

## COMPARATIVE NUMERACY IN STATISTICAL REASONING OF PRE-SERVICE EARLY CHILDHOOD TEACHERS

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### ABSTRACT

This study aims to analyze differences in statistical reasoning and numeracy skills between two groups of PG-PAUD Study Program students. Using a quantitative comparative approach, all 49 PG-PAUD students enrolled in statistics during the 2025/2026 even semester were included, divided into class A (25 students) and class B (24 students). The second group used IBM SPSS Statistics and the VClass platform for equivalent learning. Data were obtained through a digital-based final semester exam with 25 multiple-choice questions assessing statistical reasoning. Data analysis included normality and homogeneity tests, followed by an independent sample t-test and effect size analysis using Cohen's d with IBM SPSS Statistics at a significance level of 0.05. Results show no significant difference in numeracy abilities in statistical reasoning between classes ( $t = 1.295$ ;  $\text{sig.} = 0.201 > 0.05$ ; Cohen's  $d = 0.37$ ). Although class A had a higher average score ( $M = 81.28$ ;  $SD = 13.99$ ) compared to class B ( $M = 76.00$ ;  $SD = 14.54$ ), this difference was not statistically significant, and the effect size was small. Indicator analysis highlighted that students excelled most in selection analysis, but scored lower in understanding concepts, interpreting, and drawing conclusions. These findings underscore that while technology-based learning yields comparable statistical reasoning results, there is still room for deeper skill development.

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## INTRODUCTION

Numeracy is an essential competency of the 21st century, involving not only handling numbers but also understanding, interpreting, and using data for decision-making (OECD, 2019; Han et al., 2017). Within the Programme for International Student Assessment (PISA) framework, numeracy is often equated with mathematical literacy: the ability to formulate, apply, and interpret mathematics in real-life contexts, such as understanding data, variability, and making data-based decisions (OECD, 2019; Gal, 2002; Ben-Zvi & Garfield, 2005).

In this study, numeracy focuses specifically on the data and uncertainty domain, operationalized as statistical reasoning ability. Statistical reasoning encompasses the ability to understand data concepts, select appropriate analysis procedures, and interpret and draw data-based conclusions (Ben-Zvi & Garfield, 2005). This clarification is important to avoid conceptual ambiguity between numeracy, mathematical literacy, and statistical reasoning, which are often used interchangeably in the literature (Sabbag et al., 2025).

Indonesian students' numeracy achievement in international assessments remains relatively low, particularly in the areas of data and uncertainty (OECD, 2019; Hulu et al., 2025). Studies show that students tend to excel in numbers rather than data interpretation and statistical reasoning (Apryani & Pratama, 2025). This finding aligns with international research showing that data comprehension is one of the most complex aspects of mathematical literacy (Sharma, 2017). This situation indicates a gap between global competency demands and learning practices in the field.

Statistics learning still tends to be procedurally oriented, thus failing to

develop in-depth statistical reasoning (Bakker & Gravemeijer, 2004; Ben-Zvi & Garfield, 2005). As a result, students experience difficulties in understanding data distribution, selecting appropriate analysis methods, and interpreting results meaningfully (Rumsey, 2002). Therefore, strengthening numeracy skills, particularly in statistical reasoning, is an urgent need in learning.

Various efforts have been made to improve numeracy skills through the implementation of the Independent Curriculum and the Minimum Competency Assessment (AKM), which emphasize the importance of critical thinking and contextual problem-solving (Putri & Wijayanti, 2024). Furthermore, researchers have developed and proven technology- and context-based learning innovations to enhance student engagement and learning outcomes (Ilindia et al., 2024; Hajerina & Mailili, 2025). The use of statistical software, such as IBM SPSS Statistics, has also been shown to significantly impact students' conceptual understanding and data analysis skills (Sarassanti et al., 2023). Recent studies confirm that appropriate learning strategies play a crucial role in developing effective statistical reasoning (Hasim et al., 2024; Friedrich et al., 2024).

Although research on numeracy and statistical reasoning has progressed rapidly, several limitations remain, indicating research gaps. Previous research has generally focused on the effectiveness of interventions or learning models in improving numeracy and statistical reasoning skills (Ben-Zvi & Garfield, 2005; Hasim et al., 2024), resulting in a comparative approach under equivalent learning conditions (Setiawan et al., 2023). Most studies have not examined numeracy skills based on structured statistical reasoning indicators, resulting in a lack of a

comprehensive description of students' ability profiles (Kurnia et al., 2024; Utari et al., 2025). This situation indicates that previous research has not been able to fully provide a comprehensive picture of the numeracy ability profile in the statistical reasoning aspect, particularly in the context of early childhood teacher education. Therefore, there is still an urgent need to examine numeracy skills more specifically in the statistical reasoning aspect in the context of early childhood teacher education, which has different learning characteristics than other levels.

