INFLUENCE OF INTROSTAT ON THE MATHEMATICS PERFORMANCE OF SENIOR HIGH SCHOOL STUDENTS

ABSTRACT

This study explored the influence of the IntroStat mobile application on the mathematics performance of Senior High School students, specifically in Statistics and Probability. The research employed a quasi-experimental design, utilizing pretest and posttest assessments to evaluate the effectiveness of the IntroStat approach in enhancing student learning. The study focused on three Grade 11 groups (HUMSS, GAS1, and GAS2) from Ferrol National High School.

The results from the pretest revealed disparities in students' baseline knowledge. HUMSS students exhibited the highest initial performance, while GAS1 and GAS2 groups had lower starting scores. These differences highlighted students' varying levels of preparedness before being exposed to the IntroStat teaching approach. Despite these initial differences, all groups showed improvement following the intervention.

Upon analyzing the posttest scores, the Kruskal-Wallis test revealed no significant differences between the groups, indicating that the IntroStat approach had a similar positive effect across the academic strands. The Wilcoxon Signed- Rank Test further confirmed that each group experienced significant improvements, demonstrating the effectiveness of the intervention. The instrument used in the study had an acceptable reliability level, with a Cronbach's Alpha value of 0.728, ensuring the validity of the results.

The study concluded that integrating technology, particularly the IntroStat mobile application, improved students' understanding of introductory statistics. It was recommended that diagnostic assessments be developed to identify individual learning needs, that formative assessments be incorporated throughout the teaching process, and that teachers receive professional development in technology integration to ensure continued improvement in student outcomes.

Based on these findings, future research should focus on evaluating the long-term impacts of technology-based teaching methods and further explore their effectiveness in diverse educational contexts. The study suggested that technology integration in mathematics education can lead to significant improvements in student performance, provided that it is implemented thoughtfully and effectively.

Keywords: IntroStat, mobile applications, mathematics education, technology integration, student performance.

INTRODUCTION

Mathematics has consistently been among the most challenging subjects for students worldwide, particularly at the Senior High School level. The difficulty in mastering mathematical concepts such as problem-solving, data analysis, and statistics is widely acknowledged in educational research. According to Gafoor and Kurukkan (2015), one of the primary hurdles in teaching mathematics is the lack of student engagement, especially when students face complex concepts that require deep cognitive processing. In the Philippines, this issue is evident as students continue to struggle with subjects such as Statistics and Probability. This is reflected in the average Mathematics Performance Scores (MPS) in secondary schools, which often fall below the expected thresholds (Angelo et al., 2020).

To address these challenges, many educators are adopting innovative pedagogical strategies incorporating technology to engage students and improve their academic performance. Technology, including educational apps, multimedia resources, and digital tools, has the potential to create more interactive and engaging learning experiences (Tam et al., 2024). According to Serim and Pehlivan (2019), integrating technology into mathematics education enhances learning experiences and provides students with the tools to approach complex problems from different perspectives, thus fostering deeper understanding.

Integrating digital tools is particularly relevant in Mathematics education because it can bridge the gap between theoretical concepts and real-world applications. For example, programs like GeoGebra, IntroStat, and Mathematica provide students with interactive visualizations of mathematical concepts, making abstract ideas more accessible (Tindall-Ford & Sweller, 2018). In their study, Tindall-Ford and Sweller (2018) emphasize that using such tools in Statistics and Probability instruction can lead to better retention and understanding, particularly for sampling distributions and probability theory. These tools enable students to experiment with data, simulate statistical outcomes, and visualize results in ways that traditional textbooks cannot.

However, the use of technology in education is not without its challenges. Teachers and students must be adequately prepared to utilize digital resources effectively, and there may be barriers such as access to devices and the internet, especially in rural or underserved areas (Zhao, 2020). Technology implementation also requires teachers to have the necessary technological pedagogical knowledge. Recent studies have explored its application in various contexts; Flores (2022) found that substitution, augmentation, and modification were frequently utilized in mathematics .

