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RESEARCH ARTICLE

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

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Abstract

This study explored the influence of the IntroStat mobile application on the mathematics performance of Senior High School students,specifical lyinStatistics 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 HighSchool.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 effectiv eness of the intervention.The instrument used in the study had an accep tablereliabilitylevel,with a Cronbach'sAlphavalue of 0.728, ensuring the validity of theresults.The study concluded that integrating technology, particularly the IntroStat mobile application, improved students' understanding of introductory statistics. It was recommended t hat diagnosticassessments 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 studentoutcomes.Based on these findings, future research should focus on evaluating the long term impacts of technology based teaching meth ods and further explore their effectiveness in diverse educational contexts. The study suggested that technology integration in mathematics education can lead tosignificant improvements in student performance, provided that it is implemented thoughtfully and effectively.

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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 statisticsiswidelyacknowledgedineducationalresearch.AccordingtoGafoorand 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 studentscontinuetostrugglewithsubjectssuchasStatisticsandProbability.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 technologyinto mathematics educationenhances 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, especiallyinruralorunderservedareas(Zhao,2020).Technologyimplementation 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 increasinglyseenasanessentialcomponentofmodernpedagogy.Recentstudies 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 offersaninteractiveinterfaceanddiagramstohelpusersunderstandeachchapter 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 thecurrentchallengesinmathematicseducationandimprovingstudentoutcomes in thePhilippines.

Research Questions

The general goal of this study is to investigate the effectiveness of integratingIntroStatintoteachingmathematicsonstudents'performanceofSenior High School students in Statistics andProbability.

1. What are the pretest and posttest mean scores of senior high school students in summative test in statistics andprobability?
2. Isthereanysignificantdifferenceamongthepretestmeanscoresofdifferent classes before exposed to introstat teachingapproach?

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

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 teachingapproach.

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, specificallyintheareasofStatisticsandProbability.Allgroupswasexposedtothe integrationofIntroStat,amobileapplicationdesignedtoassiststudentsinlearning 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 educationalsettings.

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 integratingIntroStatintoteachingmathematicsonstudentperformance.Thestudy used pretest and posttest assessments to gather numerical data on student academicachievementinStatisticsandProbability.Thepretestwasadministered 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 integratingIntroStat.

Research Locale and Time of the Study

The research was conducted at Ferrol National High School, a public secondaryschoollocatedinthemunicipalityofFerrol.Thisschoolwaschosendue toitsvariedstudentpopulation,whichprovidedadiversesampleforthestudy.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 leastonesemesterofStatisticsandProbabilityinstruction.Thistimeframeallowed 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,andGAS2.Thesesectionswereselectedbasedontheir availability and existing classarrangements.

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 schoolyear,anditwasimpracticaltorearrangestudentsintodifferentgroups.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

Theprimaryresearchinstrumentsusedinthisstudywerepre-andposttests to measure students' performance. The tests consisted of multiple-choice questionscoveringkeyconceptsinStatisticsandProbability,includingtopicssuch 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 usedas 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

Forcontentvalidity,theinstrumentwasunderscrutinybythreeexpertswith master's degrees in education, majoring in mathematics, a doctoral degree in related fields, or mathematics teachers. A table of specification was created to ensuretherepresentationoftopicsinthetestrelativetothenumberofhoursspent 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'salpha.

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,thefoursectionsreceivedinstructionintegratingIntroStatintotheteaching and learning process. After the intervention period, the posttest was administered to all groups to measure any improvements in studentperformance.

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 mathematicsonstudentperformance.AKruskal-WallisTestwasusedtocompare 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. The decision to use non-parametric tests was based on the sample sizes of the groups, which were relatively small and unequal (n = 25, 26, and 26). With small samples, the assumptions required for parametric tests—such as normality and equal variances—are more difficult to meet. Therefore, non-parametric methods were more appropriate for providing reliable statistical inferences under these conditions.

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-experimentalmethod.

