Active Learning, Real-Time Feedback, and Academic Integrity in Business Statistics: A Study Using Scoreboard for Excel

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Abstract

Three of the Guidelines for Assessment and Instruction in Statistics Education (GAISE) emphasize fostering active learning, using technology to explore concepts and analyze data, and using assessments to improve and evaluate student learning. We incorporate these principles into an undergraduate business statistics course through a free educational technology tool called Scoreboard for Excel. Scoreboard facilitates active learning by providing real-time formative feedback, scaffolding complex tasks, and increasing student engagement. It also benefits faculty by making it easy to create assignments, automate grading, and reduce opportunities for academic integrity violations. Does the integration of Scoreboard in the classroom improve learning and performance? In a controlled experiment at a small Northeastern state college, students using Scoreboard for Excel outperformed a control group on all measured outcomes in an undergraduate business statistics class. Survey data suggest that the tool increases engagement, is well-received by students, and is useful beyond the classroom. Integrating Scoreboard into the curriculum aligns closely with GAISE guidelines and can be easily expanded to other quantitative disciplines.

Keywords: *Excel, Business Statistics, Student Learning, Student Engagement*

In 2005, the American Statistical Association released the GAISE College Report, later revised in 2016, which provides recommendations for improving the teaching of undergraduate statistics (Carver et al., 2016). These guidelines include teaching statistics as an investigative process, focusing on conceptual understanding, integrating real data, fostering active learning, using technology to explore and analyze data, and employing assessments to both improve and evaluate student learning. While traditional lecture methods and publisher-produced resources offer some support, they often lack immediate feedback mechanisms, limit instructor customization, and may not effectively promote active learning or protect academic integrity.

This paper examines an innovative approach to teaching undergraduate business statistics using a free educational technology tool called Scoreboard for Excel. Scoreboard transforms Excel assignments into interactive, self-grading learning experiences. Can we improve student performance and learning using this tool? It provides real-time, formative feedback as students complete tasks, aligning well with the GAISE principles. The design leverages three pedagogical theories to foster active learning, deeper understanding, and intrinsic motivation: scaffolding, real-time formative feedback, and self-determination. Additionally, Scoreboard relieves faculty of grading burdens, offers robust academic honesty controls, and allows full customization of assignments. The Scoreboard for Excel website (https://www.scoreboardexcel.com/) offers instructors a free download of the program and tutorial videos for assignment creation.

Our study took place at a small Northeastern state college with the appropriate IRB approval. Students in one section of an undergraduate business statistics course used Scoreboard for Excel, while students in two control sections did not. We compare their performance on objective measures from a publisher's homework manager system. Students taught with Scoreboard for Excel exhibited significantly improved performance across all examined areas, from descriptive statistics to hypothesis testing and regression. Survey responses show that students find the tool engaging, supportive, and valuable.

The remainder of this paper is organized as follows. The following section discusses the GAISE guidelines and how Scoreboard aligns with them. We next present the theoretical foundations of scaffolding, real-time feedback, and self-determination that underpin active learning. Then we address faculty needs for customization, automated grading, and academic integrity. We review the existing literature on integrating Excel and technology in teaching statistics and describe Scoreboard's mechanism with illustrative examples and figures. We present our analysis starting with an outline of the experimental design, data, and methods. A presentation of the results and discussion follows. We supplement the analysis by discussing survey findings and student feedback, followed by concluding remarks.

Aligning with GAISE Recommendations

The GAISE College Report's recommendations (Carver et al., 2016) guide educators toward more effective statistics instruction. Three of these recommendations are particularly salient to our approach:

1. **Foster active learning:** Students learn best when actively engaged. Instead of passively receiving information, they should discover solutions through hands-on tasks.
2. **Use technology to explore concepts and analyze data:** Technology can simplify complex calculations, allowing students to focus on interpreting results and understanding concepts.
3. **Use assessments to improve and evaluate student learning:** Assessments should provide timely feedback, helping students learn from errors and build conceptual mastery.

Scoreboard for Excel aligns with these goals by integrating technology directly into assignments, providing immediate feedback, and enabling students to learn actively. The tool encourages students to manipulate data, apply formulas, create graphs, and interpret outputs, all while receiving guidance. This strengthens their understanding of statistical concepts and improves their competency in Excel, which, on its own merit, is considered an essential workplace skill.

Pedagogical Foundations: Scaffolding, Real-Time Feedback, and Self-Determination

Three overlapping pedagogical frameworks support the use of Scoreboard for Excel:

Scaffolding (Vygotsky & Cole, 1978)

Scaffolding involves providing just enough support to help students bridge the gap between their current skill level and their potential capability. Scoreboard's design alerts students immediately when errors occur and provides minimally revealing hints. This allows learners to correct mistakes on their own, preserving task integrity and encouraging deeper engagement. For example, if a calculation is off, the tool indicates "Value too low, please try again" rather than giving the answer. Students learn the correct approach by refining their calculations until the cell turns green, signifying mastery.

Real-Time Formative Feedback (Hattie & Timperley, 2016; Epstein et al., 2001)

Feedback is most effective when it is immediate, goal-oriented, and delivered in a self-paced, computer-assisted environment. Many learning management systems delay feedback until after submission, which can be too late for productive learning. Scoreboard provides feedback on each cell in real-time. This immediate correction helps students understand the nature of their mistakes right at the point of error when it is most useful.

Self-Determination Theory (Ryan & Deci, 2000)

Intrinsic motivation flourishes when learners experience autonomy, receive feedback on their performance (competence), and can interact with others (relatedness). Scoreboard supports autonomy by allowing students to navigate assignments in the order they prefer, competence by providing instant performance feedback and a progress bar to show incremental successes, and relatedness by encouraging collaborative consultation among peers and with faculty. Students gain confidence as they see their correct answers turn cells green and accumulate points.

Meeting Faculty Needs: Customization, Automated Grading, and Academic Integrity

While GAISE focuses on student learning, instructors have their own needs. Scoreboard for Excel addresses these challenges:

Easy Customization of Assignments

Instructors can create assignments that align perfectly with their course objectives. They begin with an Excel file containing desired data, formulas, and questions, which can include multiple-choice, numeric answers, or complete analyses. With one click, Scoreboard converts the file into a self-grading assessment. This design gives instructors unlimited control over content, unlike many publisher tools that limit customization.

Automated Grading

Time-consuming manual grading can deter faculty from assigning frequent, robust assessments. Scoreboard automates the grading process. Students submit their auto-graded assignments through the learning management system (LMS). The instructor downloads them in bulk, and Scoreboard records all scores in minutes, eliminating grading drudgery and freeing time for more meaningful faculty-student interactions.

Academic Integrity Controls

Academic dishonesty is a concern in online assignments. Publisher resources, widely used across many courses, often have their answers posted on cheating websites. Scoreboard mitigates this by randomizing data values, shifting formula references for each student, and generating individually named start files. This reduces the benefit of copying a peer’s work or searching for an identical solution online.

Literature Review: Technology Integration and Excel in Statistics Education

The educational literature supports the integration of technology, including Excel, to enhance statistics learning. Garfield and Ben-Zvi (2007) survey the effectiveness of active learning and note that structured activities, like those Scoreboard supports, improve conceptual understanding. Moore (1997) emphasizes problem-solving practice, which aligns with allowing students to use Excel to carry out statistical procedures rather than relying solely on pen-and-paper calculations.

