

Comparing Statistical Literacy and Reasoning Abilities among Undergraduate Students

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ABSTRACT

This study aimed to compare the statistical literacy and statistical reasoning abilities of undergraduate students at the University of Bengkulu (Sumatra) and Pakuan University (Java) and to identify the factors contributing to their differences. An explanatory sequential mixed-methods design was employed. Quantitative data were obtained from a validated post-test on hypothesis testing administered to 55 students at the University of Bengkulu and 33 students at Pakuan University in the 2024/2025 academic year, followed by interviews. The data were analyzed descriptively and with a two-way analysis of variance. The statistical literacy of students at the University of Bengkulu was mostly at the consistent noncritical level (69.09%), whereas that of students at Pakuan University was mostly at the critical level (75.76%). Most students at both universities reached the integrated reasoning level (72.73% and 78.79%, respectively). Significant differences between the universities were found in statistical literacy ($p = 0.001$) and statistical reasoning ($p = 0.019$), whereas gender and its interaction with university had no significant effect. The differences were associated with more intensive and contextual project-based learning, students' enthusiasm and learning independence, and a weekly statistics discussion group at Pakuan University.

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Introduction

The rapid development of technology and knowledge in the 21st century requires citizens who are able to read, interpret, and make decisions based on data. Statistics contributes to planning, collecting, analyzing, and interpreting data and to drawing

conclusions, so that it plays an important role in developing logical reasoning and decision-making skills in everyday life, in the workplace, and in science. In higher education, statistical literacy is increasingly regarded as one of the main expected outcomes of statistics courses, although instructors in different undergraduate programs still emphasize its components differently (Ozmen & Baki, 2021). A recent systematic review also showed that research on statistical literacy has grown rapidly since 2018 and is closely related to the demands of 21st-century learning, but that studies at the higher education level are still limited (Ritmayanti et al., 2025).

Statistical literacy refers to the ability to read, interpret, evaluate, and communicate statistical information in context, whereas statistical reasoning refers to the way students reason with statistical ideas and make sense of statistical information, including when they formulate and test hypotheses. Both abilities are needed when students learn inferential statistics, because hypothesis testing requires an understanding of the null and alternative hypotheses, the choice of an appropriate test, and the correct interpretation of p-values and decisions (Rajić, 2026). Statistical literacy can be classified into hierarchical levels ranging from idiosyncratic to critical mathematical, which help teachers identify how far students are able to connect data with context (Rahman & Fa'ani, 2026). Students' statistical literacy is also related to their level of mathematical thinking, reading habits, and curiosity (Mahyudi et al., 2024).

In practice, many university students still experience difficulties in statistical reasoning. Previous studies found that students make errors in interpreting and analyzing data, choosing data processing techniques that match the type of data, formulating statistical hypotheses, using statistical symbols, and interpreting the results of data processing (Susilawati et al., 2020; Yensy et al., 2023). A study of mathematics education students taking a statistical methods course showed that most students' reasoning in two-sample hypothesis testing was still at the lower levels, with 32% at the lowest level and only 8% at the highest level (Rohana & Ningsih, 2020). These conditions show that statistical reasoning skills still need to be developed so that students are able to solve problems and make data-based decisions.

Many factors affect students' statistical literacy and reasoning, one of which is the learning model. Project-based learning has been shown to improve students' understanding of statistical concepts and their ability to analyze data (Yensy et al., 2022, 2023), as well as their statistical application literacy and learning motivation (Rusdarti et al., 2025). Learning materials that are literacy-based and integrate technology, pedagogy, and content also support conceptual understanding (Sundari, Gani, et al., 2025; Sundari, Yufiarti, & Bintoro, 2025). In addition, students' motivation toward statistics courses, including intrinsic motivation, self-efficacy, and statistics anxiety, influences how they engage in learning (Hendra et al., 2026). Learning conditions, academic culture, and supporting facilities also differ between regions, such as between universities in Java and Sumatra, and these differences may affect students' statistical literacy and reasoning.

