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Developed Spreadsheet-based System for Statistical Analysis of Grade 12 Learners

Miguel P. Salvador
Teacher III, Department of Education – Cordillera Administrative Region, Schools Division Office of Tabuk City, Tabuk City National High School, Tabuk City, Kalinga, Philippines

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Email of Author: miguelsalvador022@gmail.com

Abstract

This study examined the effectiveness of a developed spreadsheet-based system in improving the statistical analysis skills of Grade 12 learners at Tabuk City National High School. Anchored on Piaget's constructivist theory, the study investigated whether a spreadsheet-based learning environment could enhance learners' ability to compute, organize, interpret, and present statistical data. A true-experimental pretest-posttest control group design was employed involving 172 Grade 12 learners enrolled in Practical Research 2 from the Home Economics and Accountancy, Business, and Management strands. Researcher-developed pretest and posttest instruments were used to assess statistical analysis proficiency, and data were analyzed using descriptive and inferential statistics. Findings revealed that both Microsoft Excel add-ins and the developed spreadsheet-based system significantly improved learners' statistical analysis performance. The Microsoft Excel add-ins group improved from a mean score of 15.77 to 85.01, while the developed spreadsheet-based system group improved from 14.15 to 90.13. Statistical tests confirmed significant differences between pretest and posttest scores in both groups. Moreover, the developed spreadsheet-based system demonstrated significantly higher posttest performance than Microsoft Excel add-ins, indicating greater effectiveness in supporting statistical computations, data organization, and presentation. The results suggest that customized spreadsheet-based technologies can effectively address learners' difficulties in statistical analysis and strengthen research-related competencies. The study concludes that integrating accessible and user-friendly digital tools into research instruction can substantially improve learners' statistical analysis skills. It recommends the adoption and continuous enhancement of spreadsheet-based instructional technologies to support statistics and research education. This study supports Sustainable Development Goal (SDG) 4: Quality Education and SDG 9: Industry, Innovation and Infrastructure by promoting innovative and accessible technologies that enhance learning outcomes. Its sustainability contribution lies in strengthening educational practices, improving digital learning opportunities, and providing cost-effective tools that support research competence among learners, particularly in resource-constrained settings.

Keywords: Constructivist Theory; Microsoft Excel Add-ins; Spreadsheet-Based System; Statistical Analysis; Statistical Competence; Technology Integration; True-Experimental Design

1. Introduction

Statistical analysis is essential in transforming quantitative data into meaningful conclusions and supporting evidence-based decision-making in education and other fields. Despite its importance, many learners encounter difficulties in understanding statistical concepts and computations, resulting in weak performance in research-related tasks. This study examines the effectiveness of a developed spreadsheet-based system in improving the statistical analysis skills of Grade 12 learners at Tabuk City National High School.

1.1 Background of the Study

Statistics is widely utilized in education, healthcare, economics, and other disciplines to analyze data and support decision-making processes (Burrill, 2020; Sirisilla, 2023). In educational settings, it guides data gathering, analysis, interpretation, policy formulation, and instructional improvement (Jain, 2023). However, learners frequently struggle with the mathematical foundations required for statistical analysis, including algebra, probability, and computation procedures (Kurniawan & Wahyuningsih, 2018). Difficult calculations, formula application, time constraints, and inadequate learning experiences further contribute to these challenges (Ramadoni & Hafiz, 2022). Similar concerns were identified by Felix et al. (2024), who reported limited mathematical competence, insufficient statistical knowledge, and weak research skills among students. These issues highlight the need for interventions, improved learning resources, and innovative tools that can strengthen students' statistical competencies and support their academic success.

