

Application of SPSS software in learning multivariate statistical methods courses for mathematics education students

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Abstract.

This study investigates the implementation of the Statistical Package for the Social Sciences (SPSS) in teaching a Multivariate Statistics course and elucidates students' learning outcomes following participation in SPSS-assisted instruction. A quantitative descriptive approach was employed, focusing on students' conceptual comprehension, proficiency in operating SPSS, and capacity to interpret multivariate statistical outputs. The participants were undergraduate Mathematics Education students selected through purposive sampling, comprising 28 students from a single class. Data were collected utilizing learning outcome tests, performance assessment rubrics, and student response questionnaires, and were analyzed employing descriptive statistics, encompassing mean scores, standard deviations, and percentage distributions. The findings indicate that students' learning outcomes are generally categorized as favorable (mean = 78.46), with a relatively homogeneous score distribution (SD = 6.87). In terms of skills, students exhibited stronger abilities in data input and processing (80.12) and selecting appropriate analysis techniques (77.85), while their capacity to interpret statistical outputs was relatively lower (75.63). Student responses toward SPSS-assisted learning were also positive, with 88% indicating its relevance to academic needs, 85% asserting that it supports conceptual understanding, 82% perceiving it as user-friendly, and 80% reporting enhanced learning interest. Overall, the findings demonstrate that students exhibit favorable learning outcomes, practical skills in utilizing SPSS, and positive perceptions toward its use in learning. However, since this study employed a descriptive design devoid of a comparison group, the results should be interpreted cautiously and cannot be utilized to infer causal relationships.

Keywords:

Multivariate statistics; SPSS; mathematics education; statistical literacy; higher education

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INTRODUCTION

Multivariate statistics is a fundamental course in Mathematics Education that emphasizes the analysis of data involving multiple variables. Proficiency in this subject necessitates a robust conceptual comprehension and adept data interpretation abilities. Consequently, it assumes a significant role in facilitating students' quantitative research capabilities within the field of Education (Field, 2021; Pallant, 2021). Nevertheless, students frequently perceive multivariate statistics as an arduous subject due to its abstract concepts, intricate analytical methodologies, and cumbersome manual computations (Hair et al., 2022; Tabachnick & Fidell, 2021).

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These challenges are closely related to the conventional approach to teaching statistics. Constructivist theory posits that students actively construct knowledge through meaningful learning experiences (Schunk, 2021). However, statistics instruction that heavily relies on theoretical explanations and manual calculations often provides limited opportunities for contextualized and hands-on learning. Consequently, students frequently encounter difficulties in comprehending fundamental concepts, relating them to practical data analysis, and interpreting statistical outcomes. This situation results in diminished conceptual understanding and compromised data interpretation abilities among students.

To address these challenges, the integration of technology in mathematics and statistics education presents a promising solution. According to technology-assisted learning theory, software tools can facilitate data visualization, expedite data analysis, and enable students to concentrate more on interpreting results (Mayer, 2021). In this context, technology serves as a cognitive tool that supports higher-order thinking and enhances students' engagement in the learning process (Hodges et al., 2020; Kim et al., 2020).

One of the most widely utilized statistical software programs in the field of education is the Statistical Package for the Social Sciences (SPSS). SPSS offers user-friendly features and supports a wide range of multivariate statistical analyses, making it an appropriate tool for complex statistical learning. Previous research has demonstrated that integrating SPSS into statistics instruction can enhance students' conceptual understanding, data interpretation abilities, and overall learning outcomes. Research conducted by Otaya (2023) suggests that SPSS-assisted statistics learning can improve students' accuracy in data interpretation. Similarly, technology-assisted learning has been shown to increase student engagement and active participation (Bond et al, 2020).

Despite extensive research on the utilization of statistical software in statistics education over the past five years, the majority of studies have concentrated on foundational or inferential statistics courses, primarily focusing on enhancing students' learning outcomes and procedural comprehension (Syafriani, 2021; Otaya, 2023). However, research specifically investigating the application of the Statistical Package for the Social Sciences (SPSS) in multivariate statistics courses remains limited. This gap is significant, as multivariate statistics entails more intricate data analysis, necessitating a deeper analytical and interpretative proficiency compared to basic statistics (Hair et al., 2021; Tabachnick & Fidell, 2020).

Recent studies underscore the significant correlation between challenges encountered in advanced statistics and students' limited conceptual comprehension and difficulties in interpreting statistical results within research contexts (Garfield & Ben-Zvi, 2022; Zieffler et al., 2008). In this regard, technology-assisted learning, particularly through statistical software, emerges as a pivotal cognitive tool that facilitates higher-order thinking and enhances students' ability to interpret statistical outputs effectively (Mayer, 2020; Reinhold et al., 2020).