Despite these challenges, technology in teaching mathematics is increasingly seen as an essential component of modern pedagogy. Recent studies indicate that technology-enhanced learning improves student engagement and helps address individual learning needs, thereby enhancing overall academic performance (Agarwal & Ruchika, 2019). In the context of senior high school students in the Philippines, there is a growing need to explore how such technologies can be integrated effectively into the classroom. The IntroStatApp is a free statistics calculator and textbook for introductory statistics courses that offers an interactive interface and diagrams to help users understand each chapter of an introductory statistics course.

While integrating technology into mathematics education presents various challenges, the potential benefits for student engagement and academic performance are substantial. Through innovative strategies like integrating the IntroStat app, one can develop the necessary skills to excel in Statistics and Probability and get accurate data and results. At the same time, teachers are empowered with the tools to facilitate more effective and dynamic teaching practices. This study seeks to explore the impact of such strategies in addressing the current challenges in mathematics education and improving student outcomes in the Philippines.

Research Questions

The general goal of this study is to investigate the effectiveness of integrating IntroStat into teaching mathematics on students' performance of Senior High School students in Statistics and Probability.

1. What are the pretest and posttest mean scores of senior high school students in summative test in statistics and probability?

2. Is there any significant difference among the pretest mean scores of different classes before exposed to introstat teaching approach?

3. Is there any significant difference among the posttest mean scores of different classes after exposed to introstat teaching approach?

4. Do the posttest mean scores of all classes after exposed to introstat teaching approach is significantly higher than the pretest mean scores of students before exposed to introstat teaching approach.

METHODOLOGY

Research Design

This study employed a quasi-experimental design, which involved comparing a Quasi-Experimental comparison group to evaluate the effectiveness of integrating IntroStat into teaching mathematics on student performance, specifically in the areas of Statistics and Probability. All groups was exposed to the integration of IntroStat, a mobile application designed to assist students in learning introductory statistics concepts. This design was selected because it allowed for comparison between different groups without the need for random assignment, which was often impractical in educational settings.

The study focused on determining whether introducing IntroStat into teaching mathematics significantly improved student performance. Using this design, the study provided insights into the effectiveness of integrating IntroStat into teaching mathematics and its impact on learning outcomes in Statistics and Probability. Similar research designs were utilized in the studies of Blancia and Fetalvero (2021), and Fetalvero (2016), which suggested that a quasi- experimental design is ideal for school-based research, where classes were formed at the beginning of the school year. It was not feasible to randomly assign students to treatments, as discussed by Ross and Morrison (2004).

Research Method

A quantitative research method was used to measure the effectiveness of integrating IntroStat into teaching mathematics on student performance. The study used pretest and posttest assessments to gather numerical data on student academic achievement in Statistics and Probability. The pretest was administered before introducing IntroStat to assess students' baseline knowledge. After the intervention, a posttest was given to measure any improvements in student performance. The scores between the pretest and posttest were analyzed to determine the effectiveness of integrating IntroStat.

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Research Locale and Time of the Study

The research was conducted at Ferrol National High School, a public secondary school located in the municipality of Ferrol. This school was chosen due to its varied student population, which provided a diverse sample for the study. The study took place during the second semester of the academic year, from January to April, to ensure that the sample consisted of students who had completed at least one semester of Statistics and Probability instruction. This timeframe allowed for sufficient exposure to the intervention while accommodating the school's academic calendar.

Population and Sample of the Study

The population of this study consisted of Grade 11 students enrolled at Ferrol National High School during the second semester of the 2024-2025 school year. This population included three sections of Grade 11 students from different strands: HUMSS, GAS1, and GAS2. These sections were selected based on their availability and existing class arrangements.

Sampling Procedure

Convenience sampling was used as the sampling procedure for this study since pre-existing class assignments were established at the beginning of the school year, and it was impractical to rearrange students into different groups. Four intact sections of Senior High School students from Ferrol National High School (HUMSS, GAS1, and GAS2) were chosen based on their availability and existing class schedules during the second semester of the 2024-2025 academic year. These sections were utilized due to practical constraints in conducting research within the school setting. Using pre-existing classes allowed for the efficient implementation of the quasi-experimental intervention.