1.2 Themes and Insights from Related Literature

Research consistently shows that students experience difficulties in learning statistics and applying statistical methods in research. Poor retention and low understanding of statistical concepts remain common concerns among learners (Dumale & Gurat, 2023; Obrial and Lapinid, 2020). Studies also indicate that spreadsheet-based learning environments improve learners' engagement, comprehension, and confidence in quantitative tasks. Spreadsheets provide immediate feedback, support active learning, and simplify statistical procedures (Ozkale & Ozdemir Erdogan, 2023). They have been shown to positively influence learners' knowledge, attitudes, and performance while reducing anxiety associated with statistical computations (Rafter, 2019). Furthermore, learners often prefer spreadsheet-based approaches due to their accessibility and analytical capabilities (Dania & Posey, 2012).

1.3 Local, National, and Global Context

Globally, concerns regarding mathematics and statistics education persist. Findings from OECD (2023) revealed declining or stagnant student performance in mathematics and related competencies across many participating countries, emphasizing the need for improved instructional approaches. Nationally, research writing is a requirement across various educational levels in the Philippines, increasing the demand for accessible statistical tools and applications (Quinto, 2022). Many students resort to hiring statisticians or purchasing statistical software, creating financial challenges, particularly for those in rural communities. At the local level, Tabuk City National High School has identified statistical analysis as one of the least learned competencies from 2021–2024 based on School Monitoring, Evaluation, and Adjustment (SMEA) reports. Despite research-related trainings and instructional support, difficulties in statistical analysis continue to affect both learners and teachers. Obrial and Lapinid (2020) likewise reported low levels of statistical understanding among students and insufficient instructional scaffolding during data analysis activities.

1.4 Theoretical or Conceptual Basis

This study is anchored on Jean Piaget's constructivist theory, which emphasizes that learners actively construct knowledge through interaction and exploration rather than passive reception of information (McLeod, 2024; Early Years TV, 2024). Consistent with this perspective, spreadsheet-based systems promote active engagement by allowing learners to manipulate datasets, perform statistical computations, and interpret outputs in real time. Such environments support experiential learning and enhance conceptual understanding of statistical procedures (Ozkale & Ozdemir Erdogan, 2023). Microsoft Excel serves as a widely accessible platform for organizing, analyzing, and managing data (French, 2020). Spreadsheet-based systems developed within Excel provide opportunities to automate computations, simplify procedures, and support learning through interactive and structured environments.

1.5 Research Gaps and Rationale

Although several statistical software packages such as MATLAB, Minitab, SAS, R, and SPSS provide advanced analytical functions, their licensing requirements may limit accessibility for students. Spreadsheet-based systems offer a practical alternative because they are widely available, relatively easy to use, and adaptable to different educational contexts (Michelle & Ahuja, 2018). Existing studies support the educational value of spreadsheets; however, persistent difficulties in statistical analysis remain evident among Grade 12 learners at Tabuk City National High School. Students continue to struggle with computations, data organization, interpretation, and formatting requirements, while teachers face challenges in providing sufficient statistical guidance. To address these concerns, this study proposes a developed spreadsheet-based system designed to automate statistical computations, simplify data processing, and generate outputs aligned with school research standards. The innovation aims to provide a cost-effective, accessible, and user-friendly tool for statistical analysis, particularly for learners in rural areas with limited access to licensed software.

1.6 Alignment with Relevant Sustainable Development Goals (SDGs)

This study aligns with SDG 4 – Quality Education by promoting innovative and accessible learning tools that enhance students' statistical literacy, research competence, and academic performance. It also supports SDG 9 – Industry, Innovation and Infrastructure through the development and application of a localized technological solution that improves educational processes and strengthens digital learning practices.

1.7 Importance of the Study to Multidisciplinary Sustainability

The study contributes to educational sustainability by providing a practical tool that improves the teaching and learning of statistical analysis. It supports technological sustainability through the utilization of accessible spreadsheet-based innovations that can be implemented without costly software licenses. The innovation also promotes socio-economic sustainability by reducing expenses associated with statistical software and professional statistical services, making research-related activities more accessible to learners, particularly those from rural and resource-constrained communities. Furthermore, it contributes to institutional sustainability by strengthening research instruction and supporting evidence-based educational practices within schools.