Recent research corroborates the crucial role of technology-assisted statistics learning in augmenting students' statistical literacy and data interpretation abilities, particularly when students are guided to contextualize statistical outputs within real-world scenarios (Garfield & Ben-Zvi, 2021; Zieffler et al., 2008). Furthermore, the evolution of modern statistics education underscores the paramount importance of statistical literacy and the capacity to interpret data in real-world contexts (Garfield et al., 2020; Watson & Callingham, 2003). These competencies have become increasingly indispensable in the era of data science, which necessitates the development of advanced statistical thinking skills (Zieffler et al., 2008; Engel et al., 2022).

In the realm of higher education, SPSS continues to stand as one of the most extensively utilized statistical software programs in educational and social research due to its user-friendly interface and comprehensive analytical capabilities (Field, 2021; Otaya, 2023). Consequently, investigating its application in multivariate statistics learning is imperative to ensure that instructional practices align with contemporary academic and technological advancements.

Based on theoretical considerations and previous research findings, the integration of SPSS in multivariate statistics courses is deemed a pertinent approach to augmenting both the learning process and student outcomes. Consequently, this study endeavors to investigate the

implementation of SPSS in multivariate statistics instruction and to assess students' comprehension following participation in SPSS-assisted instruction. The findings are anticipated to contribute to the development of more effective and innovative approaches to statistics instruction, particularly in facilitating students' needs within an increasingly technology-integrated educational setting.

METHOD

This study employed a quantitative descriptive method to elucidate the outcomes of implementing the Statistical Package for the Social Sciences (SPSS) in a Multivariate Statistics course for Mathematics Education students. This methodology was chosen due to the study's objective of describing students' learning outcomes following participation in SPSS-assisted instruction, without comparing prior abilities or applying experimental treatment.

The study was conducted over six class meetings (each lasting 100 minutes), encompassing pivotal topics in multivariate statistics, including multiple regression analysis, factor analysis, and multivariate analysis of variance (MANOVA).

The SPSS-assisted learning was implemented through a structured sequence of activities within each meeting: (1) conceptual explanation of the statistical topic, (2) demonstration of data analysis procedures utilizing SPSS by the instructor, (3) guided practice in which students analyzed datasets employing SPSS with step-by-step instructions, and (4) independent practice where students completed data analysis tasks and interpreted the output results.

Students were provided with both real and simulated datasets pertinent to educational research contexts. The assignments entailed performing multivariate analyses utilizing SPSS, interpreting statistical outputs (such as coefficients, significance values, and model summaries), and drawing conclusions based on the analysis results.

At the conclusion of the learning process, students' comprehension was assessed through a post-instruction assessment comprising problem-solving and data interpretation tasks designed to gauge their conceptual understanding and proficiency in interpreting multivariate statistical results.

The study population comprised 48 Mathematics Education students enrolled in the Multivariate Statistics course during the 2024/2025 academic year. The sample was selected employing a purposive sampling technique, with a focus on one class that actively incorporates SPSS software into its learning activities.

The selected sample comprised 28 students from a single class, all of whom participated as research subjects. This sampling approach was chosen to provide a focused and comprehensive description of the outcomes of SPSS-assisted multivariate statistics learning within a specific instructional context.

This study focused on one research variable, namely the application of SPSS software in Multivariate Statistical Methods learning. The learning outcomes examined included students' comprehension of multivariate statistical concepts, their proficiency in operating SPSS software, and their ability to interpret multivariate statistical analysis output.

The research utilized three types of instruments. The first was a learning outcome test, designed to measure students' understanding of multivariate statistical concepts after participating in SPSS-assisted learning, covering topics such as multivariate regression analysis, factor analysis, and path analysis. The second instrument was a performance assessment sheet, used to evaluate students' proficiency in operating SPSS and accurately performing multivariate data analyses. The third instrument was a student response questionnaire, aimed at capturing students' perceptions of the use of SPSS in learning. All instruments were developed based on the course learning outcomes and validated by experts in mathematics and statistics education.

The learning outcome test comprised a descriptive instrument comprising eight questions, designed to evaluate students' conceptual comprehension and interpretation abilities in multivariate statistics. The test encompassed topics such as multivariate regression analysis, factor analysis, and path analysis. A descriptive format was selected due to its capacity to provide a more comprehensive assessment of students' conceptual understanding and statistical reasoning

compared to objective tests (Garfield & Ben-Zvi, 2021; Zieffler et al., 2008). The questions were aligned with the course learning outcomes and categorized into three difficulty levels—easy, medium, and difficult—with proportions of 25%, 50%, and 25%, respectively, in accordance with recommendations for developing statistics learning assessment instruments in higher education (Anwar, 2021; Retnawati, 2021).