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 from the HUMSS, GAS1, and GAS2 strands reveal initial differences in their understanding of introductory statistics (IntroStat) prior to the teaching intervention. The HUMSS group achieved the highest mean score of 10.88 with a standard deviation of 3.75, suggesting a relatively stronger grasp of statistical concepts and moderate variability among student performances. Despite leading among the three groups, their average still falls within the below-average range. According to Johnson et al. (2021), students' prior knowledge significantly influences their engagement and comprehension of new material—an insight that may explain the HUMSS group's initial advantage.

The GAS1 group followed with a mean score of 9.27 and a slightly higher standard deviation of 3.79. This points to a moderate understanding with greater variation among individual scores, indicating that some students were better prepared than others. This variability underscores the importance of differentiated instruction, as highlighted by Vargas and Rodriguez (2020), to address diverse learning needs and provide targeted support for students requiring additional assistance.

The GAS2 group recorded the lowest mean score of 8.88, yet showed the least variability with a standard deviation of 2.64. This close clustering suggests a more uniform, albeit limited, level of prior knowledge across the group. While their performance was the weakest overall, the consistency implies a shared baseline from which

improvement is possible. Brown and Green (2023) emphasize that students with limited initial exposure often demonstrate notable progress when supported by effective instructional strategies—offering promise for the GAS2 group under the IntroStat approach.

Across all 77 students, the distribution of pretest scores approximates normality, indicating a wide but balanced range of statistical understanding. Overall, results confirm that most students began with below-average proficiency, reinforcing the need for an adaptable teaching strategy. As Anderson et al. (2022) assert, identifying students' starting points is essential for designing effective interventions. Recognizing these initial disparities enables educators to implement responsive and differentiated instruction tailored to varied levels of readiness.

The pretest data thus serves as a critical baseline for assessing the impact of the IntroStat teaching approach. Through comparison with posttest results, educators can evaluate how well the strategy addresses learning gaps—particularly for the GAS1 and GAS2 groups. Phillips et al. (2022) stress that interventions grounded in prior knowledge are more likely to yield meaningful learning gains. With carefully planned instruction, it is anticipated that all groups will show measurable improvement in their understanding of statistics, fostering more equitable learning outcomes.

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

Group	N	Mean	SD
HUMSS	25	21.2	6.64
GAS1	26	20.81	4.82
GAS2	26	23.38	2.5
TOTAL	77	21.8	4.65

The posttest mean scores of Grade 11 students from the HUMSS, GAS1, and GAS2 strands reveal clear improvement in their understanding of statistics and probability following the implementation of the IntroStat teaching approach—directly addressing the study's research question.

The HUMSS group achieved a mean score of 21.20 with a standard deviation of 6.64, indicating a shift from below average to average-to-above average performance. The relatively high standard deviation suggests varied outcomes: while some students demonstrated substantial gains, others showed more modest improvement. This variability may stem from differing levels of prior knowledge and engagement, as discussed by Johnson et al. (2021), who emphasize how prior learning shapes the assimilation of new content.

The GAS1 group followed closely with a mean of 20.81 and a standard deviation of 4.82, indicating a consistent and moderate improvement across the group. This smaller spread suggests that most students made progress at a similar pace. The outcome aligns with findings from Vargas and Rodriguez (2020), who advocate for tailored instruction as a means to ensure more uniform student growth.

Interestingly, the GAS2 group—which had the lowest pretest scores—registered the highest posttest mean of 23.38, accompanied by the lowest standard deviation of 2.50. This result signifies not only strong overall improvement but also consistent performance across students, suggesting that the IntroStat teaching approach was particularly effective for this group. Brown and Green (2023) argue that students with limited prior knowledge often benefit most from structured and targeted instruction, which appears evident in GAS2's substantial progress.

Analyzing the standard deviations across groups provides deeper insight into the effectiveness and equity of the teaching strategy. The GAS2 group's low variability suggests a uniformly positive response to instruction. GAS1's moderate variation reflects a generally successful but slightly uneven outcome. In contrast, HUMSS's wider score distribution implies diverse levels of engagement or readiness, necessitating more differentiated support. As noted by Vargas and Rodriguez (2020), such disparities reinforce the importance of adaptive instructional strategies that accommodate varied learner needs.