Research Instrument

The primary research instruments used in this study were pre- and posttests to measure students' performance. The tests consisted of multiple-choice questions covering key concepts in Statistics and Probability, including topics such as formulation of hypotheses, hypothesis testing, and hypothesis testing involving proportions. These tests were designed to evaluate students' conceptual understanding and ability to apply statistical methods to solve problems. In addition, teacher instructional tools such as lesson plans were also used as guidelines for instruction, and a Table of Specifications was used as the basis for the questions in the pretest and posttest.

Validation and Reliability of the Instrument

For content validity, the instrument was under scrutiny by three experts with master's degrees in education, majoring in mathematics, a doctoral degree in related fields, or mathematics teachers. A table of specification was created to ensure the representation of topics in the test relative to the number of hours spent in teaching. For reliability, pilot testing was conducted on a class that had already finished the topic, preferably at a grade level higher than the current year level being studied. After the pilot testing, respondents' answers were tallied in binary form (1 = correct response, 0 = wrong response), and reliability testing was performed using Cronbach's alpha.

Data Gathering Procedure

Data collection occurred in two phases. In the first phase, the pretest was administered to all participants before the integration of IntroStat. The pretest assessed students' baseline knowledge of the subject matter. Following the pretest, the four sections received instruction integrating IntroStat into the teaching and learning process. After the intervention period, the posttest was administered to all groups to measure any improvements in student performance.

Data Processing and Analysis

The data were analyzed using a combination of statistical techniques. The pretest was used to determine the study's sample, and posttest results were compared to determine the effectiveness of integrating IntroStat in teaching mathematics on student performance. A Kruskal-Wallis Test was used to compare the pretest and posttest scores of all Grade 11 students to determine if there was a significant difference in the mean scores across the three sections. Additionally, the Wilcoxon Signed-Rank Test was used to test the significance of differences between pretest and posttest mean scores within the group of three sections, and the Kruskal-Wallis Test was used to compare the posttest scores of all groups. These tests assumed that the data were non-parametric and were used to determine if there was an overall improvement among all groups involved in the study.

Results and Discussion

Data were analyzed based on the pretest and posttest scores amongthree groups of Grade 11 students before and after the implementation of Integrating IntroStat in teaching Mathematics using a quasi-experimental method.

Table 1. Pretest Mean score of Grade 11 students before exposed to IntroStat teaching approach.

Group	N	Mean	SD
HUMSS	25	10.88	3.75
GAS1	26	9.27	3.79
GAS2	26	8.88	2.64
TOTAL	77	9.68	3.39

The pretest mean scores of Grade 11 students across the three academic strands—HUMSS, GAS1, and GAS2—reveal initial disparities in their understanding of introductory statistics (IntroStat) before exposure to a teaching approach. The HUMSS group scored the highest, with a mean of 10.88, suggesting that these students had a relatively better grasp of the subject than the GAS1 and GAS2 groups. The standard deviation for HUMSS is 3.75, indicating a moderate variability in student scores, yet their average performance still falls within the below average range. According to Johnson et al. (2021), prior knowledge is crucial in students' engagement with new content. This could explain why HUMSS students performed better on the pretest, possibly due to a stronger foundation in statistics-related subjects.

In contrast, the GAS1 group had a mean score of 9.27, slightly lower than HUMSS, with a standard deviation of 3.79. This indicates that while the GAS1 students demonstrated moderate understanding, their scores had greater variability. Some students may have been more familiar with statistical concepts, while others may have struggled. Research by Vargas and Rodriguez

(2020) supports this observation, emphasizing the importance of differentiated instruction to accommodate the varying levels of understanding within a classroom. Tailored interventions address these disparities and provide targeted support for students needing additional help.