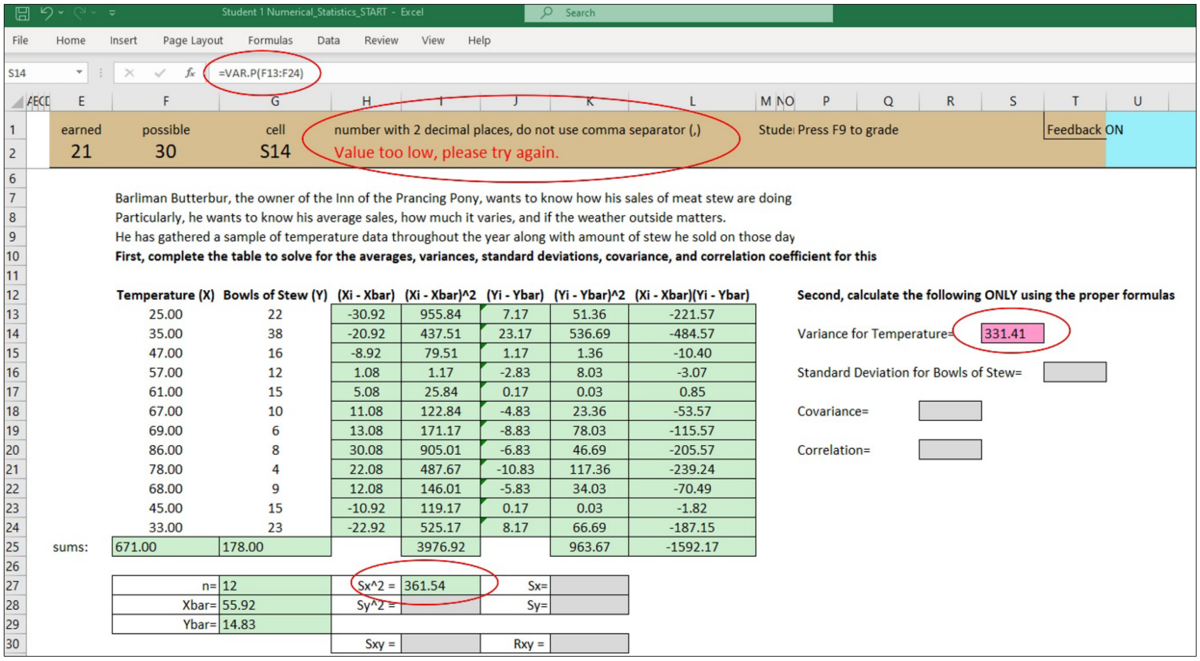
Contemporary students are comfortable with technology. TikTok and web-based applets (Lee et al., 2018; Kusumadyahdewi & Kusumarasdyati, 2021; Variyath & Nadarajah, 2022) have been used successfully to engage learners. Computer simulations (Corredor, 2008; Jamie, 2002) and spreadsheet-based assignments (Liang & Martin, 2008) have improved conceptual understanding. However, time-consuming development of spreadsheet assignments and lack of immediate feedback have posed challenges.

Excel remains a valuable and in-demand skill (Dobson, 2024; University of Reading, n.d.). Studies show that proficiency in Excel is critical for business graduates (Formby et al., 2017; Ragland & Ramachandran, 2014; Palocsay et al., 2010). Yet, many students lack basic Excel proficiency upon entering college (Creighton et al., 2006). Integrating Excel into the statistics curriculum is a natural fit. McCloskey and Bussom (2013) find that Excel better engages students and improves learning in statistics. The Technology-enhanced Supportive Instruction (TSI) model for teaching statistics promotes usage of computing software like Excel in flipped classrooms, online, and face-to-face deliveries. (Soesmanto & Bonner, 2019; Burckhardt et al., 2021; Reyneke et al., 2021). Using Excel reduces tedious manual calculations, allowing students to focus on interpretation and conceptual analysis (Bell, 2000; Erfle, 2001; Convery & Swaney, 2012; Willis, 2016; Zhang, 2014). Al-Haddad et al. (2024) promote learning through purposeful use of technology and faculty feedback to support the student. In the absence of faculty, Scoreboard can provide formative feedback to the student. By embracing Excel-based learning, Scoreboard helps students gain not only statistical knowledge but also a “transportable skill” (Velleman & Moore, 1996) applicable to future coursework and employment.

Scoreboard for Excel Mechanism and Examples

Scoreboard solves a practical problem: How can faculty provide a large workload of meaningful assignments while still offering timely, customized feedback? Faculty create an Excel “answer key” with data, formulas, pivot tables, graphs, multiple-choice questions, etc. Scoreboard converts this file into a self-grading version for students. Students complete the assignment directly in Excel and receive instant feedback. When a cell is correct, it turns green, and points are awarded. Incorrect entries turn pink, and formatting issues turn cells yellow, guiding students to correct their errors. A tutor-like environment is thus simulated.

Figure 1: Numerical Statistics Example



Example: Numerical Statistics

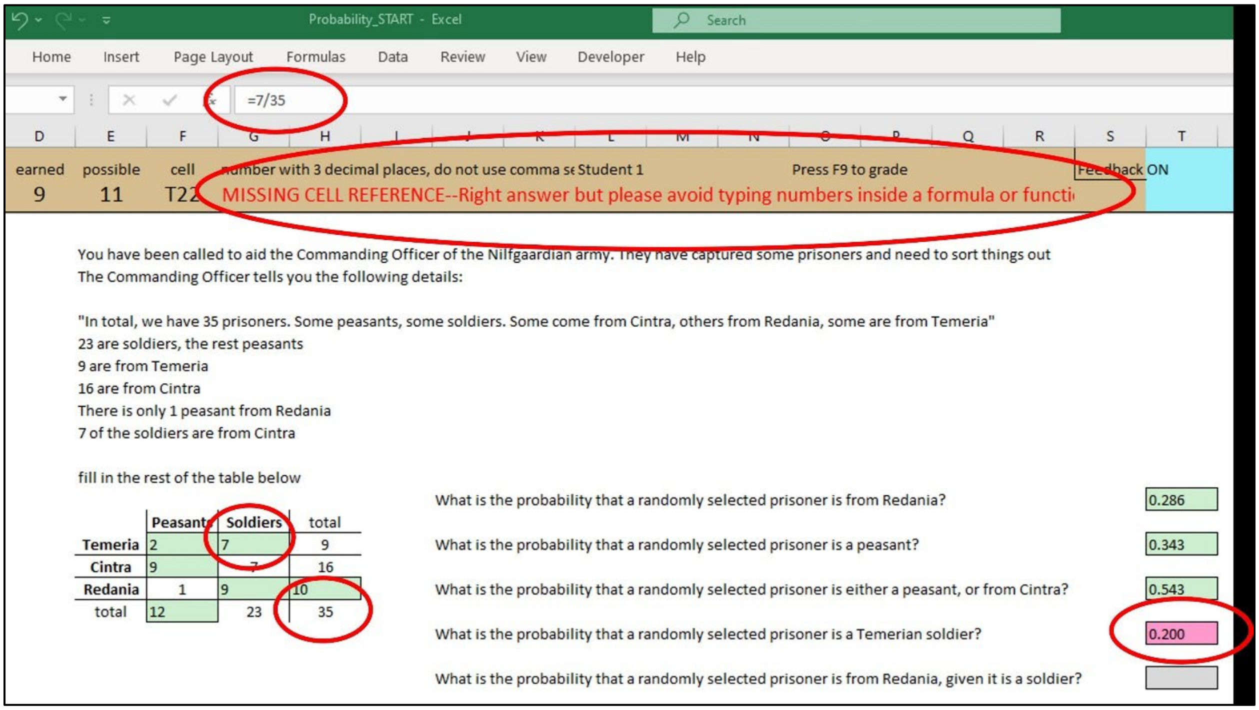
Imagine a scenario where students must calculate correlation coefficients. They are first taught to break down the formula step-by-step, computing sums of squared deviations, sample variances, and standard deviations manually. The assignment portion on the left takes the student through these steps, making use of formulas taught in class for mean, variance, standard deviation, covariance, and correlation. Seeing these cells turn green with each correct step is affirming. The second portion on the right emphasizes the use of Excel functions, which should match the answers obtained through the step-by-step route. If they err, the cell turns pink. A common example that is shown in Figure 1 is using the population variance function VAR.P instead of VAR.S. A subtle hint indicates the issue without revealing the correct function. This nudges students to recall the difference between population and sample formulas. Because Scoreboard randomizes data values and cell references, copying another student's solution is ineffective.

Example: Probability

In a probability assignment, students must identify simple events, joint events, and complements. Probability questions require the students to calculate simple probabilities, unions, intersections, and conditional probabilities. Linking the calculations to the table requires the student to deduce the empirical outcomes first and then construct the probability calculations. The error illustrated in Figure 2 showcases that typing in the numerical calculation is not accepted, forcing the student to select the values from their own created table. Points are awarded for calculations referencing cells in the table.

This cuts back on sharing answers. Faculty can also instruct Scoreboard to produce multiple variants of the questions.

