 2021; Apino et al., 2024; Nikiforidou et al., 2010; Nuzula & Ismail, 2021; Rahmawati et al., 2022; Risqi & Ekawati, 2020).

This study's results indicate that the statistical literacy level of Mathematics Education study program students is in the low category. It reflects significant challenges in understanding basic statistical concepts, interpretation of statistical data, statistical communication skills, and students' motivation and interest in learning. Research by Gönülal confirms that low statistical literacy can be caused by a lack of in-depth understanding of fundamental statistical concepts, which are crucial for proper data analysis (Gonulal, 2018). In addition, Kabael and Baran point out that ineffective teaching can hinder the development of statistical literacy, affecting students' ability to apply statistics in real contexts (Uygur Kabael & Ata Baran, 2023). This finding is in line with several previous studies that also identified challenges faced by students in developing their statistical literacy skills (Çakıroğlu & Güler, 2021; Delmas et al., 2007; Serrano & Inzunza, 2022; Yusof et al., 2021).

Students' challenges in statistical literacy are also related to motivation and interest in learning. Genç and Erbaş noted that students' low interest and confidence in learning mathematics can hinder their statistical literacy development (Genc & Erbas, 2020). There is a suggestion that a more comprehensive strategy that emphasizes students' cognitive and emotive elements is necessary to increase statistical literacy. Yusof et al. (2021) In his research, he found that although postgraduate students understand descriptive and inferential statistics well, they still struggle to interpret inferential data. (Serrano & Inzunza, 2022). It also reported that students at the end of senior secondary education still have a superficial understanding of the concept of hypothesis testing. Similar findings were also obtained in this study, where students experienced challenges in understanding basic statistical concepts and interpreting statistical data. In addition, this study also identified other challenges students face, namely in terms of statistical communication skills and motivation/interest in learning. It is in line with the findings of (Çakıroğlu & Güler, 2021), who emphasized the importance of using learning approaches that can increase students' motivation and interest in learning statistics.

This study has several advantages compared to previous studies. First, this study focuses on Mathematics Education program students, a population that has not been widely studied in the context of statistical literacy (Serrano & Inzunza, 2022; Yusof et al., 2021). Second, this study uses a comprehensive approach by evaluating the functional, interactive, and critical aspects of statistical literacy (Gieg et al., 2023; Henderson & Corry, 2021), as well as considering the factors that influence students' statistical literacy (Yusof et al., 2021). In addition, this study also provides more specific recommendations to improve the statistical literacy competencies of mathematics education students, such as developing more effective curriculum and learning strategies, increasing motivation and interest in learning, and strengthening basic mathematical skills (Çakıroğlu & Güler, 2021; Carmichael et al., 2009; Yusof et al., 2021). It is expected to significantly contribute to efforts to improve students' statistical literacy, which will impact the quality of statistics learning in schools.

Based on the research findings, several strategies are recommended to improve students' statistical literacy competencies. First, the development of more effective curricula and learning strategies is essential. Drábeková et al. emphasized that education that focuses on the application of numerical concepts in real contexts can improve students' understanding and skills in statistical literacy (Drábeková et al., 2018). Therefore, a curriculum integrating problem-based learning and case studies can help students understand and apply statistical concepts better.

Second, increasing students' motivation and interest in learning must be the main focus. This recommendation aligns with Tiro's findings, which showed that programs promoting statistical literacy can increase students' interest in education (Tiro, 2018). By creating a supportive and engaging learning environment, students are expected to be more motivated to learn statistics. Third, strengthening basic math skills is also essential in improving statistical literacy. Research by Putri shows that a realistic mathematics education approach can help students understand the basic concepts needed for statistical literacy (Putri et al., 2024). Therefore, Mathematics Education study programs must ensure students have a strong mathematical foundation before learning statistics. Implementing this recommendation is expected to help mathematics education study programs improve the quality of statistics learning and produce competent mathematics educators who can develop statistical literacy skills. Thus, students can understand and use statistics in academic contexts, their daily lives, and future professions.

Conclusions

The conclusion of this study shows that students' statistical literacy level is at a low level. This finding indicates that many students struggle to understand and apply basic statistical concepts and interpret and communicate statistical data. The challenges students face include a lack of in-depth understanding of statistics, low skills in data analysis, and insufficient motivation and interest in learning. This low level of statistical literacy can negatively impact students' ability to make data-driven decisions in both academic and professional contexts. Therefore, it is essential to identify and address the challenges so that students can develop better statistical literacy competencies. Based on the research results, several strategies are recommended to improve students' statistical literacy competencies. Developing a more effective and relevant curriculum, increasing motivation and interest in learning, and strengthening basic math skills are steps needed. Implementing these recommendations is expected to help mathematics education study programs improve the quality of statistics learning and produce mathematics educators who are competent in developing statistical literacy skills among their students in the future.

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