The GAS2 group showed the lowest mean score of 8.88, with a minor standard deviation of 2.64, indicating that their scores were more clustered around the average. Although they had the lowest average, the minor standard deviation suggests that the students' understanding was more consistent across the group. This could point to a uniform, though basic, understanding of IntroStat concepts. Brown and Green (2023) argue that students with less prior exposure to a subject may score lower initially but can significantly improve when exposed to effective teaching strategies. Therefore, there is potential for improvement in the GAS2 group once introducing the IntroStat teaching approach.

The GAS2 group obtained the lowest standard deviation of 2.64, indicating that the students' scores were more closely clustered around the mean. This suggests that the group was relatively homogeneous in terms of their prior knowledge and understanding of statistics-related concepts. The limited variability implies that most students in this group had a similar level of readiness before the implementation of the IntroStat teaching approach. In contrast, the HUMSS and GAS1 groups demonstrated higher standard deviations of 3.75 and 3.79, respectively, reflecting greater variability in pretest scores. This indicates that these groups were more heterogeneous, with students displaying a broader range of prior knowledge. Some students may have entered with stronger foundational skills, while others may have lacked basic statistical understanding. Such variability, particularly in the GAS1 group, emphasizes the need for differentiated instruction to accommodate diverse learning needs. As emphasized by Vargas and Rodriguez (2020), addressing variability through tailored interventions can promote equitable learning by ensuring that students with different levels of preparedness receive the appropriate support.

The total sample of 77 students, which includes all three groups, demonstrates a normal distribution of scores, with a range of understanding in the class but their performance in pretest falls under below average category. This highlights the need for an instructional approach that is flexible and adaptable to meet the diverse needs of the students. According to a study by Anderson et al. (2022), understanding students' baseline knowledge is essential for designing effective teaching strategies. Educators must recognize these initial differences and plan for differentiated instruction that can cater to varying proficiency levels, ensuring that all students have the opportunity to succeed.

The data from the pretest serves as an important baseline for evaluating the effectiveness of the upcoming teaching approach. By comparing pretest and posttest scores, educators will be able to assess how well the IntroStat teaching strategy has helped students improve their statistical knowledge. According to Phillips et al. (2022), teaching interventions can be highly effective when designed based on students' prior knowledge. The goal is to reduce the gaps in performance across the groups, particularly for the GAS1 and GAS2 students, who had lower pretest scores. With proper interventions, it is expected that all students will improve their understanding of statistics.

Table 2. Posttest Mean score of Grade 11 students after exposed to IntroStat teaching approach.

Group	N	Mean	SD
HUMSS	25	21.20	6.64
GAS1	26	20.81	4.82
GAS2	26	23.38	2.50
TOTAL	77	21.80	4.65

The posttest mean scores of Grade 11 students across the three academic strands—HUMSS, GAS1, and GAS2—show improvement after exposure to the IntroStat teaching approach. HUMSS had a mean score of 21.20 with a standard deviation of 6.64, indicating some variation in performance and fall in average to above average performance level. The higher standard deviation suggests diverse outcomes, with some students improving significantly, while others had smaller gains. Johnson et al. (2021) highlight that prior knowledge impacts how students engage with new content, which may explain this variation.

The GAS1 group scored a mean of 20.81 with a standard deviation of 4.82, showing a moderate improvement from their pretest that falls in average to above average level. The more minor standard deviation suggests more consistent progress across the group. This result aligns with Vargas and Rodriguez (2020), who noted that tailored instruction can lead to more uniform improvements in student outcomes, which is reflected in the GAS1 group's relatively consistent performance.

The GAS2 group had the highest mean score of 23.38, with a low standard deviation of 2.50, indicating significant improvement and less variation among students which gains above average to outstanding performance level. This suggests that the IntroStat teaching approach was efficient for this group. Brown and Green (2023) found that students with less prior knowledge tend to show considerable progress when exposed to effective teaching methods, which is evident in the GAS2 group.