Studies comparing statistical literacy and statistical reasoning among undergraduate students from different regions in Indonesia that combine quantitative results with qualitative explanations are still limited. Therefore, this study aims to describe the statistical literacy and statistical reasoning abilities of undergraduate students at the University of Bengkulu and Pakuan University, to test the differences in these abilities between the two universities and between genders, and to analyze the factors contributing to the differences. The Statistics course syllabi (RPS) at both universities are nearly identical, so the same material could be used as the basis for comparison. The findings are

expected to serve as a reference for lecturers in developing statistics learning that improves students' statistical literacy and reasoning and to strengthen interdisciplinary research collaboration between the two universities.

Method

This study employed an explanatory sequential mixed-methods design, in which quantitative data are collected and analyzed first, followed by qualitative data that are used to explain the quantitative results (Creswell & Creswell, 2023). The quantitative phase had priority in answering the research questions, whereas the qualitative phase was used to explain the differences found. The research procedure is presented in Figure 1.

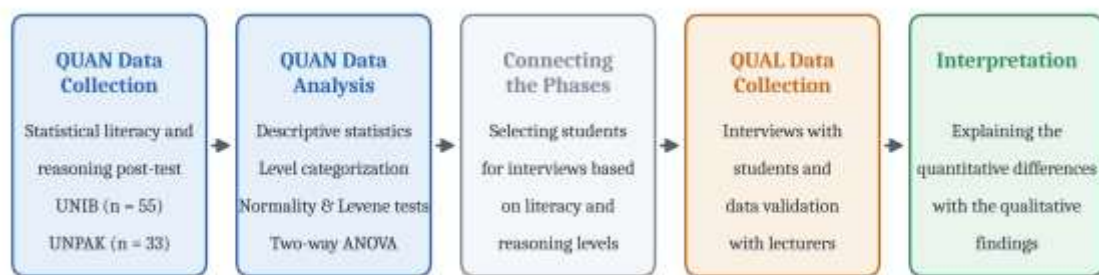


Figure 1. Explanatory Sequential Mixed-Methods Research Design

The study was conducted face-to-face at the University of Bengkulu in Bengkulu City and at Pakuan University in Bogor City during the Statistics course in the odd semester of the 2024/2025 academic year. Learning at both universities was carried out using the same syllabus and material. The participants were 55 undergraduate students of the Mathematics Education Study Program at the University of Bengkulu and 33 undergraduate students of the Mathematics and Electrical Engineering Study Programs at Pakuan University, giving a total of 88 students.

Quantitative data were collected using a post-test on hypothesis testing that was administered after the learning of this material was completed at both universities. Before use, the test items were examined for expert validity, empirical validity, and reliability. The test consisted of nine essay items measuring five indicators of statistical reasoning, as presented in Table 1. Each item was scored from 0 to 3 based on the criteria in Table 2, so that the maximum statistical reasoning score was 27.

Table 1. Grid of the Statistical Reasoning Post-test

Indicator of Statistical Reasoning	Material	Number of Items
Identifying problems using statistical symbols or terms	One-sample t-test	2
Determining the formulation of hypotheses	Two-sample t-test	2
Identifying the concepts used to solve the problem	Two-sample t-test	2
Applying appropriate statistical concepts to solve the problem	Two-sample t-test	2
Interpreting the results of statistical calculations and drawing conclusions	ANOVA	1

Indicator of Statistical Reasoning	Material	Number of Items
Total		9

Source: Research instrument developed by the authors.

Table 2. Scoring Criteria for Each Indicator of Statistical Reasoning

Score	Criterion
3	The student responds to the indicator correctly and completely.
2	The student responds to the indicator correctly, but the answer is not written completely.
1	The student responds to the indicator, but the answer still contains errors.
0	The student is unable to respond to the indicator correctly or does not respond at all.