Figure 2: Probability Example



Example: Confidence Interval

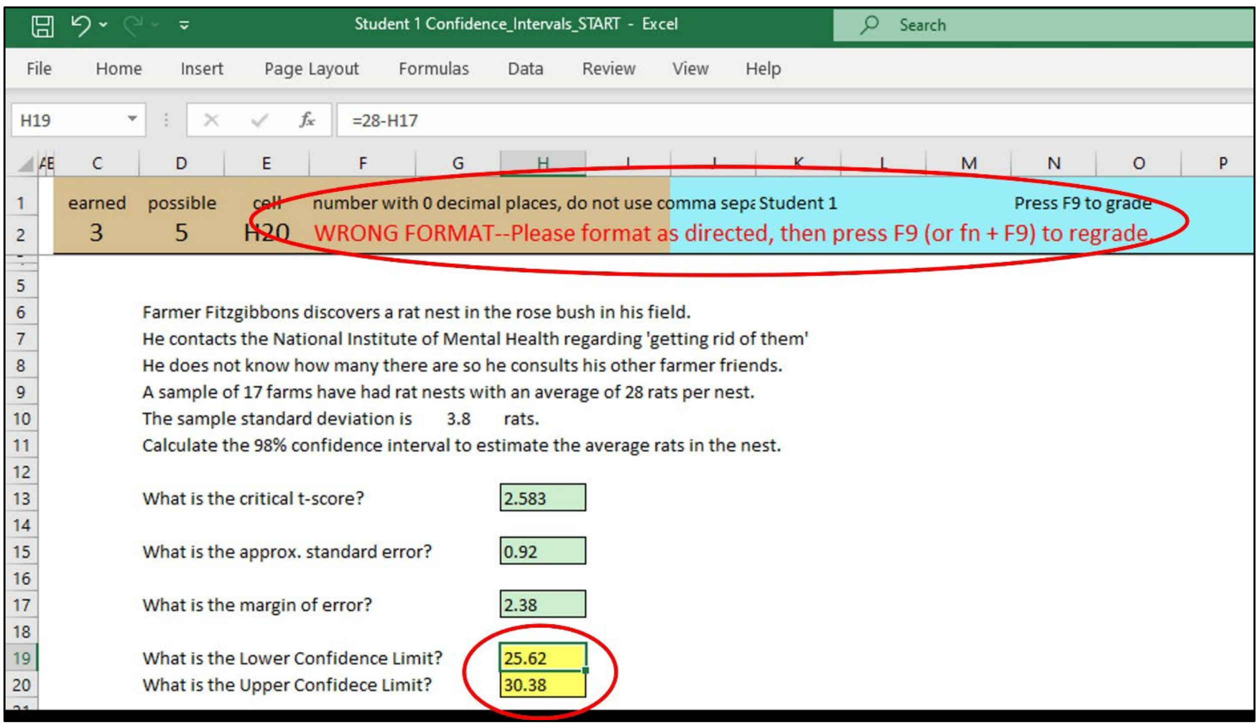
In a confidence interval assignment, students must use appropriate formulas to identify critical z-scores or t-scores, calculate approximate standard errors, and combine them to create the margin of error. The estimated confidence interval is then constructed using these components. Faculty have the flexibility to adjust the formatting such that the values are relevant to the interpretation of the question. The color and message in Figure 3 indicate that the calculation is correct, but the formatting does not match the intended outcome. The requested format is also displayed at the top so students can adjust their input. No points are awarded until this step is completed.

Example: Single Population Hypothesis Testing

For hypothesis tests, students must determine test type, tail direction, decision criteria, and interpret the conclusion. Figure 4 illustrates how Scoreboard makes use of pull-down menus and CONCAT functions to create an answer block consisting of steps 1, 2, 12, and 13. An answer block is like a parlay in betting where all items in an answer block must be correct at the same time before the answer block turns green. This prevents “guessing to green” from pull down menus. Instructors can increase assignment difficulty simply by adding more items to the answer block. This forces students to logically connect each step of the hypothesis testing process. Instead of revealing the final correct conclusion outright, Scoreboard encourages students to integrate their statistical reasoning skills, guiding them to identify test statistics, compare them to critical values or p-values, and interpret results in context.

These examples differ from publisher materials, which often provide feedback only after submission. With Scoreboard, each step is a learning opportunity. Assignments can reflect the instructor's style and desired level of rigor. Once completed, students upload their already graded files. Scoreboard runs through the submissions and creates a spreadsheet of grades.

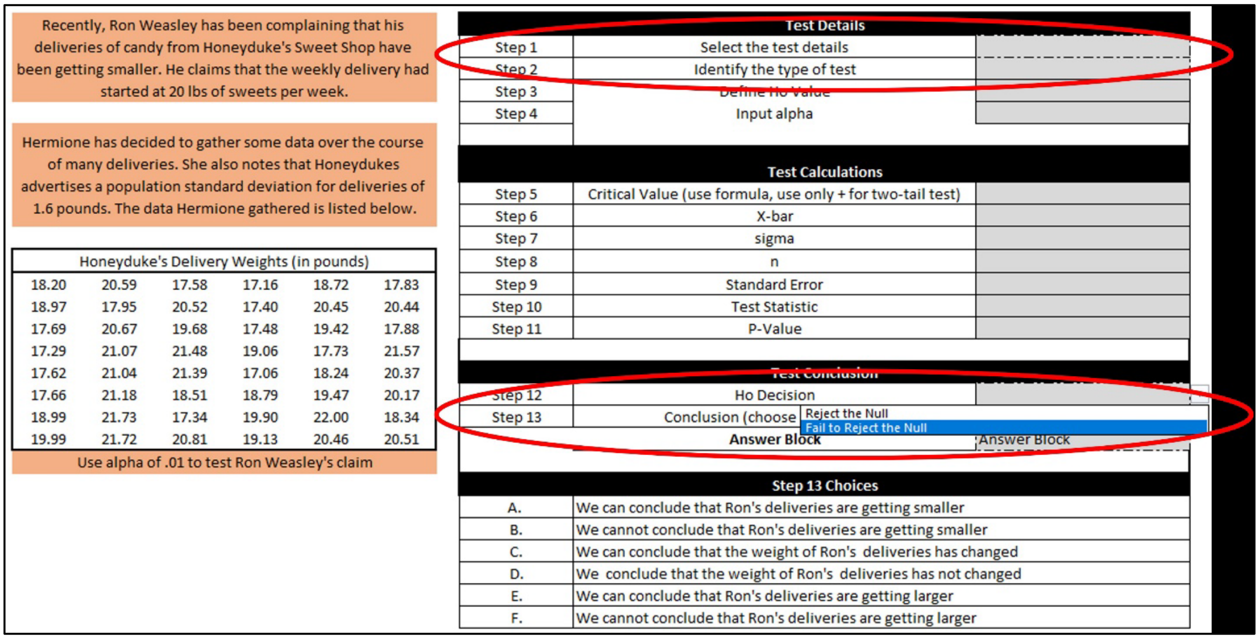
Figure 3: Confidence Interval Example



Data and Experiment Design

We conducted a study in Fall 2023 with three sections of an undergraduate business statistics course at a small Northeastern state college. The classes covered identical content, used the same textbook, and assigned homework through a publisher's companion website. The course requires a mathematics prerequisite, such as elementary probability and statistics, pre-calculus, or calculus. We surveyed students, finding that 77% took "Elementary Probability and Statistics" as their prerequisite.

Figure 4: Single Population Hypothesis Testing Example

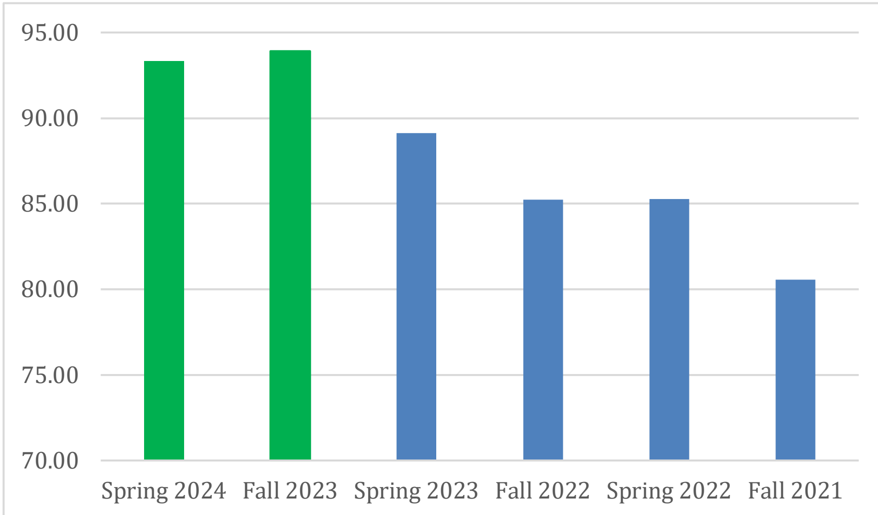


These courses were taught by two faculty members from the same department that coordinated the business statistics course in question. As a committee, the faculty work together to choose a text, course tools such as MyLab, and use a common syllabus. The two instructors have worked together teaching this same course for 15 years. In addition, one of the instructors was a student of the other when they were in college 20 years prior. The senior faculty member instructed the two control groups in the same fashion that has been upheld in the past; the other faculty member taught the section introducing the Scoreboard software. Considering the 15-year baseline of any differences in student performance, we are confident that the difference in the studied semester was due to the introduction of Scoreboard.