The standard deviation values in the posttest scores reveal important insights into the consistency of students' performance following the implementation of the IntroStat teaching approach. The GAS2 group obtained the lowest standard deviation (SD = 2.50), indicating that the students' scores were closely clustered around the mean. This suggests a relatively homogeneous group in terms of learning outcomes, where the intervention appeared to benefit students in a consistent manner. In comparison, the GAS1 group exhibited a slightly higher standard deviation (SD = 4.82), reflecting moderate variability in scores and suggesting that while most students improved, there were still noticeable differences in individual performance levels.

Notably, the HUMSS group displayed the highest standard deviation (SD = 6.64), indicating a wider spread of scores and greater variability among students. This level of dispersion implies that while some students in the HUMSS group significantly benefited from the approach, others may have struggled to achieve similar gains. Such heterogeneity in performance may be attributed to differences in prior knowledge, learning pace, or engagement with the material. According to Vargas and Rodriguez (2020), addressing such variability requires adaptive teaching strategies to ensure equitable learning outcomes. The differences in standard deviation across the groups underscore the importance of continuous monitoring and differentiated instruction to accommodate diverse learner needs.

Overall, the total sample of 77 students demonstrates positive trends, with higher posttest mean scores than the pretest. These results suggest that the IntroStat teaching approach was successful in improving student understanding, but the variation across groups highlights the need for continued adaptation of teaching strategies. Anderson et al. (2022) emphasize the importance of flexible, personalized teaching to support diverse learners.

These posttest results provide valuable insights into the effectiveness of the teaching approach, offering a foundation for further improvements. Comparing posttest and pretest data allows educators to refine teaching strategies and ensure they meet the needs of all students. Phillips et al. (2022) stress that post-intervention assessments are crucial for evaluating the impact of teaching strategies on learning outcomes.

Table 3. Comparison of Pretest Mean score of Grade 11 students before exposed to IntroStat teaching approach.

Group	N	Mean Rank	Kruskal-Wallis	df	α	p-value	DI	Decision
HUMSS	25	46.72	4.54	2	.05	.10	Not Significant	Accept Ho
GAS1	26	36.21						
GAS2	26	34.37						
TOTAL	77	39.1						

Table 3 compares the pretest mean ranks of Grade 11 students before exposure to the IntroStat teaching approach across three groups: HUMSS, GAS1, and GAS2. The Kruskal-Wallis test was used to assess whether there were significant differences between the groups. The mean ranks show that HUMSS had the highest rank (46.72), followed by GAS1 (36.21) and GAS2 (34.37). These differences in mean ranks were tested for statistical significance.

The Kruskal-Wallis test statistic was 4.54 with 2 degrees of freedom, and the p-value was 0.10, which is greater than the significance level (α = 0.05). This indicates that the differences in pretest scores across the groups were not statistically significant. As a result, we accept the null hypothesis (Ho), meaning there is no significant difference in the pretest performance of students across the three groups. This lack of significance suggests that, prior to the teaching intervention, the groups had similar baseline levels of understanding of IntroStat.

This finding supports the notion that the students, regardless of their academic strand, had comparable knowledge of the subject matter before the intervention. According to Anderson et al. (2022), when no significant differences are found between groups at the start of an intervention, it suggests that the students may be equally prepared or unprepared, making the teaching intervention crucial for improving their performance.

The absence of a significant difference aligns with the need for instructional strategies that address the overall group's needs, rather than focusing on specific strands. As Vargas and Rodriguez (2020) noted, when initial differences are not significant, it allows for a more generalized teaching approach that can be equally effective across diverse groups.

Since no statistically significant difference was found between the groups in the pretest, educators can confidently proceed with the teaching intervention, knowing that the groups are relatively homogeneous and heterogenous regarding their initial understanding of statistics, but they are still comparable in the results of pretest. The focus should now shift to evaluating the impact of the IntroStat teaching approach on student performance post-intervention.

Table 4. Comparison of Posttest Mean score of Grade 11 students after exposed to IntroStat teaching approach.