In the context of teacher education, numeracy skills in the statistical reasoning aspect are crucial because prospective teachers are required to be able to understand and use data to analyze student development and make appropriate pedagogical decisions (Franklin et al., 2007). However, empirical studies specifically examining numeracy skills in PG-PAUD students are still limited, especially those that utilize learning evaluation data as the basis for comparative analysis (Serquiña, 2025). Therefore, we need studies that not only identify numeracy achievement but also analyze differences comparatively in equivalent learning contexts.

Based on the above description, the novelty of this research lies in (1) the focus on PG-PAUD students as a context that is still rarely studied (Utari et al., 2025; Friedrich et al., 2024); (2) the use of a comparative approach in equivalent learning conditions (Hasim et al., 2024; Setiawan et al., 2023); and (3) the analysis of numeracy skills based on structured statistical reasoning indicators, namely conceptual understanding, procedure selection, and data interpretation and conclusion drawing (Sabbag et al., 2025; Kurnia et al., 2024). Unlike previous research that generally focuses on the effectiveness of learning interventions or is conducted at the elementary and secondary education levels, this study specifically examines the numeracy skills of PG-PAUD students through a comparative approach in an equivalent learning context and is analyzed

based on structured statistical reasoning indicators.

Based on this background, this study aims to analyze the differences in numeracy abilities in the statistical reasoning aspect between two groups of PG-PAUD students and examine these differences based on statistical reasoning indicators, namely understanding concepts, selecting analysis procedures, and interpreting and drawing conclusions from data.

## **METHOD**

This study used a quantitative approach with a comparative method to compare students' numeracy skills in statistical reasoning between two groups of PG-PAUD students, Class A and Class B. The comparison was based on learning evaluation results in the form of Final Semester Exam (UAS) scores for statistics. Both groups received equivalent learning processes, materials, and learning facilities, so the study focused on analyzing differences in student numeracy achievement without any special treatment or manipulation of research variables (Creswell, 2014).

The study population was all PG-PAUD students taking statistics courses in the even semester of the 2025/2026 academic year, a total of 49 students, divided into two classes: Class A (25 students) and Class B (24 students). All members of the population were included as research subjects; all students taking the statistics course were included. Although the number of subjects was relatively limited, using the entire population allowed the study to describe the empirical conditions of students taking statistics courses that semester.

During the learning process, both classes received an equal learning experience through the use of IBM SPSS Statistics software and the VClass online learning platform. This technology utilization aims to help students process, analyze, and interpret statistical data more meaningfully. The integration of technology in statistics learning is known to support the development of students' conceptual understanding and statistical reasoning

(Ben-Zvi & Garfield, 2005; Friedrich et al., 2024).

The research data were obtained from the Final Semester Exam (UAS) results for the statistics course, administered using the Wayground digital platform. The use of digital-based assessments allows for more objective, efficient, and well-documented data collection and supports the measurement of data-driven skills (OECD, 2019).

The research instrument was a numeracy ability test on statistical reasoning, consisting of 25 multiple-choice questions based on data context. The questions were structured based on statistical reasoning indicators, namely: (1) understanding statistical concepts, (2) selecting analytical procedures, and (3) interpreting and drawing conclusions from data (Gal, 2002; Ben-Zvi & Garfield, 2005). To strengthen the measurement of statistical reasoning ability, each question item was designed as a contextual stimulus that required students to analyze data, determine appropriate procedures, and draw conclusions based on statistical information. The use of context-based questions was considered to provide a more representative picture of students' numeracy and statistical reasoning abilities (Sabbag et al., 2025).

The research instrument first underwent a content validation process by lecturers in the statistics and mathematics education courses to ensure the suitability of the indicators, clarity of language, and the relevance of the question context to the measurement objectives (Creswell, 2014). Furthermore, an academic review of the question items was conducted to ensure that each question aligned with the numeracy ability indicators in the statistical reasoning aspect.

The research procedure began with the collection of final exam data from students from both classes. The data obtained consisted of student numeracy test scores, which were then analyzed to determine differences in numeracy ability between groups. Prior to the main analysis, the data were first tested for analysis prerequisites, including normality and

homogeneity tests, to ensure that the data met the assumptions of parametric analysis (Sugiyono, 2019).