2. Material and methods

2.1 Research Design

The study utilized a true-experimental research design, specifically a pretest-posttest control group design. This design was appropriate because it involved random assignment of participants into experimental and control groups. According to Tan (2024), true-experimental research includes random assignment, manipulation of independent variables, and the use of a control group. One group served as the control group using Microsoft Excel add-ins, while the other served as the experimental group using the developed spreadsheet-based system. Participants' performance was measured before and after the intervention to determine changes in statistical analysis skills. This design allowed the researcher to compare the effectiveness of the two tools under controlled conditions. As explained by Chouiery (2024), participants in a pretest-posttest control group design are randomly assigned to either a treatment or control group and assessed before and after exposure to the intervention.

2.2 Locale of the Study

The study was conducted at Tabuk City National High School under the Schools Division Office of Tabuk City. The research focused on learners enrolled in the Practical Research 2 subject within the Home Economics and Accountancy, Business, and Management strands. The school served as an appropriate setting because statistical analysis had been consistently identified as one of the least mastered competencies among learners based on school monitoring reports.

2.3 Respondents of the Study

The respondents consisted of 172 Grade 12 learners enrolled in five sections of Tabuk City National High School. These included two sections from the Home Economics strand and three sections from the Accountancy, Business, and Management strand. Of the total respondents, 77 were from Home Economics and 95 were from the Accountancy, Business, and Management strand. The participants were selected because they were enrolled in the researcher's Practical Research 2 classes and were directly involved in quantitative research activities requiring statistical analysis.

2.4 Sample and Sampling Procedure

A total enumeration technique was initially employed, including all eligible Grade 12 learners from the selected sections. Thereafter, systematic random sampling was used to assign participants to either the experimental or control group. Learners' names were arranged alphabetically regardless of strand affiliation. Those in even-numbered positions were assigned to one group, while those in odd-numbered positions were assigned to the other. The group with the lower mean pretest score was designated as the experimental group, while the group with the higher mean score became the control group. According to Thomas (2023), systematic random sampling is a probability sampling technique in which members of a population are selected at predetermined intervals, ensuring an unbiased selection process.

2.5 Research Instrument

Data were gathered using researcher-developed pretest and posttest instruments designed to assess statistical analysis proficiency. The instruments contained five research questions accompanied by tallied datasets that participants analyzed using the assigned statistical tool. Each question carried 10 points for computation and 10 points for data presentation, resulting in a maximum score of 100 points. Scoring was based on adapted rubrics from Rizzacajindos (2024). To establish validity, the instrument underwent construct validation conducted by the quality assurance team to determine whether it adequately measured the intended competencies. Reliability was assessed through internal consistency reliability using Cronbach's alpha to determine the consistency of the instrument in measuring statistical analysis skills.

2.6 Data Gathering Procedure

Prior to data collection, the researcher secured approval from the school head, curriculum head, and subject group heads. Participants were informed about the purpose of the study, confidentiality measures, voluntary participation, and their right to withdraw at any stage.A baseline assessment was first administered to evaluate learners' initial statistical analysis performance. Following the pretest, participants received training and demonstrations on the use of either Microsoft Excel add-ins or the developed spreadsheet-based system. The training covered data entry, application of statistical tools, and interpretation of results. After the intervention period, participants completed a posttest involving a new statistical dataset. The resulting scores were compared to determine the effectiveness of the two statistical analysis tools.

2.7 Data Analysis Techniques

Both descriptive and inferential statistics were utilized in analyzing the data. Descriptive statistics, particularly the mean, were used to determine learners' average performance before and after the intervention. Mean scores were interpreted using a researcher-developed performance scale aligned with the scoring rubric adapted from Rizzacajindos (2024), classifying performance levels as Outstanding, Proficient, Approaching Proficiency, Developing, and Needs Improvement. Prior to inferential analysis, data normality was examined using the Shapiro-Wilk test. If the data met the assumptions of normality, parametric tests were employed. Paired-sample t-tests were used to determine significant differences between pretest and

posttest scores within each group, while an independent-sample t-test was utilized to compare posttest performance between the Microsoft Excel add-ins group and the developed spreadsheet-based system group. When normality assumptions were not met, the signed-rank test and Mann-Whitney U-test were applied as non-parametric alternatives.

