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Mathematics Education Undergraduates' Utilization of Statistical Packages: Implications for Curriculum in the Era of the Fourth Industrial Revolution

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ABSTRACT

Statistical software packages are essential tools in undergraduate education, particularly in the Fourth Industrial Revolution, enabling students to perform complex data analyses and gain practical experience in statistical methods. The integration of these tools into the curricula enhances students' analytical skills and prepares them for data-driven decision-making in various fields. This study investigates the utilization of statistical packages by undergraduates of Mathematics Education at a university in West Africa. The study aims to determine the level of use of statistical packages among students, identify the challenges faced, and propose strategies to overcome these challenges. A descriptive survey design was used, with data collected from 150 students using structured questionnaires. The data were analysed using descriptive statistics of mean and standard deviation. The results indicate that the students showed moderate use of statistical packages, with a cluster mean of 2.88 (SD = 1.09). With respect to the challenges faced in the utilization of statistical packages, the primary barriers included limited access to computers and the internet (mean = 2.97), high software costs (mean = 2.93), and insufficient training opportunities (mean = 2.99). Based on the findings, the study concluded that while students are aware of statistical packages, their usage remains moderate, hindered by infrastructural and training deficiencies. Strategies such as integrating software training into the curriculum and providing access to free or open-source tools are recommended. Integrating these tools into curricula in the present era of the Fourth Industrial Revolution, supported by appropriate resources and training, is essential to foster a comprehensive understanding of statistical methods and their applications.

Keywords: Statistics, Statistical Packages, Mathematics Education, Fourth Industrial Revolution, Student-Researchers, Research Impact

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INTRODUCTION

The Fourth Industrial Revolution (4IR) refers to the ongoing transformation of industries through advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics, blockchain, and biotechnology. It builds upon the digital revolution but integrates cyber-physical systems, creating a more interconnected and automated world. Unlike previous industrial revolutions that focused on mechanization, mass production, and digitalization, 4IR, also known as Industry 4.0, blurs the lines between the physical, digital, and biological spheres, leading to unprecedented advancements in efficiency and innovation.[1]

In the 21st century, the pervasive use of computer technology across various sectors, including agriculture, commerce, and education, has heightened the demand for digital literacy, particularly in statistical skills. As industries increasingly rely on data analysis for decision-making, proficiency in statistics becomes essential for students to navigate and thrive in this data-driven world.[2] However, despite the growing importance of statistical skills, many students show limited interest and achievement in this field. Research indicates that this can be attributed to factors such as the perceived complexity of statistical concepts and a lack of engaging teaching methods.[3] Additionally, insufficient exposure to practical applications of statistics contributes to a gap between theoretical knowledge and real-world application.[4] Studies have shown that innovative, technology-enhanced learning approaches can help bridge this gap, improving both interest and performance.[5] This highlights the urgent need for educational reforms that integrate interactive, technology-driven methods to make statistics more accessible and relevant.

Statistics, as a field, is essential for analyzing and interpreting data, enabling individuals to draw meaningful conclusions from complex information. It plays a crucial role across disciplines, providing methods for managing uncertainty, making predictions, and supporting decision-making processes.[6] With the rapid increase in data generation across various fields, statistical literacy has become a core skill, helping individuals critically evaluate information and make informed decisions.[7] To enhance the understanding of students and their practical application of statistics, statistical software packages have become an integral part of education. These packages, such as SPSS, R, SAS, and Python, offer tools for data analysis, visualization, and interpretation, allowing students to work with real-world datasets efficiently and accurately.[8] By using these packages, students move beyond theoretical knowledge, gaining hands-on experience with data and cultivating the analytical skills required in many professional settings.[9]

However, despite the benefits, there are notable challenges associated with using statistical packages. One primary issue is the steep learning curve; many students and educators find statistical software difficult to learn, particularly packages like R and Python, which require knowledge of programming languages.[10] Another challenge is the cost of certain software packages, such as SPSS and SAS, which can be prohibitively expensive for students and institutions, limiting accessibility.[11] Additionally, students sometimes rely too heavily on software output without fully understanding the

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[1] Philip Ross and Kasia Maynard, "Towards a 4th Industrial Revolution," *Intelligent Buildings International* 13, no. 3 (July 3, 2021): 159–61, https://doi.org/10.1080/17508975.2021.1873625; Interaction Design Foundation - IxDF., " What Is The Fourth Industrial Revolution?," Interaction Design Foundation - IxDF, March 20, 2024, https://www.interaction-design.org/literature/topics/the-fourth-industrial-revolution.

[2] Cathy Smith et al., "Mathematical and Data Literacy: Competencies and Curriculum Implications at the Intersection of Mathematics, Data Science, Statistics and Computing," *Mathematical and Data Literacy: Competencies and Curriculum Implications at the Intersection of Mathematics, Data Science, Statistics and Computing*, 2023.

[3] Joan Garfield and Dani Ben-Zvi, *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice* (Springer Science & Business Media, 2008); Jane Watson and Caroline Smith, "Statistics Education at a Time of Global Disruption and Crises: A Growing Challenge for the Curriculum, Classroom and Beyond," *Curriculum Perspectives* 42, no. 2 (2022): 171–79.