Collectively, the total sample of 77 students demonstrated marked improvement from pretest to posttest. This overall gain reflects the IntroStat teaching approach's effectiveness in enhancing statistical understanding. However, the differences in score variability highlight a continuing need for responsive, learner-centered teaching practices. Anderson et al. (2022) emphasize that flexible, personalized instruction is essential to support diverse classrooms effectively.

Finally, these posttest outcomes form a key measure of instructional impact. When paired with the pretest baseline, they offer valuable insights into the strengths and limitations of the teaching approach. As Phillips et al. (2022) suggest, post-intervention assessment is critical in refining pedagogical strategies to ensure that all learners, regardless of prior knowledge, can achieve meaningful progress in statistical learning.

Table3:-ComparisonofPretestMeanscoreofGrade11studentsbeforeexposed to IntroStat teachingapproach.

Group	N	Mean Rank	Kruska-Wallis H	df	α	p	DI	Decision
HUMSS	25	46.72						
GAS1	26	36.21						
GAS2	26	34.37						
TOTAL	77	39.1						
			4.54	2	.05	.10	Not Significant	Accept H_0

Table 3 presents the comparison of pretest mean ranks among Grade 11 students from HUMSS, GAS1, and GAS2 using the Kruskal-Wallis test. The HUMSS group had the highest mean rank (46.72), followed by GAS1 (36.21) and GAS2 (34.37), suggesting initial differences in pretest performance.

However, the Kruskal-Wallis test yielded a test statistic of 4.54 with 2 degrees of freedom and a p-value of 0.10, which exceeds the significance threshold ($\alpha = 0.05$). This result indicates that the observed differences in mean ranks are not statistically significant, and therefore, the null hypothesis (H_0)—that there is no significant difference among the groups—is accepted.

This lack of statistical significance implies that the three groups had comparable baseline understanding of statistics before the implementation of the IntroStat teaching approach. As noted by Anderson et al. (2022), when no significant differences are found prior to instruction, it suggests that students began at a relatively equal level of preparedness, reinforcing the importance of the intervention itself as a key factor in driving performance improvement.

Moreover, the homogeneity in pretest scores supports the feasibility of applying a generalized instructional strategy rather than one tailored to specific academic strands. Vargas and Rodriguez (2020) emphasize that when initial performance levels are similar, a unified teaching approach can be equally effective across different learner groups.

With no significant pre-existing differences among the strands, the study proceeds from a balanced starting point. This enhances the validity of subsequent comparisons between pretest and posttest results, allowing for a clearer assessment of how the IntroStat teaching approach impacts student learning outcomes across all groups.

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

Group	N	Mean Rank	Kruskal-Wallis H	df	α	p	DI	Decision
HUMSS	25	39.78						
GAS1	26	34.12						
GAS2	26	43.13						
TOTAL	77	39.01						
			2.19	2	.05	.34	Not Significant	Accept H_0

Table 4 compares the posttest mean ranks of Grade 11 students from the HUMSS, GAS1, and GAS2 strands following their exposure to the IntroStat teaching approach. Based on the Kruskal-Wallis test, the GAS2 group obtained the highest mean rank (43.13), followed by HUMSS (39.78) and GAS1 (34.12), suggesting slight variations in performance outcomes.

To determine the statistical significance of these differences, the Kruskal-Wallis test produced a test statistic of 2.19 with 2 degrees of freedom and a p-value of 0.34—greater than the standard significance level ($\alpha = 0.05$). This result indicates no significant difference in the posttest scores across the three groups, leading to the acceptance of the null hypothesis (Ho).

This finding suggests that the IntroStat teaching approach had a similar effect across all academic strands. Despite slight differences in mean ranks, the groups achieved comparable posttest performance, pointing to the intervention's effectiveness in elevating students' understanding of statistics regardless of their academic background.