Note: The criteria are applied to each of the nine items according to the indicator it measures (Table 1).

Students' statistical reasoning scores were then categorized into five levels, adapted from the reasoning levels used in previous research on statistics courses (Rohana & Ningsih, 2020), as presented in Table 3. Statistical literacy was categorized into six hierarchical levels (Rahman & Fa'ani, 2026), as described in Table 4, based on the test results and deepened through interviews about how and why students solved the problems using certain statistical strategies or methods.

Table 3. Categories of Students' Statistical Reasoning Levels

Score Interval	Statistical Reasoning Level
0–5	No statistical reasoning
6–11	Prestructural reasoning
12–16	Transitional reasoning
17–21	Procedural reasoning
22–27	Integrated reasoning

Source: Adapted from Rohana and Ningsih (2020).

Table 4. Levels of Students' Statistical Literacy

Level	Description
Idiosyncratic	Students read, interpret, conclude, and communicate data based only on previous learning experiences.
Informal	Students draw conclusions using imagined, non-statistical, or intuitive explanations.
Inconsistent	Students try to relate the data presented to the phenomena but cannot yet give qualitative reasons.
Consistent noncritical	Students relate the data to the phenomena using appropriate statistical measures but cannot yet connect the context with the data.
Critical	Students connect the context with the data but do not yet involve accurate reasoning in evaluations and predictions.
Critical mathematical	Students connect the context with the data and use appropriate reasoning to make accurate evaluations and predictions based on statistical measures.

Source: Adapted from Rahman and Fa'ani (2026).

After the quantitative data were processed, semi-structured interviews were conducted with students at both universities to obtain deeper information about their

learning process, motivation, and learning independence, and the data were validated with the lecturers who taught the courses. The post-test data were analyzed descriptively using the mean, median, minimum and maximum scores, standard deviation, skewness, and kurtosis. Before the inferential analysis, the data were tested for normality using the one-sample Kolmogorov–Smirnov test and for homogeneity of variance using Levene’s test at a significance level of 0.05. The differences in statistical literacy and statistical reasoning were then tested using a two-way analysis of variance with university and gender as factors, assisted by SPSS 26. A difference was considered significant if the p-value was less than 0.05.

Results and Discussion

Students’ Statistical Literacy

The distribution of students’ statistical literacy levels at the two universities is presented in Table 5 and illustrated in Figure 2.

Table 5. Distribution of Students’ Statistical Literacy Levels

Statistical Literacy Level	Pakuan University (%)	University of Bengkulu (%)
Idiosyncratic	0.00	0.00
Informal	3.03	3.64
Inconsistent	12.12	9.09
Consistent noncritical	6.06	69.09
Critical	75.76	18.18
Critical mathematical	3.03	0.00
Total	100.00	100.00

Source: Post-test and interview results, processed by the authors.

Table 5 shows that the statistical literacy of students at the University of Bengkulu tended to be at the consistent noncritical level (69.09%), meaning that most students were able to find the relationship between the data presented and the phenomena using appropriate statistical measures but were not yet able to connect the context with the data. Meanwhile, the statistical literacy of students at Pakuan University tended to be at the critical level (75.76%), meaning that most students were able to connect the context with the data but did not yet involve accurate reasoning in making evaluations and predictions. Only 3.03% of students at Pakuan University reached the critical mathematical level, and none of the students at either university were at the idiosyncratic level. This pattern is consistent with studies showing that students’ statistical literacy is spread across several levels and is influenced by their thinking patterns and learning experiences (Mahyudi et al., 2024; Rahman & Fa’ani, 2026).

Students’ Statistical Reasoning

The distribution of students’ statistical reasoning levels is presented in Table 6 and Figure 2.