We also looked longitudinally at historic courses taught by the Scoreboard instructor. Figure 5 displays aggregate mean MyLab scores for six semesters taught by the instructor who used Scoreboard. Aggregate class averages increase with its introduction in Fall 2023 and a single-factor ANOVA test confirms the difference in means is significant. Summary statistics and ANOVA results are posted in Tables 1a and 1b in the appendix. Therefore, the difference in performance of the treatment group we believe is attributable to Scoreboard.

Treatment vs. Control*:* One section of 35 students (the Scoreboard class) integrated Scoreboard for Excel assignments throughout the semester. Two sections totaling 68 students served as the control group, taught traditionally. All sections completed publisher assignments as part of their grade.

Figure 5: Mean Overall MyLab Scores by Semester



Note: Mean performance scores are calculated by the authors. They represent the students taught by the instructor who introduced Scoreboard in the Fall 2023 semester. The semesters when Scoreboard is used have been colored green.

Instructional Differences*:* The Scoreboard class received the same theoretical instruction but focused practice sessions on Excel-based tasks. Students learned how to use Excel formulas, the data analysis toolpak, and other functionalities. Each chapter had a Scoreboard assignment tailored to that chapter's content, ensuring alignment with GAISE goals.

Performance Measurement*:* We used the publisher's companion site data as an objective measure of performance. Students completed assignments with algorithmic questions that varied slightly between students. We aggregated performance by topic, such as measures of central tendency, variability, distributions, and hypothesis testing. Survey responses provided additional insight into student backgrounds, attitudes, and perceived usefulness of the tool.

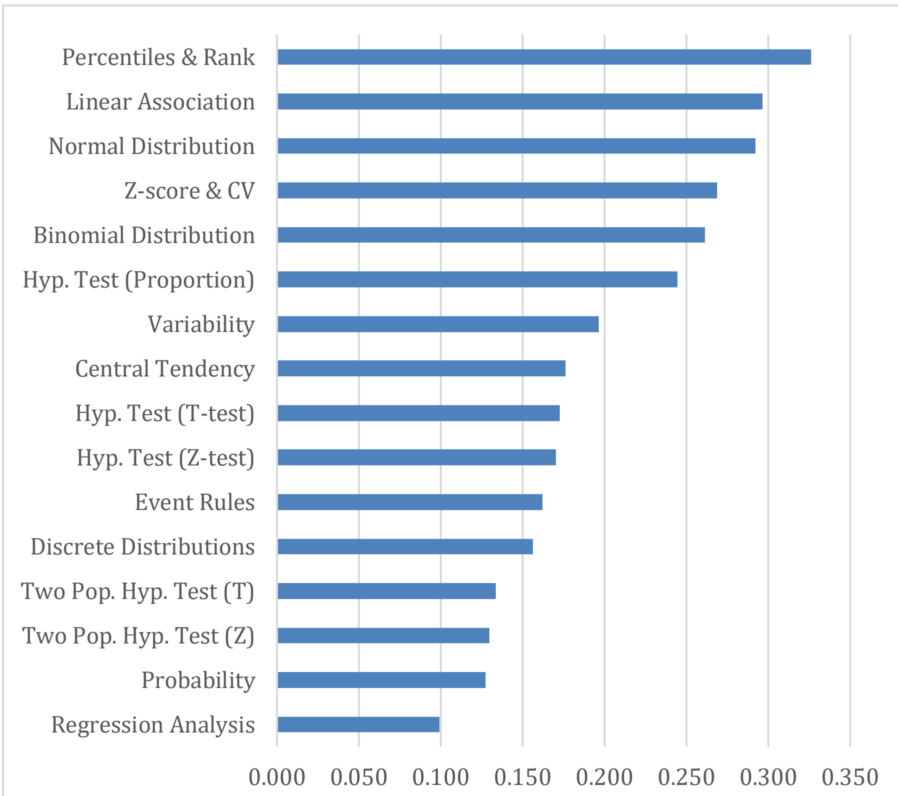
Sample Size*:* A total of 103 students participated. Approximately 68% completed the survey. Thirty-four percent reported familiarity with spreadsheet programs before enrolling.

Results and Discussion

Overall Performance Improvements

Figure 6 displays the difference in average performance scores between the Scoreboard class and the control group for all completed assignments. The results consistently favor the Scoreboard class. For instance, Scoreboard students outperformed by 17.6 percentage points on questions pertaining to central tendency (Cohen's d = 0.732). On questions about variability, Scoreboard students scored 19.7 percentage points higher (Cohen's d = 0.741), and they outscored the control group by 32.6 percentage points on questions about percentiles and rank (Cohen's d = 1.083). These substantial differences and effect sizes suggest that real-time feedback and guided practice improve comprehension, reducing calculation errors and enhancing conceptual understanding. See Table 2 in the appendix for more details.

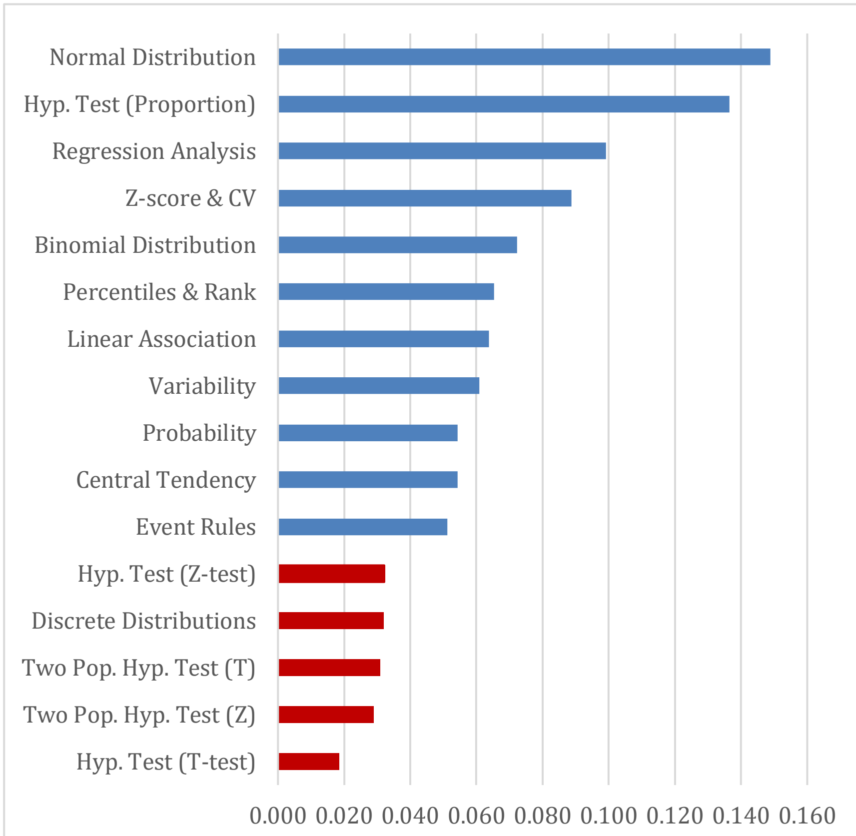
Figure 6: Difference in Mean Section Score: All Students



Note. Graphed values represent the difference between the mean MyLab section score from the Scoreboard section and the mean MyLab section score from the Control group. Scores are measured objectively on a scale of 0 to 1 where 1 represents 100% correct responses.
Two Pop. Hyp. Test (T) and Test (Z) are significant at the 5% level; Regression Analysis is significant at the 10% level; all others are significant at the 1% level. The corresponding Table 2 is located in the Appendix.

The benefit extends to probability distributions (binomial, normal) and hypothesis testing. For instance, the Scoreboard class significantly outperformed the control group on discrete probability distributions and normal distributions. The improved performance on hypothesis testing is particularly noteworthy, given its complexity. By simplifying calculations and providing immediate feedback, Scoreboard helps students focus on interpreting results rather than getting lost in computation.