2.8 Ethical Considerations

The study obtained approval from the Schools Division Superintendent, Assistant Schools Division Superintendent, District Supervisor, and School Heads prior to implementation. Informed assent was secured from participants below 18 years old, while informed consent was obtained from participants aged 18 years and above. Parental consent was likewise required for minors. Participants were informed of their rights, including voluntary participation and withdrawal without penalty. Confidentiality and privacy were maintained throughout the study by protecting personal information and limiting data use solely to research purposes. Academic integrity was upheld through proper acknowledgment and citation of all sources utilized in the study.

3. Results and Discussion

3.1 Learners' Performance in Statistical Analysis

3.1.1 Performance Before and After Using Microsoft Excel Add-ins

Before using Microsoft Excel add-ins, learners obtained a mean score of 15.77, classified as "Needs Improvement," indicating limited knowledge of statistical analysis and frequent computational errors. After the intervention, the mean score increased substantially to 85.01, corresponding to an "Outstanding" performance level. The results indicate considerable improvement in learners' ability to compute, organize, and present statistical data. The findings suggest that Microsoft Excel add-ins served as effective learning aids by simplifying statistical computations and improving data presentation. These results support the findings of George, Kumah, and Seyram (2021), who reported that Microsoft Excel enhanced students' performance in statistical chart interpretation and presentation. Similarly, Kazika and Malambo (2025) found that Excel-based activities improved students' statistical performance and facilitated data visualization and analysis.

3.1.2 Significance of the Difference Before and After Using Microsoft Excel Add-ins

The statistical analysis revealed a significant increase in learners' performance after using Microsoft Excel add-ins. The mean score increased from 15.77 to 85.01, with a computed t-value of -69.84 and a p-value of 0.00, indicating a statistically significant difference between pretest and posttest performance. This finding demonstrates that Microsoft Excel add-ins effectively enhanced learners' statistical problem-solving skills and reduced computational difficulties. The result is consistent with Lay, Wulandari, and Andayani (2025), who highlighted the positive effects of digital technologies on conceptual understanding and problem-solving abilities. Likewise, Ahumaraeze and Nlewedim (2024) reported that spreadsheet-based instruction improved retention and comprehension in mathematics.

3.1.3 Performance Before and After Using the Developed Spreadsheet-Based System

Prior to using the developed spreadsheet-based system, learners achieved a mean score of 14.15, which was classified as "Needs Improvement." Following the intervention, the mean score increased to 90.13, corresponding to an "Outstanding" level. The results indicate a substantial improvement in learners' ability to analyze, compute, and present statistical data accurately. The findings imply that the developed spreadsheet-based system effectively supported statistical analysis by automating computations and improving data organization through a user-friendly interface. These results support the findings of Rohaeti, Fitriani, and Akbar (2020), who emphasized the value of Excel-based learning environments in improving mathematical reasoning and analytical skills. Similarly, Arcilla and De Jesus (2025) concluded that Excel-based exercises strengthened learners' statistical competencies and confidence in handling numerical data.

3.1.4 Significance of the Difference Before and After Using the Developed Spreadsheet-Based System

A significant improvement in performance was observed after learners used the developed spreadsheet-based system. The mean score increased from 14.15 to 90.13, with a computed t-value of -88.3 and a p-value of 0.00. This result confirms a statistically significant difference between pretest and posttest scores. The findings indicate that the developed system effectively enhanced learners' understanding, computation, and presentation of statistical data. The result supports McCloskey and Bussom (2013), who identified spreadsheets as effective tools for active learning and student engagement. Likewise, Wang and Zhao (2016) and Rohaeti, Fitriani, and Akbar (2020) emphasized that spreadsheet-based instructional systems improve computational accuracy, reasoning, and problem-solving skills.