Table 6. Distribution of Students’ Statistical Reasoning Levels

Statistical Reasoning Level	Pakuan University (%)	University of Bengkulu (%)
No statistical reasoning	0.00	0.00

Statistical Reasoning Level	Pakuan University (%)	University of Bengkulu (%)
Prestructural reasoning	0.00	3.64
Transitional reasoning	9.09	5.45
Procedural reasoning	12.12	18.18
Integrated reasoning	78.79	72.73
Total	100.00	100.00

Source: Post-test results, processed by the authors.

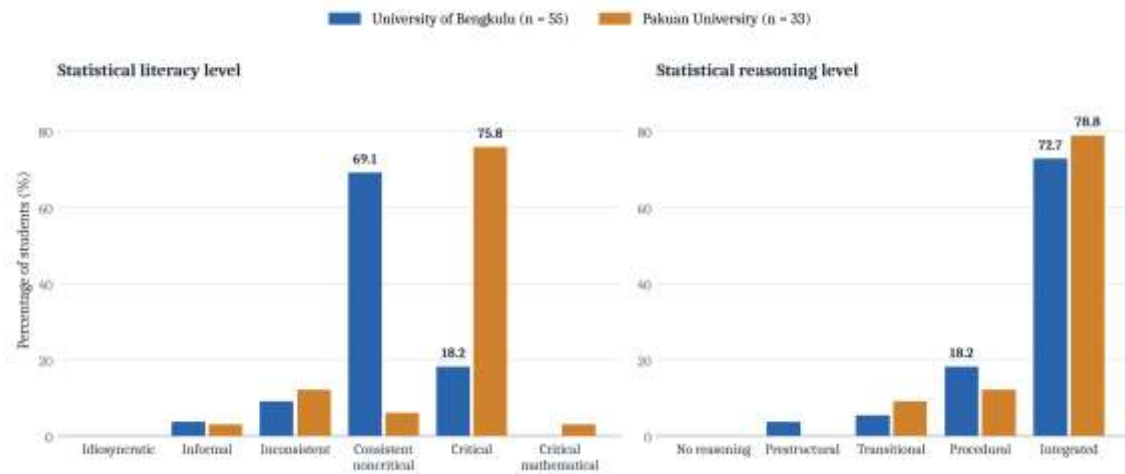


Figure 2. Distribution of Statistical Literacy and Statistical Reasoning Levels of Students at the University of Bengkulu and Pakuan University

Table 6 and Figure 2 show that most students at both universities reached the integrated reasoning level, namely 72.73% at the University of Bengkulu and 78.79% at Pakuan University. This means that most students were able to apply statistical concepts correctly to solve problems and to interpret the results and relate them to the original problem. However, a larger proportion of students at the University of Bengkulu remained at the procedural (18.18%) and prestructural (3.64%) levels, indicating that some students could perform calculations but had not yet interpreted and concluded the results. This finding is more favorable than that of earlier research, in which most students’ reasoning in hypothesis testing was still at the lower levels (Rohana & Ningsih, 2020), and suggests that the learning process at both universities has supported the development of students’ statistical reasoning.

Differences in Statistical Literacy and Statistical Reasoning between the Two Universities

The descriptive statistics of the combined statistical literacy and reasoning scores are presented in Table 7, and the mean scores with their 95% confidence intervals are shown in Figure 3.

Table 7. Descriptive Statistics of Students’ Statistical Literacy and Reasoning Scores

Statistic	University of Bengkulu	Pakuan University
Number of students (n)	55	33
Mean	79.1	85.4
Standard deviation	13.8	10.3

Statistic	University of Bengkulu	Pakuan University
Minimum	55.6	62.9
Maximum	90.3	96.3
Median	85.2	88.9
Skewness	-0.27	-0.87
Kurtosis	-1.40	-0.42

Source: Post-test results, processed by the authors.