Figure 7: Difference in Mean Section Score: Incompletes Omitted



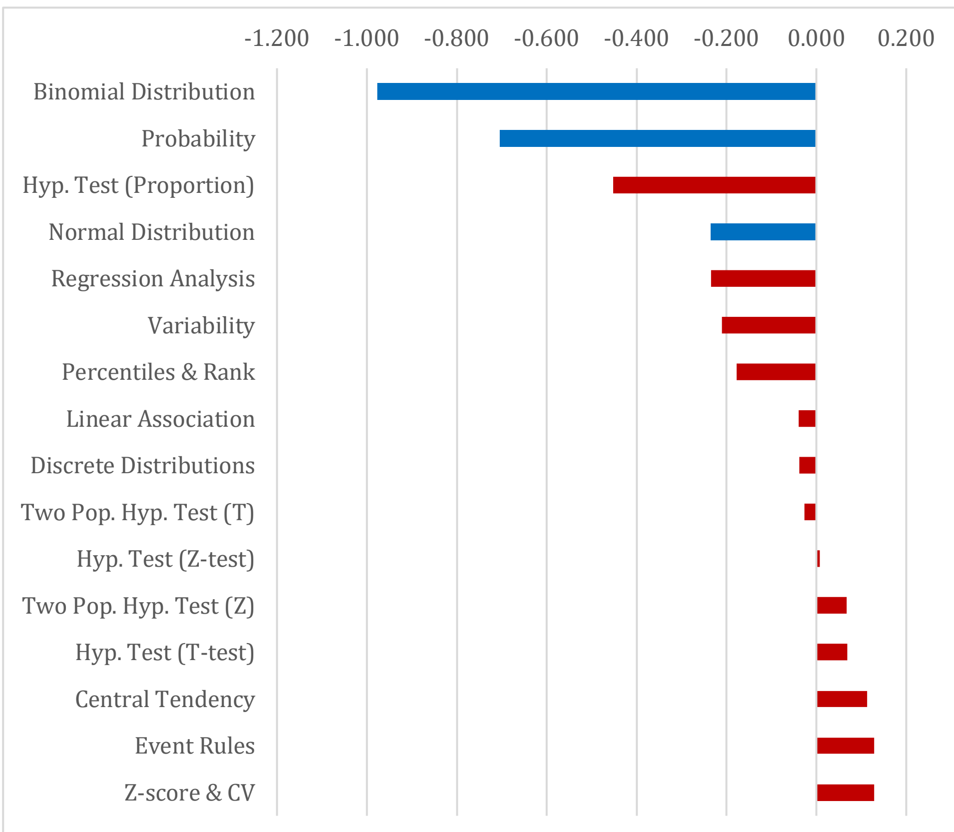
Note. Graphed values represent the difference between the mean MyLab section score from the Scoreboard section and the mean MyLab section score from the Control group. Scores are measured objectively on a scale of 0 to 1 where 1 represents 100% correct responses. Students who did not finish the assignment are omitted. The categories in red do not have any statistical significance. The blue categories are significant at the 1%, 5%, or 10% level.
The corresponding Table 3 is located in the Appendix.

Controlling for Completion and Attempts

Some students did not complete every assignment. Figure 7 focuses on those who finished their work. Many differences remain significant, indicating that the advantage is not merely due to completion rates. Omission of incomplete assignments does lower the effect size as measured by Cohen's d. Every significant difference does yield an effect size larger than the threshold of a small effect with some notable differences. Central tendency, percentile and rank, and hypothesis tests for the proportion have medium effect size values, while the normal distribution maintains a large effect. See Table 3 in the appendix for more details.

We also examined the average number of attempts per question to gauge efficiency. Figure 8 shows minor differences; Scoreboard students required fewer attempts in certain areas (e.g., Probability, Binomial and Normal Distribution), though not universally. The effect size for these significant differences is categorized as a medium effect for the binomial distribution, and a large effect for probability. Even when attempts did not drop, the quality of learning, measured by final accuracy, increased. See Table 4 in the appendix for more details.

Figure 8: Difference in Attempts by Section: Incomplete Assignments Omitted



Note. Graphed values represent the difference between the mean MyLab section attempt from the Scoreboard section and the mean MyLab section attempt from the Control group.
The categories in red do not have any statistical significance. The blue categories are significant at the 1%, 5%, or 10% level.
The corresponding Table 4 is located in the Appendix.

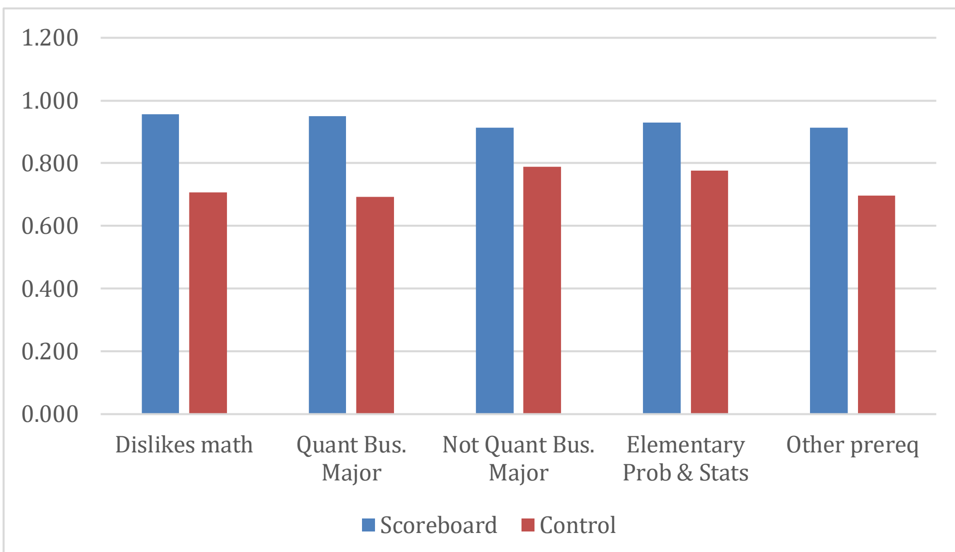
Performance Across Topics and Backgrounds

Breaking down performance by topical sections highlights the consistent advantage of Scoreboard-based learning. Students also outperformed in more advanced areas such as regression analysis, although significance levels slightly decreased as fewer students completed late-semester assignments.

Survey Results and Student Feedback

We administered an end-of-semester survey to gather qualitative feedback. Institutional Review Board approval was obtained for this survey. Figure 9 displays the summary findings. Of 103 students, 70 responded: 32 from the Scoreboard class (91.43% response rate) and 38 from the control group (55.88% response rate). The higher response rate suggests greater engagement in the Scoreboard class.

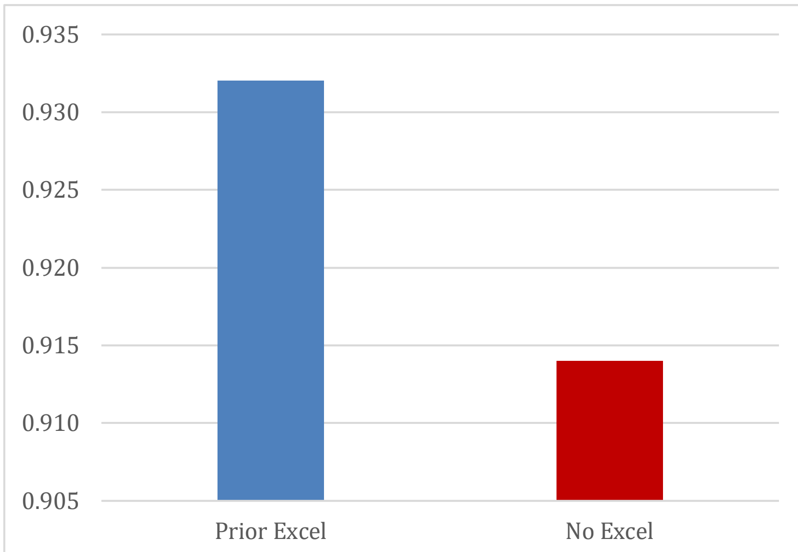
Figure 9: Summary of Assignment Performance by Survey Responses



Note. The corresponding Table 5 is located in the Appendix

Students who disliked math but learned with Scoreboard still performed significantly better, by about 25 percentage points, than similar students in the control group. Students with previous exposure to introductory statistics also benefited more in the Scoreboard section, scoring 93% compared to 77.7% in the control group. Both quantitative and non-quantitative majors in the Scoreboard class outperformed their counterparts.