[4] Beth L Chance and Allan J Rossman, *Investigating Statistical Concepts, Applications and Methods* (Duxbury Harrisonburg, 2006).

[5] Angel J Y Tan et al., "A Technology-Enhanced Learning Intervention for Statistics in Higher Education Using Bite-Sized Video-Based Learning and Precision Teaching," *Research and Practice in Technology Enhanced Learning*, 2023.

[6] Wendy L Martinez, "Computational Statistics in MATLAB®," *Wiley Interdisciplinary Reviews: Computational Statistics* 3, no. 1 (2011): 69–74.

[7] Deborah J Rumsey, "Discussion: Statistical Literacy: Implications for Teaching, Research, and Practice," *International Statistical Review/Revue Internationale de Statistique* 70, no. 1 (2002): 32–36.

[8] Dazhi Yang, "Instructional Strategies and Course Design for Teaching Statistics Online: Perspectives from Online Students," *International Journal of STEM Education* 4, no. 1 (2017): 34; Nicholas J Horton and Johanna S Hardin, "Teaching the next Generation of Statistics Students to 'Think with Data': Special Issue on Statistics and the Undergraduate Curriculum," *The American Statistician* 69, no. 4 (2015): 259–65.

[9] Michael R Hulsizer and Linda M Woolf, *A Guide to Teaching Statistics: Innovations and Best Practices* (John Wiley & Sons, 2009).

[10] Svetlana Tishkovskaya and Gillian A Lancaster, "Statistical Education in the 21st Century: A Review of Challenges, Teaching Innovations and Strategies for Reform," *Journal of Statistics Education* 20, no. 2 (2012); Bryson Stemock and Lucy Kerns, "Use of Commercial and Free Software for Teaching Statistics," *Statistics Education Research Journal* 18, no. 2 (2019): 54–67.

[11] Garfield and Ben-Zvi, *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice*; Jamie D Mills and Dheeraj Raju, "Teaching Statistics Online: A Decade's Review of the Literature about What Works," *Journal of Statistics Education* 19, no. 2 (2011).

underlying statistical concepts, which can lead to misinterpretations of data.[12] Furthermore, integrating statistical packages into coursework can be time-consuming and require instructors to be proficient with these tools themselves, posing a barrier for educators unfamiliar with the technology.[13] These challenges underscore the need for comprehensive training and support for both students and educators to maximize the benefits of statistical packages in educational environments.[14]

With the growing reliance on statistical software, there is still much to learn about how these tools impact students' learning outcomes, particularly in the context of Mathematics Education undergraduates. The available research indicates that multiple factors contribute to the under-utilization of statistical packages by students. Limited access to software, insufficient technical training, perceived complexity of statistical software, and lack of integration into the curriculum may impact students' willingness and ability to use these tools. Additionally, institutional challenges, such as limited availability of software licenses and inadequate instructional support, may prevent students from acquiring the hands-on experience needed to apply statistical software in real-world situations.[15] According to Chen and Vijayakumar, Børte *et al.*, and Uchima-Marin *et al.*, more empirical research is needed to explore the effectiveness of different statistical packages in improving students' comprehension and application of statistical concepts.[16] This study seeks to fill that gap by investigating how Mathematics undergraduate students utilize statistical packages in their learning of statistics, examining both the benefits and challenges associated with their use.

The core objective of the present study is to determine the level of utilization of statistical packages by mathematics education undergraduates and the related challenges they face. The following questions guide the study.

i. What is the level of utilization of statistical packages by mathematics education undergraduates?
ii. What are the challenges mathematics education students face when using statistical software tools, and what are the suggested strategies for overcoming them?

These objectives translate into two research questions. The literature review of the study examines the context of the Fourth Industrial Revolution (4IR) along with the use of statistical packages by students of mathematics education. The results of the study are presented in line with the stated research questions, and the findings are subsequently discussed. This is followed by a detailed discussion of the implications of the empirical findings for curriculum in the era of the fourth industrial revolution. The conclusion section summarizes the essence of the research work, and key recommendations are offered with a dedicated focus on the much-needed curriculum enhancement.

LITERATURE REVIEW

The Fourth Industrial Revolution (4IR)

Historically, the First Industrial Revolution started in the 18th century and was characterized by the emergence of the steam engine and new materials as energy sources, such as coal. Due to these advances, the economy shifted from an agriculture-based to an industry-based economy. The Second Industrial Revolution began at the end of the 19th century, with the appearance of automated machines, allowing a new economic and commercial order to emerge. This period was marked by the development of industries

[12] Rumsey, "Discussion: Statistical Literacy: Implications for Teaching, Research, and Practice."

[13] Jenna Joo and Richard R Spies, "Aligning Many Campuses and Instructors around a Common Adaptive Learning Courseware in Introductory Statistics," *Lessons from a Multi-Year Pilot in Maryland*, 2019; Horton and Hardin, "Teaching the next Generation of Statistics Students to 'Think with Data': Special Issue on Statistics and the Undergraduate Curriculum."