The difficulty level of the test items was analyzed using a difficulty index based on a limited trial conducted prior to the study. Student learning outcomes were assessed using a scoring rubric ranging from 0 to 100, which evaluated the accuracy of analysis procedures, interpretation of statistical outputs, and conclusions drawn. The utilization of an analytical rubric aimed to enhance the objectivity and consistency of assessing students' proficiency in solving multivariate statistical problems (Brookhart, 2021; Panadero et al., 2018). Data obtained from the learning outcome test were utilized to elucidate students' comprehension of multivariate statistics concepts following participation in SPSS-assisted learning.

The research was conducted in three stages: preparation, implementation, and data analysis. The preparation stage involved developing learning materials for SPSS-assisted multivariate statistics, creating and validating research instruments, and preparing the necessary data and teaching resources. During the implementation stage, instruction focused on using SPSS as the primary tool for multivariate data analysis, covering data entry, selection of analysis techniques, and interpretation of statistical outputs. At the end of the course, students completed a learning outcomes test, a performance assessment, and a questionnaire to collect research data.

The collected data were analyzed using descriptive statistics, including the mean, minimum and maximum scores, standard deviation, and the percentage of learning outcomes achieved. Student learning outcomes were further categorized using predetermined assessment criteria adapted from Arikunto (2021) and Widoyoko (2020), with the following intervals: very good (≥ 85), good (70–84), sufficient (60–69), and poor (< 60). This categorization was used to interpret students' achievement levels in the Multivariate Statistics course. These analyses were used to describe students' understanding of multivariate statistical concepts and their ability to operate and interpret SPSS outputs. Questionnaire data were analyzed descriptively to identify trends in students' responses to the use of SPSS in learning. Additionally, observation results and performance assessments were analyzed descriptively to provide supporting evidence and strengthen the research findings.

RESULTS AND DISCUSSION

This section presents research findings on the application of the Statistical Package for the Social Sciences (SPSS) in teaching Multivariate Statistics to Mathematics Education students. The discussion focuses on students' learning outcomes, their proficiency in operating and interpreting SPSS outputs, and their responses to SPSS-assisted learning. The findings are presented using descriptive statistics and are further supported by qualitative analyses from classroom observations.

The learning outcomes of students in the Multivariate Statistics course, following SPSS-assisted instruction, were analyzed using descriptive statistics. A summary of these outcomes is presented in Table 1.

Table 1. Descriptive statistics of students' multivariate statistics learning outcomes

Statistics	Score
Maximum score	92
Minimum score	65
Mean	78,46
Standard deviation	6,87

Table 1 presents the learning outcomes of students, categorized as “good” based on the criteria established by Widoyoko (2020) and Arikunto (2021). The average score is 78.46, indicating satisfactory performance.

Further analysis of the score distribution reveals that the majority of students fall within the “good” category (70–84), suggesting proficiency in data input and testing technique selection. However, there remains a potential for inaccuracies in interpreting SPSS output. A smaller proportion of students achieve the “very good” category (≥ 85), demonstrating the ability to input data, analyze, formulate statistical models, and interpret SPSS output accurately. Conversely, a few students remain in the “sufficient” category (60–69), characterized by the ability to input data, select testing techniques, analyze data, and draw simple conclusions without comprehending the underlying reasons.

The standard deviation of 6.87 indicates a relatively homogeneous distribution of student scores. According to Field (2020) and Pallant (2020), a low standard deviation signifies minimal variation in the data, implying that students achieved comparable levels of learning outcomes. This finding suggests that the utilization of SPSS software in learning can provide a consistent and equitable learning experience for the majority of students. However, it is important to note that SPSS-assisted learning has not fully optimized high achievement for all learners.

The proficiency of students in operating SPSS and interpreting statistical analysis output was assessed through a performance evaluation. The results of this evaluation are presented in **Table 2**.

Table 2. Descriptive statistics of SPSS operation and output interpretation skills

Assessment aspects	Mean	Category
Data Input and Processing	80,12	Good
Multivariate Analysis Technique Selection	77,85	Good
SPSS Output Interpretation	75,63	Good

Table 2 presents the results of a study examining students’ proficiency in SPSS-assisted statistical skills. The study revealed that students demonstrated varying levels of proficiency across different aspects of SPSS-assisted statistical skills.