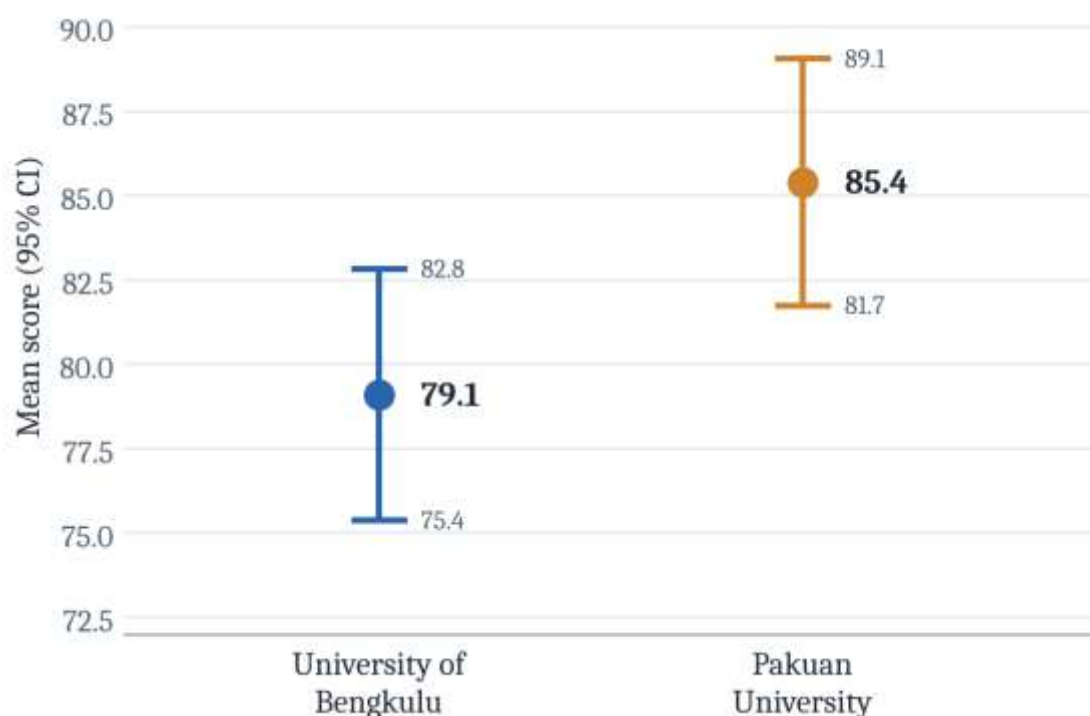


Figure 3. Mean Scores and 95% Confidence Intervals of Students' Statistical Literacy and Reasoning at the Two Universities

Table 7 and Figure 3 show that the mean score of students at Pakuan University (85.4) was higher than that of students at the University of Bengkulu (79.1), with a smaller standard deviation (10.3 compared with 13.8). The minimum score and median of students at Pakuan University were also higher. The skewness values did not exceed -1 or $+1$ and the kurtosis values were between -2 and $+2$, indicating that the data were approximately normally distributed. The results of the two-way analysis of variance are summarized in Table 8.

Table 8. Summary of the Two-Way Analysis of Variance

Source of Variation	Statistical Literacy (p)	Statistical Reasoning (p)
University (region)	0.001*	0.019*
Gender	0.691	0.538
University $\times$ gender	0.368	0.441

Note: * significant at the 0.05 level.

Table 8 shows a significant difference between students at Pakuan University and the University of Bengkulu in statistical literacy ($p = 0.001$) and statistical reasoning ($p = 0.019$). In contrast, there were no significant differences between male and female students in statistical literacy ($p = 0.691$) or statistical reasoning ($p = 0.538$), and there was no interaction effect between gender and university ($p = 0.368$ for literacy and $p = 0.441$ for reasoning). Thus, the place of study had a significant influence on students' statistical literacy and reasoning, whereas gender did not.