[14] Katherine R Friedrich and Laura Armer, "The Instructional and Technological Challenges of a Web Based Course in Educational Statistics and Measurement," in *Society for Information Technology & Teacher Education International Conference* (Association for the Advancement of Computing in Education (AACE), 1999), 959–65.

[15] Aneta Mazouchová, Tereza Jedlicková, and Lucie Hlavácová, "Statistics Teaching Practice at Czech Universities with Emphasis on Statistical Software.," *Journal on Efficiency and Responsibility in Education and Science* 14, no. 4 (2021): 258–69; Kimberlee C Everson, "Statistical Skills Gaps of Professors of Education at US Universities and HBCUs," *Journal of Statistics and Data Science Education* 30, no. 1 (2022): 45–53.

[16] Li-Ting Chen and Tejaswini Vijayakumar, "Teaching Statistics Online: A Literature Review and Our Lessons Learned," in *Society for Information Technology & Teacher Education International Conference* (Association for the Advancement of Computing in Education (AACE), 2023), 191–96; Kristin Børte, Katrine Nesje, and Sølvi Lillejord, "Barriers to Student Active Learning in Higher Education," *Teaching in Higher Education* 28, no. 3 (2023): 597–615; Cristian Uchima-Marin et al., "Integration of Technological Tools in Teaching Statistics: Innovations in Educational Technology for Sustainable Education," *Sustainability* 16, no. 19 (2024): 8344.

and the appearance of new energy sources, such as electricity and carbon fuels for combustion engines, alongside communication technologies.[17] The Third Industrial Revolution emerged in the mid-1940s with the so-called "Information Society". Internet communication technology and renewable energy sources in the 21st century led to major innovations, such as the smart distribution grid and the widespread adoption of digital technology and automation, particularly in areas like computing, telecommunications, and manufacturing. This era continues today, marked by innovations such as the Internet, personal computers, and advancements in telecommunications.[18]

Presently, we are at the start of the Fourth Industrial Revolution, also known as Industry 4.0, a term that was coined in 2011 by economist Klaus Schwab, founder of the World Economic Forum.[19] This concept defines computerized manufacturing, which combines advanced production techniques with smart technologies that will be integrated into organizations and people's lives. In Industry 4.0, industrial automation systems are used to computerize, control, and monitor a process, machine, or device to perform repetitive tasks. This new industry is characterized by emerging technological advances in different fields, such as robotics, artificial intelligence, and autonomous vehicles, among many others.[20]

One of the defining characteristics of 4IR is automation and AI-driven decision-making. Smart factories and AI-powered systems can analyse vast amounts of data in real-time, optimizing processes and reducing human intervention. Technologies like machine learning and big data analytics enhance productivity across industries such as manufacturing, healthcare, finance, and logistics. However, this shift raises concerns about job displacement, as machines and algorithms replace traditional labour in many sectors.[21] The revolution also fosters connectivity and communication through IoT and 5G technology. With billions of interconnected devices, businesses and consumers can access real-time information, improving decision-making and operational efficiency. Smart cities, autonomous vehicles, and digital healthcare systems exemplify the transformative potential of enhanced connectivity. However, this increased reliance on technology also raises concerns about cybersecurity, data privacy, and ethical considerations regarding surveillance and digital rights.[22] The Fourth Industrial Revolution is driving significant changes in education and workforce development. As automation redefines job markets, there is a growing need for reskilling and upskilling workers to adapt to new technological demands. Emphasis on STEM (science, technology, engineering, and mathematics) education, along with creativity and problem-solving skills, is becoming crucial. Governments, businesses, and educational institutions must collaborate to ensure a smooth transition for workers and prevent widespread unemployment and economic disparity. The Fourth Industrial Revolution (4IR) and STEM education are closely intertwined, with STEM becoming increasingly crucial for individuals and nations to thrive in the rapidly evolving technological landscape. STEM education equips students with the skills and knowledge needed to understand, develop, and use the technologies that drive the 4IR, fostering innovation and economic growth.[23] Innovations in clean energy, precision medicine, and smart infrastructure are contributing to a more sustainable and inclusive future.

Utilization of Statistical Packages in Educational Research

Undergraduate students in disciplines such as Mathematics, Economics, Social Sciences, Biology, and Business Studies especially benefit from proficiency in these statistical tools. For Mathematics students, statistical software helps them to apply statistical theories to real-world problems.[24] In the Social Sciences,

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[17] Repsol, "The Fourth Industrial Revolution: Everything about Industry 4.0," 2025, https://www.repsol.com/en/energy-and-the-future/technology-and-innovation/fourth-industrial-revolution/index.cshtml.

[18] Haradhan Mohajan, "Third Industrial Revolution Brings Global Development," 2021.

[19] Repsol, "The Fourth Industrial Revolution: Everything about Industry 4.0."

[20] Repsol, "The Fourth Industrial Revolution: Everything about Industry 4.0."