Figure 10: Assignment Score by Excel Familiarity: Scoreboard Section



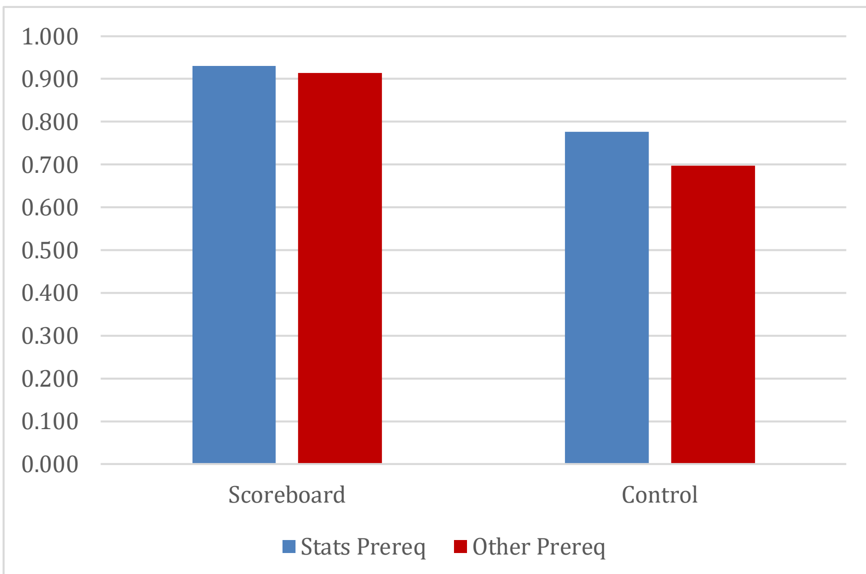
Note. The blue bar represents the overall MyLab assignment average for students in the Scoreboard group who disclosed that they had prior familiarity with Excel. The red bar represents students from the Scoreboard group who claimed no prior familiarity with Excel. The difference is statistically insignificant at all levels.
The corresponding Table 6 is located in the Appendix.

We included a question in the Scoreboard class's survey to gauge prior familiarity in Excel. Out of the 32 respondents, 24 claimed to have familiarity with Excel. This group's MyLab average score was 93.2%. The group of students who were not familiar had an average MyLab score of 91.4%. Figure 10 displays these means. A test for difference in means indicates the means are not uniquely different.

Lastly, we compare subsets of students based on their prior knowledge. Figure 11 highlights the overall average MyLab score for students who stated they previously enrolled in the elementary statistics prerequisite and for students who disclosed they enrolled in a different prerequisite. We display these averages for both the Scoreboard and Control groups. A simple test for the difference in means suggests there is no significant difference based on prerequisite in either group.

Figure 12 displays the difference in performance for individual topic sections in the Scoreboard group compared to the Control group. Only students who enrolled in the elementary statistics prerequisite course are considered. Even those previously exposed to statistics improved with Scoreboard, suggesting that prior course completion alone does not guarantee mastery, but active, feedback-rich practice does. The subjects with significant differences maintain effect size values above the low effect threshold. Central tendency, percentile and rank, probability, and hypothesis tests for the proportion all have Cohen's d values considered as medium effect; the normal distribution subject still maintains a large effect. See Table 8 in the appendix for more details.

Figure 11: Assignment Performance by Prerequisite: Section Comparison



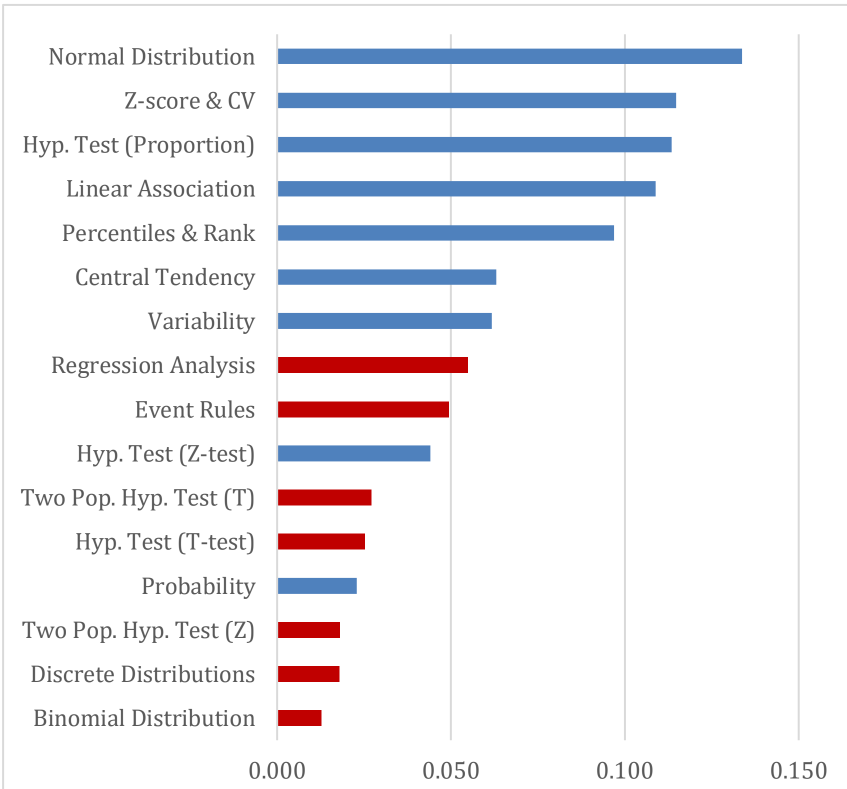
Note. Blue bars represent the overall MyLab assignment average for students who disclosed that they took the elementary statistics prerequisite. Red bars represent students who took a different prerequisite. The difference is statistically insignificant for both course groups.
The corresponding Table 7 is located in the Appendix.

Open-ended survey comments reinforce that students found Scoreboard helpful. Some called it a "great learning tool," while others recognized the importance of Excel proficiency for business students. A few found it challenging, reflecting normal variation in learning styles, but overall responses were positive.

Broadening the Scope: Applications Beyond Statistics

While our study focused on business statistics, Scoreboard's principles and approach are transferable. Any quantitative domain, such as accounting and finance to economics and operations management, can benefit. In accounting, for instance, Scoreboard can guide students through adjusting journal entries, highlighting formatting or calculation issues and prompting them to learn from mistakes (Sasmaz, et al., 2025). In finance, assignments might involve computing various investment metrics or analyzing financial statements, with immediate feedback ensuring that students understand not only how to run calculations but also how to interpret results meaningfully.

Figure 12: Difference in Assignment Performance: Stats Prerequisite



Note. Graphed values represent the difference between the mean MyLab section score from the Scoreboard section and the mean MyLab section score from the Control group. Only students who disclosed that they took the elementary statistics prerequisite are considered.
The categories in red are not statistically significance. The blue categories are significant at the 1%, 5%, or 10% level.
The corresponding Table 8 is located in the Appendix.

Because Excel remains ubiquitous in professional settings, developing these skills in an educational environment where feedback is immediate prepares students more effectively for the workforce. As hiring managers consistently value Excel proficiency, Scoreboard helps bridge the gap between academic exercises and professional analytical tasks. This approach can enrich internship readiness, job market competitiveness, and long-term professional development.

Future Directions and Limitations

Several avenues for future research and development arise from this study. One direction is exploring the long-term retention of material. While Scoreboard improves immediate performance, do students remember these concepts a semester or a year later? Another area involves adaptive complexity. Faculty can design assignments using Scoreboard that reduce scaffolding as students demonstrate mastery. Similarly, faculty might experiment with varying feedback intensity or delaying certain hints to encourage deeper reasoning.

There is also the question of scaling. For larger courses or cross-institutional collaborations, could Scoreboard files be shared, adapted, and improved upon by multiple instructors? A community of practitioners could emerge, exchanging best practices and innovative assignment designs. Additionally, investigating how Scoreboard interacts with different learning styles, or how it may benefit students with varying levels of technological fluency, would provide valuable insights. Students struggling with Excel basics may initially need more explicit scaffolding, while advanced users may appreciate more open-ended tasks.

We also acknowledge certain limitations. The study took place at one institution with a relatively small sample size, focusing on one semester and one particular course context. Further replication across different institutions, student populations, and course formats would strengthen the case for generalizability. Moreover, while we observed positive student feedback and engagement, more detailed qualitative research, such as focus groups or interviews, could reveal nuanced insights into how students experience Scoreboard and which features they find most beneficial.

Conclusion

This study demonstrates that integrating Scoreboard for Excel in an undergraduate business statistics course leads to significant improvements in student performance, engagement, and overall learning quality. By aligning with the GAISE recommendations of fostering active learning, using technology to deepen conceptual understanding, and employing assessments as tools for learning improvement, Scoreboard transforms assignments from static tasks into interactive, feedback-rich experiences.

Students using Scoreboard performed notably better in fundamental and advanced statistical topics. They received immediate, formative feedback that guided them to correct errors in real time, strengthening their understanding and reducing guesswork. Survey data indicated that students valued this approach, found it engaging, and saw its utility beyond the classroom. Faculty benefited from customizable assignments, automated grading, and robust academic integrity controls, freeing them from tedious tasks and allowing them to focus on teaching excellence.