Data analysis was performed using IBM SPSS Statistics. Differences in numeracy ability between the two groups were tested using an independent-samples t-test at a significance level of 0.05. Decision-making was based on the significance value: if the significance value is  $< 0.05$ , it indicates a significant difference, while if the significance value is  $> 0.05$ , it indicates no significant difference. To strengthen the interpretation of the results, this study also calculated effect sizes using Cohen's *d* to determine the strength of the differences in numeracy ability between groups (Lakens, 2013).

In addition to inferential analysis, descriptive analysis was also conducted using mean scores, standard deviations, percentages of achievement scores, and the distribution of student numeracy ability categories to provide a general overview of the data distribution and student ability profiles (Gravetter & Wallnau, 2014; Creswell, 2014). For descriptive interpretation purposes, numeracy ability categories were determined based on the percentage of achievement scores, namely  $\geq 80\%$  (high), 60–79% (moderate), and  $< 60\%$  (low) (Arikunto, 2013; Sugiyono, 2019). Descriptive analysis was used to provide a more comprehensive overview of students' numeracy ability profiles for each statistical reasoning indicator.

This study was limited by the relatively small number of subjects and the involvement of only one study program at one university, so generalization of the results requires caution. Furthermore, the use of multiple-choice instruments allows for efficient measurement of statistical reasoning ability but does not fully explore students' argumentation and thought processes in depth for each statistical reasoning indicator.

## RESULT AND DISCUSSION

### Result

The results of this study describe students' numeracy abilities in the statistical

reasoning aspect and test the differences in abilities between the two class groups studied.

Table 1. Descriptive Statistics of Student Numeracy Skills

Class	N	Mean	Std. Deviation
A	25	81.28	13.987
B	24	76.00	14.542

Based on Table 1, there are 25 students in class A and 24 in class B. Based on the average scores, descriptively, the numeracy skills of students in class A are higher than those in class B. Meanwhile, the standard deviation values for both groups are not significantly different, indicating that the data distribution is relatively similar.

Before testing the hypotheses, a prerequisite analysis test was conducted to ensure that the data met the assumptions of parametric statistics. Normality testing using the Kolmogorov-Smirnov test demonstrated that the data in both groups were normally distributed.

Table 2. Summary of Prerequisite Analysis Tests

Test Type	Sig.	Description
Normality (Class A)	0.200	Normal
Normality (Class B)	0.070	Normal

Based on Table 2, the significance values for both classes A and B are greater than 0.05, thus concluding that the data in both groups are normally distributed.

Next, a homogeneity test was performed using Levene's test to determine the equality of variance between groups.

Table 3. Results of the Homogeneity Test

Levene Statistic	Sig.
—	0.954

Based on Table 3, the significance value is greater than 0.05; thus, it can be concluded that the variances of the two groups are homogeneous.

After all prerequisites were met, the analysis continued with a hypothesis test using an independent sample t-test to determine differences in numeracy abilities between the two groups.

Table 4. Results of the Independent Sample t-test

t	df	Sig. (2-tailed)	Cohen's d	Interpretation
1,296	47	0.201	0,37	Not significant; Small effect

Based on Table 4, the significance value is 0.201 ( $>0.05$ ), indicating no significant difference between the numeracy skills of class A and class B students in statistical reasoning. Cohen's d of 0.37 indicates a small effect size (Lakens, 2013). This indicates that the difference in average

numeracy skills between the groups is relatively small in practical terms, although descriptively, class A has a higher average score than class B.

Thus, the analysis results indicate that both groups have relatively equal numeracy skills in statistical reasoning.

In addition to the overall analysis, student numeracy skills were also analyzed based on statistical reasoning indicators.

Table 5. Numeracy Summary Based on Statistical Reasoning Indicators

Indicator	Class A		Class B	
	Average	Category	Average	Category
Understanding of statistical concepts	19,46 (77,84%)	Moderate	17,15 (68,60%)	Moderate
Selection of analytical procedures	21,88 (87,52%)	High	20,25 (81,00%)	High
Data interpretation and conclusion drawing	20,00 (80,00%)	High	17,75 (71,00%)	Moderate

Based on Table 5, students' numeracy abilities for each statistical reasoning indicator show variations in the level of achievement. In the indicator of understanding statistical concepts, class A and Class B are included in the medium category. In the indicator of selection of analytical procedures, both classes show relatively high achievements. Meanwhile, in terms of data interpretation and conclusion drawing, class A falls into the high category,

while class B falls into the moderate category.