The highest mean score was observed in data input and processing (Mean = 80.12), indicating that students were able to operate SPSS procedures effectively and follow technical steps accurately. However, errors often occurred due to carelessness in data input or a lack of preparation in presenting the data beforehand. For instance, data was not inputted first into Excel, preventing it from being inputted into SPSS by simply copying.

Students’ ability to select appropriate multivariate analysis techniques (Mean = 77.85) was also relatively strong, suggesting that they have a sufficient understanding of when to apply specific statistical methods. However, the lowest mean score was observed in interpreting SPSS output (Mean = 75.63), indicating that students still face difficulties in understanding statistical results and drawing meaningful conclusions. This pattern suggests that students tend to master procedural skills more easily than interpretative skills.

The lower performance in output interpretation reflects the complexity of higher-order thinking processes required in multivariate statistics, which involve integrating conceptual understanding, data context, and statistical reasoning. This finding is consistent with previous studies (Zieffler et al., 2008; Garfield & Ben-Zvi, 2022), which highlight that students’ main difficulties in advanced statistics lie in interpreting results rather than performing calculations.

Therefore, while SPSS facilitates computational and procedural aspects of statistical analysis, it does not automatically enhance students’ ability to interpret results without proper conceptual guidance. Student responses to the application of SPSS software were analyzed using a questionnaire. A summary of the questionnaire results is presented in **Table 3**.

Table 3. Student responses to SPSS-assisted learning

Aspect Response	Percentage	Category
Ease of use of SPSS	82%	Very positive
Helps with conceptual understanding	85%	Very positive
Increases interest in learning	80%	Positive
Relevance to academic needs	88%	Very positive

Table 3 presents the results of a study examining the positive impact of SPSS-assisted learning on students' academic performance. The highest percentage, at 88%, was observed in the aspect of relevance to academic needs, indicating that students perceive SPSS as a valuable tool that supports their academic tasks, particularly in conducting research and analyzing data.

Furthermore, students reported that SPSS enhances their conceptual understanding (85%), suggesting that the use of statistical software can make abstract multivariate concepts more concrete and easier to comprehend.

The ease of use of SPSS (82%) further indicates that students are able to operate the software without significant technical difficulties. However, the "increase in learning interest" aspect shows a relatively lower percentage (80%), although it still falls within the positive category. This suggests that while SPSS supports understanding, it does not automatically lead to a significant increase in students' motivation.

These findings indicate that SPSS not only functions as a computational tool but also as a cognitive aid that facilitates students' engagement with statistical concepts. This is consistent with the theory of technology-assisted learning, which posits that digital tools can enhance cognitive engagement when properly integrated into instruction. However, the relatively lower impact on learning interest suggests that instructional strategies and teaching approaches remain crucial factors in fostering student motivation.

The findings of this study suggest that the utilization of SPSS in multivariate statistics learning is positively correlated with students' overall learning outcomes, particularly in facilitating procedural comprehension and general conceptual understanding. This observation aligns with previous research indicating that the application of statistical software supports students' comprehension of statistical concepts (Syafriani, 2021; Ota, 2023).

This is evident in the distribution of student scores, where a majority of students attained the "good" category, implying that SPSS-assisted learning promotes a relatively equitable level of achievement among students. However, only a limited percentage of students achieved a high level of mastery, suggesting that the use of SPSS has not fully optimized higher-order understanding.

This condition is consistent with studies emphasizing that higher-order statistical understanding necessitates deeper conceptual engagement beyond procedural competence (Zieffler et al., 2008; Engel et al., 2022).

Further analysis of students' performance reveals a distinct distinction between procedural and interpretative skills. Students demonstrated superior abilities in operating SPSS and selecting appropriate analysis techniques compared to their proficiency in interpreting statistical outputs. This indicates that while SPSS effectively supports the execution of statistical procedures, interpreting the results remains a more intricate cognitive task.

This pattern is widely reported in statistics education research, where students tend to excel in procedural tasks but encounter difficulties with interpretation and reasoning (Garfield et al., 2020; Zieffler et al., 2008).

This finding is consistent with Mayer (2021) and Field (2021), who argue that technology integration enhances learning when it supports meaningful cognitive processing, rather than merely procedural execution.

From a mathematics education perspective, this pattern underscores that technology-assisted learning can facilitate procedural fluency but necessitates additional instructional support

to enhance conceptual understanding and reasoning abilities (Kilpatrick et al., 2021; Chan et al., 2023).

This observation is corroborated by research demonstrating that the effective utilization of technology in mathematics learning hinges on its integration with pedagogical strategies that foster active and meaningful learning (Hodges et al., 2020; Bond et al., 2023).

This approach not only emphasizes procedural proficiency but also fortifies conceptual understanding, which serves as a fundamental foundation for mathematics education at the higher education level.