3.2 Comparative Effectiveness of Statistical Analysis Tools

3.2.1 Comparison Between Microsoft Excel Add-ins and the Developed Spreadsheet-Based System

Both Microsoft Excel add-ins and the developed spreadsheet-based system improved learners' statistical analysis performance. However, the developed spreadsheet-based system produced a higher mean score of 90.13 compared with 85.01 for Microsoft Excel add-ins. Statistical analysis yielded a t-value of -5.79 and a p-value of 0.00, indicating a significant difference between the two interventions. The findings suggest that while both tools were effective, the

developed spreadsheet-based system provided greater support in performing statistical procedures. Its customized features, automated functions, and user-friendly design likely contributed to improved learner performance. These results are consistent with Rohaeti, Fitriani, and Akbar (2020), who reported that structured spreadsheet-based learning environments improve reasoning skills. Tomasik et al. (2020) further emphasized the importance of tailored digital tools in enhancing learning outcomes, while Ersozlu (2024) found that accessible technologies reduce learner anxiety and improve academic performance. Similarly, Almutairi (2025) and Sadikin, Mustaffa, Hasbullah, and others (2021) highlighted the effectiveness of spreadsheet-based learning tools in simplifying analytical tasks and strengthening learners' confidence in data analysis.

3.3 Overall Implications of the Findings

The findings demonstrate that integrating digital tools into statistical instruction significantly improves learners' statistical analysis skills. Both Microsoft Excel add-ins and the developed spreadsheet-based system transformed learners' performance from "Needs Improvement" to "Outstanding," indicating their effectiveness as instructional supports. The stronger performance achieved through the developed spreadsheet-based system suggests that customized and localized educational technologies may better address learners' needs than generic software tools. The results reinforce the importance of integrating accessible, user-friendly, and context-specific technologies into research and statistics instruction to improve learning outcomes and strengthen learners' analytical competencies.

4. Conclusion and Recommendations

The study established that both Microsoft Excel add-ins and the developed spreadsheet-based system significantly improved the statistical analysis performance of Grade 12 learners. While both tools enhanced learners' understanding, computation, and presentation of statistical data, the developed spreadsheet-based system produced higher performance outcomes. The findings demonstrate that integrating accessible and user-friendly digital tools into research instruction can effectively strengthen learners' statistical competencies and support more efficient data analysis.

Teachers are encouraged to integrate Microsoft Excel add-ins and the developed spreadsheet-based system into data analysis instruction to improve learners' engagement, accuracy, and understanding of statistical concepts. The developed spreadsheet-based system may be adopted as a primary instructional tool due to its ease of use and stronger impact on learner performance. School administrators and curriculum planners should support the utilization and continuous improvement of similar educational technologies, while future researchers may further examine the effectiveness of spreadsheet-based systems across other subject areas and learning contexts.

The study was limited to Grade 12 learners from the Home Economics and Accountancy, Business, and Management strands of Tabuk City National High School enrolled in Practical Research 2. The evaluation focused only on learners' performance in statistical analysis using Microsoft Excel add-ins and the developed spreadsheet-based system within the duration of the intervention. As such, the findings are confined to the participants, setting, and statistical competencies examined in the study.

Compliance with ethical standards

The author declares no conflict of interest. This study received funding support through the Basic Education Research Fund (BERF) of the Department of Education. Participation was voluntary, and informed assent, informed consent, and parental consent, when applicable, were obtained prior to data collection. Data were collected using non-invasive educational assessments, and all participant information was treated confidentially, with no identifying information disclosed; the author also acknowledges the participation of the Grade 12 learners of Tabuk City National High School who contributed to the study.

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