According to Anderson et al. (2022), when post-intervention differences are statistically insignificant, it reflects the equitable impact of the teaching strategy. This outcome supports the conclusion that the IntroStat approach was equally practical and inclusive, addressing the varied learning needs of HUMSS, GAS1, and GAS2 students.

Moreover, the lack of significant variation affirms Vargas and Rodriguez's (2020) assertion that structured and student-centered instruction can lead to uniform academic gains across diverse learner groups. The findings further imply that the approach provided a level playing field, helping all students reach similar levels of statistical competence.

In summary, the absence of significant posttest differences reinforces the idea that the IntroStat teaching approach was effective across all strands, fulfilling its goal of improving statistical understanding across the board. This provides a strong foundation for further refinement and application of the method in future instructional planning.

Table 5:-Significantdifferencebetweenthepretestmeanscorebeforeexposedto IntroStat teaching approach and the posttest mean scores after exposed to IntroStat teaching approach of Grade 11students.

Groups	N	Mean	SD	z	p	DI	Decision
A. HUMSS							
PRETEST	25	10.88	3.75	- 4.11	.000	Significant	Reject H_0
POSTTEST	25	21.20	6.64				
B. GAS 1							
PRETEST	26	9.27	3.79	- 4.36	.000	Significant	Reject H_0
POSTTEST	26	20.81	4.83				
C. GAS 2							
PRETEST	26	8.88	2.64	- 4.47	.000	Significant	Reject H_0
POSTTEST	26	23.38	2.50				

Table 5 presents the Wilcoxon Signed-Rank Test results comparing pretest and posttest mean scores of Grade 11 students from HUMSS, GAS1, and GAS2 after exposure to the IntroStat teaching approach. The data show statistically significant improvements in all groups, as evidenced by negative z-scores and p-values of 0.000.

For the HUMSS group, the pretest mean score was 10.88 (SD = 3.75), which increased to 21.20 (SD = 6.64) in the posttest. The z-score of -4.11 confirms a significant gain in performance, leading to rejection of the null hypothesis. This result aligns with Brown and Green (2023), who assert that significant score improvements indicate effective instructional strategies that successfully address students' prior knowledge gaps.

The GAS1 group also demonstrated notable progress, with mean scores rising from 9.27 (SD = 3.79) in the pretest to 20.81 (SD = 4.83) post-intervention. The z-score of -4.36 further supports the effectiveness of the IntroStat approach in enhancing student learning. Vargas and Rodriguez (2020) emphasize that targeted teaching methods can produce significant improvements, especially in areas where students initially struggle.

Similarly, the GAS2 group showed the largest increase, from a pretest mean of 8.88 (SD = 2.64) to a posttest mean of 23.38 (SD = 2.50). The z-score of -4.47 and corresponding p-value confirm a highly significant improvement. This supports Brown and Green's (2023) observation that students with lower baseline knowledge often exhibit substantial gains when exposed to well-structured, effective teaching interventions.

The consistent significant improvements across all three academic strands demonstrate the overall success of the IntroStat teaching approach in enhancing students' statistical understanding. Anderson et al. (2022) suggest that when an instructional method yields positive results across diverse groups, it indicates the strategy's adaptability and effectiveness in meeting varied student needs.

In conclusion, the data from Table 5 confirm that the IntroStat teaching approach was highly effective in improving the statistical knowledge of Grade 11 students across different strands. These findings underscore the potential for this approach to be applied broadly, with future research encouraged to explore additional strategies that support ongoing student growth in statistics.

Conclusion and Recommendations:-

Conclusions:-

Before the intervention, students showed varied baseline knowledge, indicating the need for differentiated instruction. The IntroStat teaching approach significantly enhanced students' understanding of introductory statistics across all academic strands, including those with lower initial proficiency (GAS2). The absence of significant

differences in pretest and posttest scores suggests that the approach was equally effective for all groups, helping to level their performance. The reliability of the research instrument supports the validity of these findings. Overall, the results demonstrate that the IntroStat teaching method is an effective strategy for improving statistical proficiency in senior high school students.

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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