In general, these results indicate that students' numeracy skills tend to be higher in the procedural aspect compared to the conceptual and interpretive aspects.

To provide a clearer picture of the instrument used, the following is a sample question on numeracy skills in the statistical reasoning aspect.

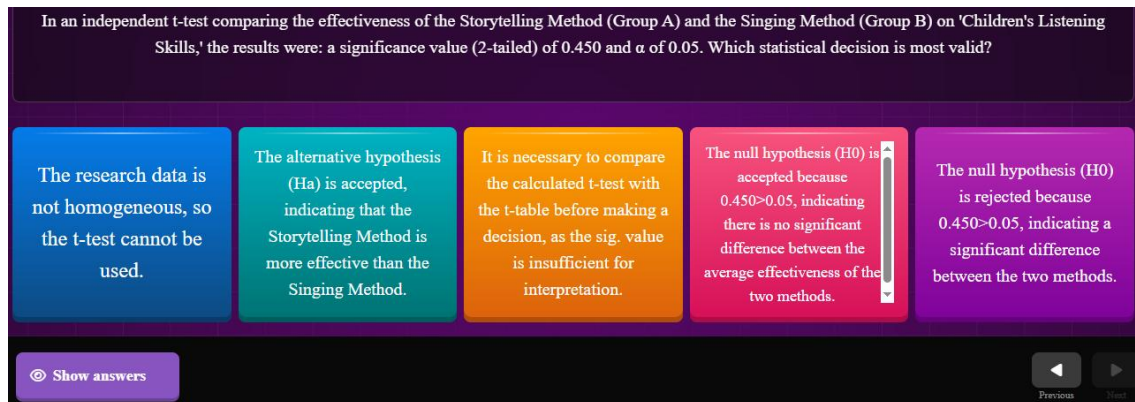


Figure 1. Example of a statistical reasoning numeracy test item

The sample instrument in Figure 1 is designed based on data context and requires students to understand statistical information, determine appropriate analysis procedures, and interpret data results. Therefore, although the questions are multiple-choice, they are still aimed at measuring students' statistical reasoning skills contextually (Gal, 2002; Ben-Zvi & Garfield, 2005).

### Discussion

The results of the research show that students' numeracy abilities in the statistical reasoning aspect do not differ significantly between class A and class B. These findings indicate that both groups have relatively equal levels of ability in understanding, processing, and interpreting statistical data. This equality is also supported by the results of descriptive analysis, which show that although there are differences in average scores between classes, these differences are

not large enough to produce statistical significance. Apart from that, the effect size value is relatively small (Cohen's  $d = 0.37$ ), indicating that the strength of differences between groups is in the low category (Lakens, 2013).

The equality of achievement can be explained by the similarity of learning experiences applied to the two groups. Students in both classes receive the same learning through the use of IBM SPSS Statistics software and the VClass online learning platform. This equal learning experience provides relatively equal opportunities for students to develop numeracy skills, especially in aspects of statistical reasoning. The integration of technology in statistics learning is known to be able to support a more systematic understanding of concepts and data analysis processes (Ben-Zvi & Garfield, 2005; Friedrich et al., 2024).

The findings of this research are in line with the OECD numeracy literacy framework, which emphasizes that abilities in the data and uncertainty domains are strongly influenced by data-based learning experiences and problem-solving contexts (OECD, 2019). In the context of this research, the use of digital-based statistical and assessment software allows students to obtain a relatively uniform learning experience, resulting in ability achievements that do not differ significantly between groups. However, these results also show that equal learning experience does not necessarily result in an increase in in-depth statistical reasoning abilities, especially in aspects of higher-order thinking.

When compared with previous research, the results of this study show interesting dynamics. Hajerina & Mailili (2025) found that the use of local wisdom-based worksheets was able to increase students' numeracy literacy significantly, with a high effect size. These findings indicate that contextual learning that is close to students' experiences has the potential to be more effective in improving the quality of numeracy than learning that only emphasizes the use of technology. Thus, although the technology in this research is

able to create relatively equal learning outcomes, more meaningful context integration may be needed to improve the quality of students' statistical reasoning optimally.