Factors Contributing to the Differences

The interviews with Mathematics and Electrical Engineering students at Pakuan University and Mathematics Education students at the University of Bengkulu revealed several similarities in the learning conditions. Students at both universities reported high learning motivation and high learning independence, both groups learned through project-based learning and problem-based learning models, and both carried out statistics practicum activities once a week. The main differences lay in the intensity and context of learning. Lecturers at Pakuan University applied project-based learning more intensively, with cases linked to students' everyday lives and fields of study, and students at Pakuan University had a special statistics discussion group that met once a week, which was not yet available at the University of Bengkulu.

Project-based learning places students at the center of learning and positions the lecturer as a facilitator, so that students manage their own activities and become more independent. This is in line with studies reporting that project-based learning increases student engagement (Nugroho et al., 2025), improves students' understanding of statistical concepts and data analysis (Yensy et al., 2022, 2023), and strengthens statistical application literacy and motivation (Rusdarti et al., 2025). In the project-based learning applied at Pakuan University, statistical reasoning developed most clearly at the stages of testing the project results and evaluating the learning experience, when students discussed the feasibility of their projects, presented written reports, received feedback from peers, and reflected on the results together with the lecturer. These stages encouraged students to correct their errors and to interpret their statistical results more carefully.

Students at Pakuan University were also more enthusiastic about learning Statistics because the learning was more contextual, the material was linked to everyday life, and the case examples were more real. Contextual and engaging learning media are known to increase students' enthusiasm and learning outcomes (Sumirat et al., 2024), and positive motivation toward statistics helps students persist when facing difficult problems (Hendra et al., 2026). This enthusiasm helped students understand the meaning of the questions, use statistical symbols and terms correctly, formulate hypotheses, and select appropriate tests such as the t-test, z-test, or ANOVA, although some students still made calculation errors and did not write complete formulations. Nevertheless, motivation and independence do not automatically lead to higher achievement (Berek et al., 2023), so the additional weekly discussion group and the more intensive project-based learning at Pakuan University are likely to have played an important role.

These findings can also be understood through the heutagogical perspective, in which adult learners are given autonomy to determine their own learning goals, activities, and assessment, which can increase engagement, self-reflection, and self-motivation (Hamdan et al., 2021). University students who have reached intellectual maturity benefit from learning environments that encourage self-determined learning, such as project work and peer discussion, which support the development of higher-order reasoning. This study

has several limitations: the samples came from different study programs and were not equal in size, and the reasons for the differences were explored mainly through interviews. Future studies are recommended to involve more universities and study programs and to measure learning motivation and independence quantitatively.

Conclusion

This study concludes that the statistical literacy of undergraduate students at the University of Bengkulu was mostly at the consistent noncritical level (69.09%), whereas that of students at Pakuan University was mostly at the critical level (75.76%), and that most students at both universities had reached the integrated statistical reasoning level, with a higher proportion at Pakuan University (78.79%) than at the University of Bengkulu (72.73%). There were significant differences in statistical literacy and statistical reasoning between students at the two universities, while gender and the interaction between gender and university had no significant effect. The differences were associated with the more intensive and contextual project-based learning applied by lecturers, students' enthusiasm and learning independence, and the availability of a weekly statistics discussion group at Pakuan University, even though students at both universities reported high motivation and attended weekly practicum activities. Therefore, lecturers are encouraged to implement contextual project-based learning, facilitate regular statistics discussion groups, and give greater attention to the interpretation and evaluation stages of statistical problem solving in order to raise students' statistical literacy to the critical mathematical level.

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Author Contributions

Conceptualization: NAY, FV; Methodology: NAY, FV; Investigation: NAY, FV, TAS; Formal analysis: FV, TAS; Writing – original draft: NAY, FV; Writing – review & editing: FV, TAS; Supervision: NAY, FV.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of Artificial Intelligence

The authors used Grammarly to assist with grammar checking, language refinement, and improvements in sentence clarity and readability. All AI-assisted suggestions were carefully reviewed and verified by the authors, who take full responsibility for the accuracy, originality, and final content of the manuscript.

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