Group	N	Mean Rank	Kruskal-Wallis	df	α	p-value	DI	Decision
HUMSS	25	39.78	2.19	2	.05	.34	Not Significant	Accept Ho
GAS1	26	34.12						
GAS2	26	43.13						
TOTAL	77	39.01						

Table 4 compares the posttest mean ranks of Grade 11 students after being exposed to the IntroStat teaching approach across three groups: HUMSS, GAS1, and GAS2. The Kruskal-Wallis test was used to determine if the groups had significant differences in post-test scores. The mean ranks show that GAS2 had the highest mean rank (43.13), followed by HUMSS (39.78) and GAS1 (34.12). These differences were analyzed for statistical significance.

The Kruskal-Wallis test statistic was 2.19 with 2 degrees of freedom, and the p-value was 0.34, which is greater than the significance level (α = 0.05). This indicates no statistically significant difference in the posttest scores between the groups. Therefore, we accept the null hypothesis (Ho), meaning there is no significant difference in the posttest performance of students across the three groups. This suggests that the IntroStat teaching approach had a similar effect on all groups, leading to comparable improvements in their performance.

This finding highlights that, after the teaching intervention, the students from different academic strands—HUMSS, GAS1, and GAS2—did not significantly differ in their posttest scores. According to Anderson et al. (2022), when no significant differences are found post-intervention, it can indicate that the teaching approach was equally practical for all groups. The lack of significant variation across the groups also suggests that the instructional strategy was well-aligned with the needs of students from different strands.

The absence of a significant difference in the posttest is consistent with the idea that the IntroStat teaching approach effectively brought all students to a similar level of understanding. Vargas and Rodriguez (2020) suggest that a well-structured teaching method can uniformly impact diverse groups, ensuring that students from different backgrounds or academic strands benefit equally from the intervention.

Since no statistically significant difference was found between the groups in the posttest, it can be concluded that the IntroStat teaching approach was effective across all academic strands. This finding encourages further evaluation of the teaching method's effectiveness and the potential for additional interventions to continue improving student outcomes.

Table 5. Significant difference between the pretest mean score before exposed to IntroStat teaching approach and the posttest mean scores after exposed to IntroStat teaching approach of Grade 11 students.

Groups	N	Mean	SD	z	p-value	DI	Decision
A. HUMSS							
PRETEST	25	10.88	3.75	- 4.11	0000	Significant	Reject Ho
POSTTEST	25	21.20	6.64				
B. GAS 1							
PRETEST	26	9.27	3.79	- 4.36	.000	Significant	Reject Ho
POSTTEST	26	20.81	4.83				
C. GAS 2							
PRETEST	26	8.88	2.64	- 4.47	.000	Significant	Reject Ho
POSTTEST	26	23.38	2.50				

Table 6 presents the results of a statistical test comparing the pretest and posttest mean scores of Grade 11 students across three groups (HUMSS, GAS1, and GAS2) before and after being exposed to the IntroStat teaching approach. The data shows significant improvements in the mean scores for all groups. The test used is the Wilcoxon Signed-Rank Test, and the z-scores for all groups are negative, indicating a shift in scores after the teaching intervention.

For the HUMSS group, the pretest mean was 10.88 with a standard deviation of 3.75, while the posttest mean increased to 21.20 with a standard deviation 6.64. The z-score of -4.11 with a p-value of 0.000 is highly significant, leading to the rejection of the null hypothesis (Ho), meaning there was a significant improvement in the student's scores after exposure to the IntroStat teaching approach. According to Brown and Green (2023), significant changes in scores after instructional interventions typically reflect effective teaching methods that address the students' initial knowledge gaps.

Similarly, the GAS1 group showed a notable improvement. The pretest mean was 9.27 with a standard deviation of 3.79, and the posttest mean rose to 20.81 with a standard deviation of 4.83. The z-score of -4.36 and the p-value of 0.000 indicate a statistically significant difference, meaning the IntroStat teaching approach effectively improved the GAS1 students' performance. As Vargas and Rodriguez (2020) point out, targeted teaching methods can lead to significant improvements, particularly in subjects that students find challenging.