Apart from learning factors, numeracy abilities are also influenced by affective factors. Research (Ratih, 2023) shows that self-efficacy has a positive relationship with students' mathematical literacy abilities. This shows that numeracy skills are not only influenced by cognitive factors but are also influenced by students' self-confidence and readiness in facing data-based tasks. In the context of this research, variations in ability on certain indicators may be influenced by differences in individual student characteristics, especially in data interpretation abilities, which require confidence in drawing statistical conclusions.

Analysis based on indicators shows that the highest abilities in both classes are found in the indicators for selecting analytical procedures. These results indicate that students are relatively better able to determine appropriate statistical steps or procedures rather than understand statistical concepts in depth. These findings indicate that applied statistics learning tends to strengthen procedural aspects so that students are more accustomed to following analysis steps rather than understanding concepts conceptually (Ben-Zvi & Garfield, 2005).

On the other hand, indicators of understanding of statistical concepts are still in the medium category in both classes. This shows that students do not fully understand the basic concepts of statistics, such as the meaning of analysis results, assumptions about the use of statistical techniques, or the interpretation of certain statistical measures. This condition shows that learning still tends to be oriented towards completing procedures rather than strengthening conceptual understanding. This finding is in line with research by Gal (2002) and Garfield (2017), which states that conceptual understanding in statistics is generally lower than procedural ability.

In terms of data interpretation and drawing conclusions, class A is in the high category while class B is in the medium category. These results indicate that students' ability to connect the results of statistical analysis with the context of the problem is still a challenge in learning. In fact, data interpretation skills are the main component in statistical reasoning because they require students to understand the context, variability of data, and the meaning of analysis results critically (Gal, 2002; Bakker & Gravemeijer, 2004).

Overall, the results of this study strengthen that numeracy abilities in the statistical reasoning aspect do not only depend on procedural mastery but are also influenced by conceptual understanding, learning context, and students' affective factors. Therefore, even though technology-based learning in this research was able to produce relatively equal learning outcomes, developing statistical reasoning in more depth still requires a learning approach that is more contextual, reflective, and oriented towards data interpretation.

In the context of PAUD teacher education, these findings have important implications because prospective teachers are not only required to be able to carry out data analysis but also to understand the meaning of the data and relate it to pedagogical decision-making. Therefore, more adaptive and contextual learning innovations are needed to strengthen the statistical reasoning abilities of PG-PAUD students, for example, through integrating real contexts, analyzing educational cases, and strengthening reflective aspects in statistics learning.

## CONCLUSION

The results of the research show that there is no significant difference in students' numeracy abilities in the statistical reasoning aspect between class A and class B. This finding is strengthened by the effect size value, which is in the small category (Cohen's  $d = 0.37$ ), so that the average difference between groups is relatively weak. These conditions show that an equivalent learning experience through the

use of IBM SPSS Statistics and the VClass platform results in relatively similar numeracy ability achievements in both groups of students.

However, analysis based on indicators shows that students' abilities tend to be stronger in procedural aspects compared to conceptual and interpretive aspects. The indicator for selecting analytical procedures obtained the highest achievement in both classes, while understanding statistical concepts, as well as interpreting and drawing conclusions from data, was still in the medium category for some students. These findings indicate that the statistics learning carried out has not been fully capable of developing in-depth statistical reasoning, especially in understanding the meaning of data and connecting it to the context of real problems.

In the context of prospective PAUD teacher education, the results of this research have important implications because students are not only required to be able to carry out statistical analysis procedures but also to be able to interpret data to support pedagogical decision-making. Therefore, statistics learning for PG-PAUD students needs to be directed at a more contextual, reflective, and experience-based approach. One alternative that can be implemented is project-based learning with themes that are relevant to early childhood education, such as analysis of child development, growth data, or children's learning activities based on simple observations. This approach has the potential to help students understand the relationship between statistical concepts and educational practice more meaningfully.

This research still has limitations in the relatively small number of subjects and the scope of the research, which only involves one study program, so generalization of the results needs to be done carefully. Therefore, it is recommended that further research involve a wider sample, use more varied learning designs, and combine objective instruments and descriptions so that students' statistical reasoning abilities can be analyzed in more depth.

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## AUTHOR CONTRIBUTIONS

**Author One:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, writing – original draft, editing, and visualization;

**Author Two:** Conceptualization, writing - original draft, editing, and visualization;

**Author Three:** Writing - review & editing, formal analysis, and methodology;

**Author Four:** Writing – review & editing, visualization, and validation;

**Author Five:** Investigation, resources, and data curation.

**Author Six:** Investigation, resources, and data curation.

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