The relatively lower performance in interpreting SPSS outputs suggests that the primary challenge lies in connecting statistical results with their conceptual significance and real-world context. This difficulty reflects the complexity of statistical literacy, which encompasses not only computation but also interpretation, reasoning, and contextual comprehension (Watson & Callingham, 2003; Engel et al., 2022). This supports the notion that statistical understanding necessitates the integration of procedural knowledge, conceptual understanding, and contextual reasoning (Garfield et al., 2020). Consequently, the utilization of SPSS should be accompanied by instructional strategies that prioritize interpretation, reflection, and critical thinking, rather than solely focusing on technical proficiency.

Students' responses further indicate that SPSS is perceived as highly relevant to their academic needs, particularly in supporting research activities. This finding aligns with previous studies suggesting that students perceive statistical software as beneficial and pertinent for academic and research purposes (Kallivokas, 2023; Subali et al., 2025).

Despite its relatively lower impact on learning interest, technology alone is insufficient to significantly enhance motivation. This aligns with research indicating that student motivation is influenced by technology use, instructional design, and the learning environment (Hodges et al., 2020; Mayer, 2021).

Effective learning necessitates the integration of technology into pedagogy, including interactive and student-centered approaches.

From a pedagogical perspective, SPSS-assisted learning fosters active engagement by involving students in data processing, analysis technique selection, and result interpretation. Such active engagement is crucial for developing higher-order thinking and statistical reasoning skills in higher education (Panadero et al., 2018; Garfield et al., 2020).

This aligns with the mathematical competency framework Kilpatrick et al. (2021), which emphasizes the significance of conceptual understanding, strategic competence, and adaptive reasoning.

Overall, the findings suggest that SPSS functions as a supportive tool in facilitating students' engagement with data analysis and statistical reasoning. However, its effectiveness hinges on its integration with instructional strategies that prioritize higher-order thinking and interpretation. To maximize its impact, SPSS-assisted learning should be integrated with instructional approaches that explicitly target higher-order thinking, particularly in interpreting statistical results and connecting them to real-world scenarios.

CONCLUSIONS

The findings of this study elucidate the learning outcomes, skills, and responses of students who participated in SPSS-assisted learning within the Multivariate Statistics course. The results indicate that students' learning outcomes are generally categorized as satisfactory, suggesting that the majority of students possess the ability to comprehend and apply multivariate statistical concepts at a satisfactory level. In qualitative terms, this satisfactory level of understanding is evidenced by students' proficiency in performing data analysis using SPSS procedures, selecting appropriate statistical techniques, and interpreting basic output results, although deeper interpretation remains limited.

Students demonstrated relatively strong procedural skills, particularly in data input and selecting appropriate analysis techniques. However, their ability to interpret statistical outputs was

comparatively lower, indicating that students still encounter challenges in connecting statistical results with conceptual meaning and research context. This suggests that understanding in multivariate statistics is not solely dependent on technical proficiency but also encompasses higher-order thinking skills, such as reasoning, interpretation, and contextualization.

The positive responses of students to the utilization of SPSS suggest that technology-assisted learning is perceived as a supportive mechanism for the learning process, particularly in facilitating the comprehension of statistical concepts and the execution of data analysis. These findings are consistent with previous studies that indicate that students perceive SPSS as user-friendly, pertinent to academic requirements, and instrumental in comprehending statistical concepts through data visualization and output interpretation (Kallivokas, 2023; Subali et al., 2025). Furthermore, SPSS is regarded as beneficial in supporting quantitative research endeavors and the preparation of final projects, thereby reinforcing students' perceptions of the relevance and significance of statistics learning (Kismiantini et al., 2025; Kallivokas, 2023). Consequently, SPSS can be conceptualized not only as a computational tool but also as a learning aid that facilitates students' engagement with data analysis and the development of their reasoning in interpreting statistical outcomes.

From a pedagogical standpoint, the integration of SPSS promotes active and student-centered learning, wherein students actively participate in data analysis and interpretation activities. This aligns with constructivist and technology-assisted learning principles, which emphasize meaningful engagement and the acquisition of conceptual understanding through experiential learning.

Nevertheless, this study presents several limitations. The sample was restricted to a single class of students, and no comparison group or pretest–posttest design was employed. Consequently, the findings should be interpreted with caution and cannot be generalized broadly or utilized to infer causal relationships between SPSS utilization and learning enhancement. Future research is recommended to involve larger and more diverse samples, as well as experimental or mixed-methods designs, to comprehensively examine the efficacy of SPSS-assisted learning and to delve deeper into the development of students' conceptual understanding and statistical interpretation abilities.

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