[21] D. McGinnis, "What Is the Fourth Industrial Revolution? ," SalesForce, July 5, 2023, https://www.salesforce.com/blog/what-is-the-fourth-industrial-revolution-4ir/.

[22] McKinsey, "What Are Industry 4.0, the Fourth Industrial Revolution, and 4IR? ," August 17, 2022, https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-are-industry-4-0-the-fourth-industrial-revolution-and-4ir.

[23] Intel, " Preparing to Teach in the 4th Industrial Revolution," 2025, https://www.intel.com/content/www/us/en/education/teaching-strategy/teaching-4th-industrial-revolution.html.

[24] Rolf Biehler et al., "Technology for Enhancing Statistical Reasoning at the School Level," in *Third International Handbook of Mathematics Education* (Springer, 2012), 643–89; Johanna S Hardin and Nicholas J Horton, "Ensuring That Mathematics Is Relevant in a World of Data Science," *Notices of the AMS* 64, no. 9 (2017): 986–90.

tools like SPSS are commonly used to analyze survey data, an essential skill for research.[25] For Business and Economics students, statistical packages are vital for financial analysis, forecasting, and market research.[26] Therefore, integrating statistical software into education is invaluable, equipping students in these fields with the digital and analytical skills demanded in the modern workforce.

The integration of statistical packages in education has become increasingly significant in the context of higher education, particularly for Mathematics Education undergraduate students. As the demand for data-driven decision-making continues to grow across various industries, the need for proficiency in statistical tools has never been greater.[27] Statistical packages, such as SPSS, R, MATLAB, SAS, Excel, and Minitab, have become essential tools in both academia and industry, providing students with the capability to perform complex data analysis, visualize data, and apply statistical models.[28]

Research has shown that the use of statistical software can significantly improve students' understanding of statistical concepts by allowing them to engage in practical, hands-on learning experiences.[29] For instance, R and RStudio have been praised for their flexibility and extensive libraries, which enable students to explore a wide range of statistical methods beyond the limitations of traditional classroom instruction.[30] Similarly, SPSS, known for its user-friendly interface, is often used in introductory courses to help students grasp foundational statistical techniques with ease.[31]
Statistical packages provide substantial benefits in educational and professional settings by simplifying complex data analysis tasks. These packages, such as SPSS, R, and Python, streamline data management, allowing users to input, organize, and analyze large datasets quickly and efficiently.[32] Through these tools, students can engage in hands-on data analysis, which improves their learning by allowing them to directly apply statistical theories to real-world data.[33] Additionally, the data visualization capabilities of many packages make it easier to interpret and communicate results, providing students with a more intuitive understanding of statistical concepts.[34] For educators, statistical software facilitates the teaching process by allowing demonstrations of complex procedures, making abstract concepts more accessible to students.[35] Beyond education, proficiency in statistical packages prepares students for data-centric roles in various industries, as these tools are standard in fields such as economics, public health, social sciences, and business.[36]

Recent research has examined diverse dynamics associated with the use of statistical packages in learning. A study by Arel-Bundock *et al.*, highlighted that while tools like SPSS and Excel are more accessible and easier to learn, they may limit students' ability to engage with more advanced statistical analyses.[37] In contrast, software like R and MATLAB, although more powerful, often have a steeper

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[25] Andy Field, *Discovering Statistics Using IBM SPSS Statistics* (Sage publications limited, 2024).
[26] Damodar N Gujarati, "Basic Econometrics 4th Ed.," 2002.
[27] Dave Pratt, Neville Davies, and Doreen Connor, "The Role of Technology in Teaching and Learning Statistics," in *Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education: A Joint ICMI/IASE Study: The 18th ICMI Study* (Springer, 2011), 97–107.
[28] Martin Andre and Zsolt Lavicza, "Technology Changing Statistics Education: Defining Possibilities, Opportunities and Obligations.," *Electronic Journal of Mathematics & Technology* 13, no. 3 (2019).
[29] Maria Meletiou-Mavrotheris, "Technological Tools in the Introductory Statistics Classroom: Effects on Student Understanding of Inferential Statistics," *International Journal of Computers for Mathematical Learning* 8, no. 3 (2003): 265–97; Martinez, "Computational Statistics in MATLAB®."
[30] Benjamin S Baumer, Daniel T Kaplan, and Nicholas J Horton, *Modern Data Science with R* (Chapman and Hall/CRC, 2017); W. Hadley and G. Garrett, *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data* (O'Reilly Media, Inc., 2016).
[31] Zhenjie Sun, "A Study on the Educational Use of Statistical Package for the Social Sciences," *International Journal of Frontiers in Engineering Technology* 1, no. 1 (2019): 20–29; Field, *Discovering Statistics Using IBM SPSS Statistics*.
[32] Field, *Discovering Statistics Using IBM SPSS Statistics*.
[33] Johanna Hardin et al., "Data Science in Statistics Curricula: Preparing Students to 'Think with Data,'" *The American Statistician* 69, no. 4 (2015): 343–53.
[34] Biehler et al., "Technology for Enhancing Statistical Reasoning at the School Level."
[35] David Zapletal and Viera Pacakova, "Statistical Software Packages as an Innovative and Motivational Tool for Teaching Statistics," in *Recent Advances in Education and Educational Technologies, Proceedings of the 2013 International Conference on Education and Educational Technologies (EET 2013), Rhodes Island, Greece*, 2013, 120–22; Horton and Hardin, "Teaching the next Generation of Statistics Students to 'Think with Data': Special Issue on Statistics and the Undergraduate Curriculum."
[36] Sun, "A Study on the Educational Use of Statistical Package for the Social Sciences"; Martinez, "Computational Statistics in MATLAB®."
[37] Vincent Arel-Bundock, Noah Greifer, and Andrew Heiss, "How to Interpret Statistical Models Using Marginaleffects for R and Python," *Journal of Statistical Software* 111 (2024): 1–32.