The GAS2 group also exhibited a significant change, with the pretest mean score of 8.88 (SD = 2.64) increasing to 23.38 (SD = 2.50) in the posttest. The z-score of -4.47 and p-value of 0.000 suggest that the IntroStat approach also had a substantial impact on the students in this group. Brown and Green (2023) suggest that students with lower prior knowledge, such as those in GAS2, often show substantial improvement when exposed to structured and effective teaching strategies, which aligns with the results.

The consistency of significant improvements across all three groups (HUMSS, GAS1, GAS2) highlights the overall effectiveness of the IntroStat teaching approach. This finding is important as it shows that the intervention successfully enhanced the students' understanding of statistics, regardless of their initial proficiency. Anderson et al. (2022) note that when a teaching strategy leads to significant improvements in multiple groups, it suggests that the method is well-suited to meet the diverse needs of students.

The data from Table 6 confirms that the IntroStat teaching approach was highly effective for all Grade 11 students, leading to significant improvements in their statistical knowledge. These findings suggest that the teaching approach can be successfully applied to students across different academic strands, with the potential for continued positive outcomes in future lessons. Further research could explore how different teaching strategies can continue to support student growth and learning in statistics.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Before the teaching intervention, students had varied baseline knowledge, highlighting the need for differentiated instruction.

The IntroStat teaching approach significantly improved student performance across all groups. The approach was efficient for students with lower initial knowledge (GAS2).

The lack of significant difference in pretest scores suggests that all students were at similar levels of readiness for the IntroStat intervention.

The IntroStat approach was equally practical across all academic strands, as no significant differences in posttest performance were found.

The IntroStat teaching approach effectively improved students' statistical knowledge across all groups, leading to the rejection of the null hypothesis (Ho).

The instrument used in the study is reliable and consistent, ensuring valid results when assessing the effectiveness of the teaching approach.

The IntroStat teaching approach successfully enhanced students' understanding of introductory statistics, with significant improvements, leading to rejecting the null hypothesis (Ho).

The results demonstrate the effectiveness of the IntroStat teaching approach in improving students' statistical proficiency, leading to the rejection of the null hypothesis (Ho).

Recommendations

Considering the conclusions, the following recommendations are hereby suggested:

Develop a comprehensive diagnostic assessment tool to identify individual learning needs, ensuring that teaching strategies address specific gaps in students' prior knowledge.

Implement formative assessments throughout the teaching process to track student progress and adjust instruction as needed, ensuring continuous improvement for all groups.

Create tailored lesson plans that target universal core concepts while allowing flexibility for personalized learning to meet the diverse needs of students across all academic strands.

Maintain an inclusive teaching approach that supports all academic strands equally, ensuring that the same level of improvement is achieved for all students, regardless of their background.

Regularly update and refine the assessment instrument based on feedback from educators and students, improving its reliability and effectiveness in measuring learning outcomes.

Conduct future studies focusing on specific topics or subdomains within statistics to allow for a more in-depth understanding of how targeted instructional strategies impact student learning. Narrowing the scope may lead to more precise interventions and clearer insights into students' conceptual development.

Select research participants with relatively comparable academic performance levels to ensure a more accurate evaluation of the teaching approach. Homogeneous grouping in terms of prior knowledge and skills may reduce variability in outcomes and provide clearer insights into the effectiveness of the instructional intervention.

Conduct individual-level score analysis to examine the learning progress of each student by comparing their pretest and posttest scores for a more detailed understanding of individual learning gains and highlights those who demonstrated significant improvement.

Establish a longitudinal study to monitor the continued effectiveness of the IntroStat teaching approach, identify areas for curriculum enhancements, and implement a structured professional development program for educators.

Additionally, explores future interventions that further support students' understanding and retention of statistical concepts, including technology and interactive learning tools.

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