Scoreboard is not limited to statistics. Its flexibility and principles apply broadly, potentially raising the bar for technology integration and active learning in various quantitative disciplines. As data literacy becomes increasingly important, equipping students with both conceptual knowledge and practical tool proficiency positions them for success in their academic and professional journeys.

In essence, Scoreboard for Excel offers a way to systematically incorporate GAISE-aligned practices into the heart of course assignments. By doing so, it helps bridge the gap between theoretical ideals and practical classroom realities, ultimately fostering a learning environment where students become more confident, skilled, and engaged analysts of data.

References

Al-Haddad, S., Chick, N., & Safi, F. (2024). Teaching statistics: A technology-enhanced supportive instruction (TSI) model during the Covid-19 pandemic and beyond. *Journal of Statistics and Data Science Education*, *32*(2), 129-142.

Bell, P. C. (2000). Teaching business statistics with Microsoft Excel. *INFORMS Transactions on Education*, *1*(1), 18-26.

Burckhardt, P., Nugent, R., & Genovese, C. R. (2021). Teaching statistical concepts and modern data analysis with a computing-integrated learning environment. *Journal of Statistics and Data Science Education*, *29*(1), 61-73.

Carver, R., Everson, M., Gabrosek, J., Horton, N., Lock, R., Mocko, M., ... Wood, B. (2016). *Guidelines for assessment and instruction in statistics education (GAISE) college report 2016*.

Convery, S. P. (2012). Analyzing business issues—With Excel: The case of Superior Log Cabins, Inc. *Issues in Accounting Education*, *27*(1), 141-156.

Cornock, C. (2016). Teaching mathematics to business and enterprise students in a module based around Excel. *MSOR Connections*, *15*(1), 22-27.

Corredor, J. A. (2008). *Learning statistical inference through computer-supported simulation and data analysis* [Doctoral dissertation, University of Pittsburgh].

Creighton, W. K. (2006). Computer literacy levels of students enrolling in a post-secondary computer applications/information technology course. *Information Technology, Learning & Performance Journal*, *24*(1).

Dobson, I. (2024, January 14). *20 must-have Excel skills for professionals in 2024*. One Education. https://www.oneeducation.org.uk/must-have-excel-skills-for-professionals/

Epstein, M. L., Epstein, B. B., & Brosvic, G. M. (2001). Immediate feedback during academic testing. *Psychological Reports*, *88*(3), 889-894.

Erfle, S. (2001). Excel as a teaching platform for managerial economics. *Social Science Computer Review*, *19*(4), 480-486.

Formby, S. K., Medlin, B. D., & Ellington, V. (2017). Microsoft Excel®: Is it an important job skill for college graduates? *Information Systems Education Journal*, *15*(3).

Garfield, J. (1995). How students learn statistics. *International Statistical Review*, *63*(1), 25-34.

Garfield, J., & Ben-Zvi, D. (2007). How students learn statistics revisited: A current review of research on teaching and learning statistics. *International Statistical Review*, *75*(3), 372-396.

Hakeem, S. A. (2001). Effect of experiential learning in business statistics. *Journal of Education for Business*, *77*(2), 95-98.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, *77*(1), 81-112.

Jamie, D. M. (2002). Using computer simulation methods to teach statistics: A review of the literature. *Journal of Statistics Education*, *10*(1).

Kusumadyahdewi, & Kusumarasdyati. (2021). Learners' perceptions about TikTok tutorial videos as instructional media in learning statistics. *Letters in Information Technology Education*, *4*(2), 80-85.

Lee, C. B., Tank, H., Sam, K. M., & Xiong, G. (2018). Spreadsheet proficiency: Which spreadsheet skills are important? *Journal of Information Technology Management*, *29*(3), 35-44.

Lee, J. J., Kang, G., & Han, K. S. (2002). Computer aided teaching for statistics in internet age. *Computational Statistics*, *17*(3), 355-365.

Liang, J., & Martin, L. (2008). An Excel-aided method for teaching calculus-based business mathematics. *College Teaching Methods & Styles Journal*, *4*(11), 11-24.

McCloskey, D. W., & Bussom, L. (2013). Active learning and student engagement in the business curriculum: Excel can be the answer. *Journal of Learning in Higher Education*, *9*(2), 1-12.

Moore, D. S. (1997). New pedagogy and new content: The case of statistics. *International Statistical Review*, *65*(2), 123-137.

Palocsay, S. W., Markham, I. S., & Markham, S. E. (2010). Utilizing and teaching data tools in Excel for exploratory analysis. *Journal of Business Research*, *63*, 191-206.

Ragland, L., & Ramachandran, U. (2014). Towards an understanding of Excel functional skills needed for a career in public accounting: Perceptions from public accountants and accounting students. *Journal of Accounting Education*, *32*(2), 113-129.

Reyneke, F., Fletcher, L., & Harding, A. (2021). Enhancing a flipped statistics first year course by using QT-clickers. *Journal of Statistics and Data Science Education*, *29*(1), 71-83.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68-78.

Sasmaz, M., Frost, R., Gordon, E., Kenyo, L., Matta, V., & Raisch, M. (2025). Scoreboard for Excel: The design and implementation of software to advance active learning, automate grading, and reduce cheating. *Issues in Accounting Education*.

Soesmanto, T., & Bonner, S. (2019). Dual mode delivery in an introductory statistics course: Design and evaluation. *Journal of Statistics Education*, *27*(2), 90-98.

University of Reading. (n.d.). *Excel skills*. Gaining Experience. https://www.reading.ac.uk/essentials/Careers/Gaining-experience/Excel-skills

Variyath, A. M., & Nadarajah, T. (2022). Improving the students' learning process through the use of statistical applets. *Teaching Statistics*, *44*(1), 5-14.

Velleman, P. F., & Moore, D. S. (1996). Multimedia for teaching statistics: Promises and pitfalls. *The American Statistician*, *50*(3), 217-225.

Vygotsky, L. S., & Cole, M. (1978). *Mind in society: Development of higher psychological processes*. Harvard University Press.

Willis, V. F. (2016). A model for teaching technology: Using Excel in an accounting information systems course. *Journal of Accounting Education*, *36*, 87-99.

Zhang, C. (2014). Incorporating powerful Excel tools into finance teaching. *Journal of Financial Education*, *40*(3-4), 87-113.

Appendix: Tables 1-8

Table 1a

Summary Statistics by Semester

Statistic	Spring 2024	Fall 2023	Spring 2023	Fall 2022	Spring 2022	Fall 2021
n	67	35	34	71	70	72
M	93.32	93.91	89.13	85.22	85.26	80.58
Mdn	98.59	94.67	94.73	94.10	91.98	87.46
SD	10.26	6.91	17.64	19.42	22.57	20.88

Note. These mean performance scores represent the students taught by the instructor who introduced Scoreboard in the Fall 2023 semester. This table displays population standard deviations since the entire class was utilized for each semester.

Table 1b

Single Factor ANOVA

Source	*SS*	*df*	*MS*	*F*	*P*	*F crit*
Between	8806.957	5	1761.391	5.077964	0.000166	2.240228
Within	119323.2	344	346.8696			
Total	128130.1	349				

Table 2

Assignment Performance by Section: All Students

Course Section	SCOREBOARD			CONTROL			Difference			
	n	*M*	*SD*	n	*M*	*SD*	*M*	*SE*	*p*	*d*
Central Tendency	35	0.993	0.042	68	0.817	0.338	0.176	0.057	0.001***	0.732
Variability	35	0.983	0.069	68	0.787	0.369	0.197	0.063	0.001***	0.741
Z-score & CV	35	0.939	0.177	68	0.671	0.402	0.269	0.071	0.000***	0.866
Percentiles & Rank	35	0.975	0.069	68	0.649	0.420	0.326	0.072	0.000***	1.083
Linear Association	35	0.929	0.134	68	0.632	0.438	0.296	0.076	0.000***	0.914
Probability	35	0.998	0.014	68	0.870	0.303	0.128	0.051	0.007***	0.595
Event Rules	35	0.930	0.102	68	0.768	0.321	0.162	0.056	0.002***	0.680
Discrete Distributions	35	0.929	0.151	68	0.772	0.337	0.156	0.060	0.005***	0.598
Binomial Distribution	35	0.934	0.195	68	0.673	0.410	0.261	0.073	0.000***	0.813
Normal Distribution	35	0.989	0.036	68	0.697	0.351	0.292	0.060	0.000***	1.169
Hyp. Test (Z-test)	35	0.930	0.102	68	0.759	0.349	0.170	0.060	0.003***	0.662
Hyp. Test (T-test)	35	0.832	0.246	68	0.659	0.377	0.173	0.071	0.008***	0.542
Hyp. Test (Proportion)	35	0.844	0.284	68	0.600	0.378	0.244	0.073	0.001***	0.732
Two Pop. Hyp. Test (Z)	35	0.848	0.271	68	0.718	0.393	0.130	0.074	0.042**	0.384
Two Pop. Hyp. Test (T)	35	0.765	0.298	68	0.632	0.398	0.133	0.076	0.042**	0.380
Regression Analysis	19	0.900	0.164	45	0.801	0.300	0.099	0.073	0.091*	0.410