learning curve, which can be daunting for students who are less experienced with programming.[38] These challenges underscore the importance of providing adequate support and training to help students use these tools effectively in their learning process.[39] Recent studies also suggest that the use of statistical packages is not only about learning statistics but also about developing critical thinking and data literacy skills, which are essential in today's data-driven world.[40] For example, the application of MATLAB in computational statistics courses helps students understand the underlying mathematical models and algorithms, thereby deepening their conceptual understanding of statistics.[41]

Moreover, the rapid advancement in statistical software has led to a shift in pedagogical strategies within mathematics departments.[42] Educators are increasingly incorporating these tools into their curricula to bridge the gap between theoretical knowledge and practical application.[43] This approach aligns with the findings of Kwashabawa who emphasize that the use of software, such as Microsoft Excel (MS-Excel), Minitab, Matlab, Stata, Statistical Package for the Social Sciences (SPSS), R, Statistical Analysis System (SAS), and Econometric Views (Eviews) are particularly beneficial in advanced courses where students must handle large datasets and perform complex statistical modeling.[44] Similar outcomes were reported by the work of Sakaria *et al.*, which provides findings implying that six types of proprietary statistical software packages emerged as an optimal choice in Mathematics Education research, namely: Lisrel, Amos, Mplus, SmartPLS, R package (plspm), and WarpPLS.[45] Despite the widespread usage of a variety of statistical applications, SmartPLS and AMOS were rigorously utilized in VB-SEM/PLS-SEM and CB-SEM, respectively. Thus, it is important for practitioners to discover which statistical tools are relevant to use and to identify gaps to sustain mathematics education for the future.

For instance, SPSS is a statistical software in both academic and professional settings. Its ease of use and comprehensive set of statistical tools make it a popular choice among students and educators. Field emphasizes that SPSS's user-friendly interface allows students to focus on understanding statistical concepts rather than getting bogged down by complex coding.[46] The research suggests that SPSS is particularly effective in teaching basic to intermediate statistics, such as descriptive statistics, correlations, and linear regression.

On the other hand, R is a programming language and a free software environment for statistical computing and graphics. RStudio is an IDE that enhances the user experience with R. Hadley *et al.* discuss the power of R in providing flexibility and extensive functionality through packages like GGPLOT2 for visualization and DPLYR for data manipulation.[47] They note that although R has a steeper learning curve, it is invaluable for students who pursue more advanced statistical methods and research.

In the same vein, SAS is known for its ability to handle large datasets and perform advanced statistical analyses. It is extensively used in industry and research. Blades *et al.* (2015) opined that SAS is particularly useful in advanced coursework where students deal with large datasets or complex modeling techniques, such as survival analysis or multivariate statistics. Hughes highlights that although SAS may not be as intuitive as other packages, its power and scalability make it a valuable tool for students who

38 C S Mukhopadhyay and Kanwaljeet Rana, "Introduction to Python, R, and MATLAB," *Sushrirekha Das and Parkash Singh Brar (2023)*, n.d., 34; Weiyao Zhu et al., "Exploring the Learning Difficulty of Data: Theory and Measure," *ACM Transactions on Knowledge Discovery from Data* 18, no. 4 (2024): 1–37.

39 Garfield and Ben-Zvi, *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice*; Gail Burrill and Maxine Pfannkuch, "Emerging Trends in Statistics Education," *ZDM–Mathematics Education* 56, no. 1 (2024): 19–29.

40 Jessica Bates et al., "Cultivating Critical Thinking Skills: A Pedagogical Study in a Business Statistics Course," *Journal of Statistics and Data Science Education* 33, no. 2 (2025): 166–76; Sri Rahayu Pudjiastuti, "The Role of Statistics in Research to Improve Critical Thinking Skills," *JHSS (Journal of Humanities and Social Studies)* 6, no. 3 (2022): 417–22.

41 Irene David and Jennifer Ann Brown, "Beyond Statistical Methods: Teaching Critical Thinking to First-Year University Students," *International Journal of Mathematical Education in Science and Technology* 43, no. 8 (2012): 1057–65; Martinez, "Computational Statistics in MATLAB®."

42 Jane Watson and Noleine Fitzallen, "Statistical Software and Mathematics Education: Affordances for Learning," in *Handbook of International Research in Mathematics Education* (Routledge, 2015), 563–94.