Note. *, **, *** indicate significance at the 10%, 5%, and 1% levels

Table 3

Assignment Performance by Section: Incomplete Assignments Omitted

Course Section	SCOREBOARD			CONTROL			Difference			
	n	*M*	*SD*	n	*M*	*SD*	*M*	*SE*	*p*	*d*
Central Tendency	35	0.993	0.042	60	0.939	0.144	0.054	0.025	0.016**	0.512
Variability	35	0.983	0.069	58	0.922	0.180	0.061	0.032	0.029**	0.447
Z-score & CV	35	0.939	0.177	54	0.851	0.224	0.089	0.045	0.026**	0.440
Percentiles & Rank	35	0.975	0.069	50	0.910	0.144	0.065	0.026	0.007***	0.580
Linear Association	35	0.929	0.134	51	0.865	0.259	0.064	0.048	0.093*	0.308
Probability	35	0.998	0.014	63	0.943	0.164	0.054	0.028	0.027**	0.466
Event Rules	35	0.930	0.102	61	0.879	0.162	0.051	0.030	0.047**	0.378
Discrete Distributions	35	0.929	0.151	60	0.897	0.152	0.032	0.032	0.163	0.211
Binomial Distribution	35	0.934	0.195	55	0.862	0.237	0.072	0.048	0.068*	0.333
Normal Distribution	35	0.989	0.036	62	0.840	0.211	0.149	0.036	0.000***	0.983
Hyp. Test (Z-test)	35	0.930	0.102	58	0.897	0.138	0.032	0.027	0.118	0.264
Hyp. Test (T-test)	35	0.832	0.246	57	0.813	0.183	0.018	0.045	0.341	0.085
Hyp. Test (Proportion)	33	0.895	0.195	56	0.759	0.258	0.137	0.052	0.005***	0.597
Two Pop. Hyp. Test (Z)	34	0.873	0.231	57	0.844	0.243	0.029	0.052	0.288	0.122
Two Pop. Hyp. Test (T)	32	0.837	0.188	55	0.806	0.249	0.031	0.051	0.273	0.140
Regression Analysis	19	0.900	0.164	45	0.801	0.300	0.099	0.073	0.091*	0.410

Note. *, **, *** indicate significance at the 10%, 5%, and 1% levels

Table 4

Attempts by Section: Incomplete Assignments Omitted

Course Section	SCOREBOARD			CONTROL			Difference			
	n	*M*	*SD*	n	*M*	*SD*	*M*	*SE*	*p*	*d*
Central Tendency	35	1.471	0.606	60	1.358	0.471	0.114	0.112	0.311	-0.209
Variability	35	1.343	0.684	58	1.554	0.818	-0.211	0.165	0.205	0.279
Z-score & CV	35	1.571	1.112	54	1.443	0.443	0.129	0.169	0.448	-0.152
Percentiles & Rank	35	1.447	0.950	50	1.624	0.748	-0.177	0.184	0.339	0.207
Linear Association	35	1.400	0.736	51	1.439	0.526	-0.039	0.136	0.776	0.061
Probability	35	1.371	0.587	63	2.075	0.872	-0.704	0.165	0.000***	0.947
Event Rules	35	1.750	0.600	61	1.622	0.615	0.128	0.129	0.323	-0.211
Discrete Distributions	35	1.857	1.287	60	1.895	1.295	-0.038	0.275	0.890	0.030
Binomial Distribution	35	1.143	1.309	55	2.119	1.906	-0.976	0.368	0.009***	0.597
Normal Distribution	35	1.357	0.589	62	1.592	0.652	-0.235	0.133	0.081*	0.378
Hyp. Test (Z-test)	35	1.762	0.731	58	1.755	0.750	0.007	0.159	0.964	-0.010
Hyp. Test (T-test)	35	1.714	0.972	57	1.646	0.721	0.068	0.177	0.701	-0.080
Hyp. Test (Proportion)	33	1.743	1.502	56	2.195	1.332	-0.452	0.307	0.144	0.318
Two Pop. Hyp. Test (Z)	34	1.912	1.422	57	1.844	1.101	0.068	0.266	0.799	-0.053
Two Pop. Hyp. Test (T)	32	1.609	1.014	55	1.636	0.662	-0.026	0.180	0.884	0.031
Regression Analysis	19	1.457	1.540	45	1.691	0.674	-0.235	0.275	0.397	0.197

Note. *, **, *** indicate significance at the 10%, 5%, and 1% levels

Table 5

Summary of Assignment Performance by Survey Responses

Survey Feedback	SCOREBOARD			CONTROL		
	n	*M*	*SD*	*n*	*M*	*SD*
Dislikes math	8	0.957	0.040	16	0.706	0.219
Quant Bus. Major	13	0.949	0.061	14	0.693	0.244
Not Quant Bus. Major	19	0.913	0.077	24	0.789	0.201
Elementary Prob & Stats	27	0.930	0.072	27	0.777	0.207
Other prereq	5	0.914	0.077	11	0.697	0.248

Table 6

Assignment Score by Excel Familiarity: Scoreboard Section

Student Group	n	*M*	*SE*	*p*
Prior Excel	24	0.932	0.028	
No Excel	8	0.914	0.014	
Difference		0.018	0.030	0.532

Note. *, **, *** indicate significance at the 10%, 5%, and 1% levels

Table 7

Assignment Performance by Prerequisite: Section Comparison

Course Section	Stats Prereq			Other Prereq			Difference		
	n	*M*	*SD*	n	*M*	*SD*	M	*SE*	*p*
Scoreboard	27	0.930	0.014	5	0.914	0.035	0.016	0.036	0.646
Control	27	0.777	0.039	11	0.697	0.075	0.079	0.078	0.318

Note. *, **, *** indicate significance at the 10%, 5%, and 1% levels

Table 8

Assignment Performance by Section: Stats Prerequisite

Course Section	SCOREBOARD			CONTROL			Difference			
	n	*M*	*SD*	n	*M*	*SD*	*M*	*SE*	*p*	*d*
Central Tendency	27	0.991	0.048	25	0.928	0.169	0.063	0.034	0.035**	0.506
Variability	27	0.978	0.079	24	0.917	0.170	0.062	0.036	0.048**	0.465
Z-score & CV	27	0.921	0.199	23	0.807	0.301	0.115	0.071	0.057*	0.450
Percentiles & Rank	27	0.968	0.077	22	0.871	0.177	0.097	0.038	0.007***	0.710
Linear Association	27	0.932	0.131	22	0.823	0.294	0.109	0.063	0.045**	0.478
Probability	27	0.997	0.016	25	0.974	0.050	0.023	0.010	0.014**	0.614
Event Rules	27	0.917	0.111	25	0.867	0.173	0.049	0.040	0.111	0.340
Discrete Distributions	27	0.917	0.165	25	0.899	0.156	0.018	0.045	0.345	0.111
Binomial Distribution	27	0.924	0.217	23	0.911	0.178	0.013	0.057	0.411	0.064
Normal Distribution	27	0.991	0.033	26	0.857	0.200	0.134	0.039	0.001***	0.933
Hyp. Test (Z-test)	27	0.938	0.091	26	0.894	0.149	0.044	0.034	0.099*	0.356
Hyp. Test (T-test)	27	0.862	0.209	26	0.836	0.189	0.025	0.055	0.323	0.127
Hyp. Test (Proportion)	27	0.887	0.204	26	0.774	0.246	0.113	0.062	0.037**	0.502
Two Pop. Hyp. Test (Z)	26	0.888	0.202	26	0.870	0.251	0.018	0.063	0.389	0.079
Two Pop. Hyp. Test (T)	25	0.852	0.200	25	0.825	0.212	0.027	0.058	0.322	0.132
Regression Analysis	16	0.885	0.175	20	0.831	0.287	0.055	0.082	0.254	0.230

Note. *, **, *** indicate significance at the 10%, 5%, and 1% levels