43 Chance and Rossman, *Investigating Statistical Concepts, Applications and Methods*.

44 Bala Bakwai Kwashabawa, "Empirical Research in Education: Do Statistical Packages for Data Analysis Matter?," *European Journal of Training and Development Studies* 8, no. 1 (2021): 27–35.

45 Darmaraj Sakaria, Siti Mistima Maat, and Mohd Effendi Ewan Mohd Matore, "Examining the Optimal Choice of SEM Statistical Software Packages for Sustainable Mathematics Education: A Systematic Review," *Sustainability* 15, no. 4 (2023): 3209.

46 Field, *Discovering Statistics Using IBM SPSS Statistics*.

47 Hadley and Garrett, *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*.

need to perform sophisticated analyses.[48] MATLAB is a high-level language and interactive environment used by millions of engineers and scientists worldwide. It is especially popular for tasks that require matrix manipulation and algorithm development. Martinez discusses MATLAB's applications in statistical learning, particularly in courses that involve computational statistics, such as Monte Carlo simulations or numerical methods.[49] Other studies have emphasized MATLAB's ability to integrate statistical learning with other fields such as engineering and physics.[50]

Microsoft Excel is a widely accessible tool that offers basic statistical functions. It is often used in introductory statistics courses.[51] Excel is often the first software that students encounter for statistical analysis due to its accessibility. The research suggests that while Excel is sufficient for introductory statistics, its limitations become apparent in more advanced courses, where specialized software, such as R or SPSS, becomes necessary.[52] Similarly, Minitab is designed with education in mind, offering a user-friendly interface that simplifies statistical analysis for students. Lesik highlights how Minitab is particularly well-suited for teaching basic statistics.[53] Many studies have noted that Minitab's step-by-step tutorials and easy-to-understand output are beneficial for students new to statistics.[54] Regarding the use of MINITAB as a learning tool, García *et al.*, report that a large percentage of the surveyed population would like to be trained, expressing interest in using it in their teaching, emphasizing that commitment to using technology brings great benefits and produces better academic results.[55]

The list of existing and useful statistical software is inexhaustible. Statistical packages play a crucial role in the Fourth Industrial Revolution (4IR) by enabling businesses and researchers to analyse vast amounts of data efficiently. As 4IR is driven by big data, artificial intelligence (AI), and automation, statistical software such as R, Python, SPSS, SAS, and STATA help process and interpret complex datasets.[56] These tools allow organizations to extract meaningful insights, make data-driven decisions, and optimize operations in industries, such as manufacturing, healthcare, finance, and logistics.[57]

One of the key functions of statistical packages in 4IR is predictive analytics. By leveraging machine learning algorithms and statistical models, these tools can forecast trends, detect patterns, and anticipate future outcomes. Businesses use predictive analytics for demand forecasting, risk management, and fraud detection, while healthcare professionals apply it to disease prediction and personalized medicine. This capability improves decision-making and reduces uncertainties in various fields.[58]

Another important role for statistical packages is in automating and real-time data analysis. With the integration of IoT devices and AI, businesses generate massive amounts of data that require real-time processing. Statistical software enables automation of data analysis, reducing human effort and improving

[48] Troy Martin Hughes, *SAS Data Analytic Development: Dimensions of Software Quality* (John Wiley & Sons, 2016).
[49] Martinez, "Computational Statistics in MATLAB®."
[50] M Abdul Majid et al., "MATLAB as a Teaching and Learning Tool for Mathematics: A Literature Review," *International Journal of Arts & Sciences* 6, no. 3 (2013): 23; Martin Miškuf, Peter Michalik, and Iveta Zolotová, "Data Mining in Cloud Usage Data with Matlab's Statistics and Machine Learning Toolbox," in *2017 IEEE 15th International Symposium on Applied Machine Intelligence and Informatics (SAMI)* (IEEE, 2017), 377–82.
[51] Duilio Divisi et al., "Basic Statistics with Microsoft Excel: A Review," *Journal of Thoracic Disease* 9, no. 6 (2017): 1734.
[52] Bates et al., "Cultivating Critical Thinking Skills: A Pedagogical Study in a Business Statistics Course."
[53] Sally A Lesik, *Applied Statistical Inference with MINITAB®* (Chapman and Hall/CRC, 2018).
[54] Noriah Yusoff et al., "Design of Experiment Using Minitab for Screening Breath Sensor Workability Performance," *Jurnal Teknologi (Sciences & Engineering)* 76, no. 9 (2015); T. A. Jr. Ryan and Brian L. Joiner, "Minitab: A Statistical Computing System for Students and Researchers," *The American Statistician* 27, no. 5 (December 1973): 222, https://doi.org/10.2307/3087405.
[55] Javier Rossette García, Diego Arturo Soto Monterrubio, and Gabriela Clemente Martínez, "Minitab as a Didactic Resource for Teaching Statistics at Higher Education Level," *Revista de Gestão Social e Ambiental* 18, no. 4 (2024): e07787.
[56] Guru Selvarajan, "Leveraging AI-Enhanced Analytics for Industry-Specific Optimization: A Strategic Approach to Transforming Data-Driven Decision-Making," *International Journal of Enhanced Research In Science Technology & Engineering* 10 (2021): 78–84.
[57] Sai Teja Boppiniti, "Machine Learning for Predictive Analytics: Enhancing Data-Driven Decision-Making across Industries," *International Journal of Sustainable Development in Computing Science* 1, no. 3 (2019): 13; Ibrahim Adedeji Adeniran et al., "Optimizing Logistics and Supply Chain Management through Advanced Analytics: Insights from Industries," *Engineering Science & Technology Journal* 5, no. 8 (2024).
[58] Obinna Nweke and Louis Owusu-Berko, "Integrating AI-Driven Predictive and Prescriptive Analytics for Enhancing Strategic Decision-Making and Operational Efficiency across Industries," *International Research Journal of Modernization in Engineering Technology and Science* 7, no. 2 (n.d.): 4013–35.

efficiency.[59] Industries such as manufacturing use these tools to monitor production quality, detect anomalies, and optimize supply chains, leading to cost savings and increased productivity.[60]
Statistical packages also contribute to data visualization and reporting, making complex datasets more accessible and interpretable. Tools, such as Tableau, Power BI, and R's ggplot2, allow organizations to present data in graphical formats such as charts, graphs, and dashboards.[61] These visualizations enhance decision-making by providing clear insights into trends and patterns. In 4IR, where data-driven strategies are essential, effective visualization tools help stakeholders understand and act on key information quickly.[62]

Similarly, statistical packages support research and innovation in the Fourth Industrial Revolution by facilitating data-driven discoveries.[63] In fields such as artificial intelligence, biotechnology, and environmental science, researchers use statistical software to analyse experimental data, test hypotheses, and develop new technologies. By ensuring accuracy and efficiency in data analysis, these tools contribute to scientific advancements that drive progress in 4IR.[64] As technology continues to evolve, statistical packages will remain essential to harness the power of big data for innovation and decision-making.[65]

Despite the pivotal role statistical packages are expected to play in the Fourth Industrial Revolution, there is a major drawback in users who do not have the technical knowledge to use technology or software. There is a general lack of technical literacy among students in effectively using statistical software packages.[66] Statistical software such as SPSS, R, and SAS are vital tools for data analysis, yet many students pursuing statistics-related courses struggle with these technologies. Research indicates that inadequate training and exposure to statistical tools during their academic journey contribute significantly to this challenge.[67] Furthermore, the complexity of these tools, coupled with limited access to resources such as tutorials and practical exercises, hinders the ability of students to harness their full potential.[68] Without hands-on experience, students are unable to translate theoretical knowledge into practical problem-solving, reducing their competitiveness in academic and professional environments.[69] Most of the students who offer statistical-related courses are not vibrant and are not statistically proficient/efficient in using the packages.[70]

Another contributing factor to this issue is the insufficient integration of technology-based learning in the curriculum.[71] Studies show that in many institutions, traditional methods of teaching statistics dominate, sidelining modern computational tools.[72] This approach not only limits the scope of student

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59 A. Novak, D., Bennett, and T. Kliestik, "Product Decision-Making Information Systems, Real-Time Big Data Analytics, and Deep Learning-Enabled Smart Process Planning in Sustainable Industry 4.0," *Journal of Self-Governance and Management Economics* 8, no. 3 (2020): 16, https://doi.org/10.22381/JSME8320202.

60 K J Kachiashvili et al., "Software Packages for Automation of Environmental Monitoring and Experimental Data Processing," in *Geoecology and Computers* (Routledge, 2018), 273–78; Dariush Shirmohammadi et al., "Distribution Automation System with Real-Time Analysis Tools," *IEEE Computer Applications in Power* 9, no. 2 (1996): 31–35.

61 Wenyi Ouyang, "Data Visualization in Big Data Analysis: Applications and Future Trends," *Journal of Computer and Communications* 12, no. 11 (2024): 76–85.

62 Vimolan Mudaly, "Work-Integrated Learning in a Changing Educational Context," *Research in Social Sciences and Technology* 10, no. 2 (May 12, 2025): 108–29, https://doi.org/10.46303/ressat.2025.29.

63 K. Phaswana, " Amplifying Human Capital Investment Planning at National Statistics Offices in SACU Region during the 4th Industrial Revolution" (North-West University - South Africa, 2021).

64 O. P. Popoola and O. N. Adeboye, " Fourth Industrial Revolution and Evolution of Data Science: Challenges for Official Statistics," 2023, https://www.econstor.eu/bitstream/10419/268717/1/Data Science ConferencePDF.pdf.

65 Joshua Abah Abah, "Recency Bias in the Era of Big Data: The Need to Strengthen the Status of History of Mathematics in Nigerian Schools," *Advances in Multidisciplinary Research Journal*, 2017.

66 Etem Yeşilyurt and Rabia Vezne, "Digital Literacy, Technological Literacy, and Internet Literacy as Predictors of Attitude toward Applying Computer-Supported Education," *Education and Information Technologies* 28, no. 8 (2023): 9885–9911.

67 Victoria Woodard and Hollylynne Lee, "How Students Use Statistical Computing in Problem Solving," *Journal of Statistics and Data Science Education* 29, no. sup1 (2021): S145–56; Xuming He et al., "Statistics at a Crossroads; Who Is for the Challenge?," *ArXiv Preprint ArXiv:2503.22945*, 2025.

68 Elfatih A Hasabo et al., "Statistics for Undergraduate Medical Students in Sudan: Associated Factors for Using Statistical Analysis Software and Attitude toward Statistics among Undergraduate Medical Students in Sudan," *BMC Medical Education* 22, no. 1 (2022): 889.

69 Sampson Nwaomah, "A Contextual Reading of 1 Timothy 3:1-7," *The American Journal of Biblical Theology* 24, no.26 (2023): 15.

70 Adrian Bromage et al., "Teaching Statistics to Non-Specialists: Challenges and Strategies for Success," *Journal of Further and Higher Education* 46, no. 1 (2022): 46–61.

71 Børte, Nesje, and Lillejord, "Barriers to Student Active Learning in Higher Education."

72 Elinor Jones and Tom Palmer, "A Review of Group-Based Methods for Teaching Statistics in Higher Education," *Teaching Mathematics and Its Applications: An International Journal of the IMA* 41, no. 1 (2022): 69–86.

learning but also fails to prepare them for real-world data analysis tasks, where proficiency in statistical software is a prerequisite.[73] Moreover, the reluctance of some educators to adapt to technology-enhanced teaching further exacerbates the situation.[74] Addressing this drawback requires a paradigm shift in pedagogical strategies, including the incorporation of statistical software training into coursework and the provision of adequate resources and support for students.[75]

METHODOLOGY

The research adopted a descriptive survey design. A survey design was chosen because it enables the collection of information from a large group of students through questionnaires, which helps to understand their usage patterns of statistical packages in learning statistics.[76] Surveys are particularly suitable for understanding behaviours, perceptions, and attitudes within a specific group, such as university students.

The population of the study consisted of all undergraduate students of the B.Sc.(Ed.) Statistics/Computer Science programme (in the Department of Mathematics Education) at Joseph Sarwuan Tarka University, Makurdi, Nigeria, who are enrolled in statistics-related courses. The total population included both third-year and final-year students, who had taken at least one course in statistics. The choice of this population was based on their exposure to statistical packages and their experience in using these tools for learning.

A stratified random sampling technique was used to select a sample from the population. This method ensured that different groups (strata) of students were represented in the sample. The sample size was determined using a sample size formula for finite populations, ensuring that it is large enough to provide reliable results. A total of 150 students were selected from the Department, ensuring good representation across the different academic years.

The primary instrument for data collection was a structured questionnaire designed by the researchers from existing literature to gather information on the students' utilization of statistical software in learning statistics. The questionnaire consisted of three sections, with section A covering students' personal information, B containing items on utilization of statistical packages, while C containing items on the challenges of using statistical packages. Items in sections B and C are positively scored on four-point Likert scale responses starting from Strongly Agree = 4, Agree = 3, Disagree = 2, to Strongly Disagree = 1. An item is considered significant if it has a mean score of 2.50 or above.

To ensure the validity of the instrument, the questionnaire was subjected to face and content validity checks. The instrument was reviewed by experts in the field of Statistics Education and Research Methodology to ensure that the questions are relevant, clear, and capable of measuring the intended variables. The experts' comments were used to modify the instrument to ensure that it measured what it was intended to measure.

The reliability of the instrument was assessed to ensure the clarity, accuracy, and consistency of the questionnaire items. To test its internal reliability, the questionnaire was administered to a small sample of respondents from the target population who were not part of the sample of the study. Using the Cronbach Alpha, a reliability coefficient of 0.78 was obtained, implying an acceptable measure of internal consistency.

Data were collected by administering the structured questionnaire to the selected sample of students. The questionnaires were distributed during class sessions, and the students will be given ample time and assistance to complete them. The questionnaires were collected immediately after they were completed.

The data collected was analyzed using both descriptive statistical techniques. Specifically, descriptive statistics of mean and standard deviation were used to summarize the responses from the students regarding their utilization of statistical packages.

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[73] Liliia V Pavlenko, Maksym P Pavlenko, and Vitalii H Khomenko, "Teaching Statistics to Future Programmers Using Real Data Sets and R Programming Language," in *CEUR Workshop Proceedings*, 2024, 102–17.

[74] Dawn L Denny et al., "Teaching Statistics Online: Comparing Competency-Based and Traditional Learning," *Teaching and Learning in Nursing* 19, no. 1 (2024): e170–75.

[75] García, Monterrubio, and Martínez, "Minitab as a Didactic Resource for Teaching Statistics at Higher Education Level"; Alaa Althubaiti and Suha M Althubaiti, "Flipping the Online Classroom to Teach Statistical Data Analysis Software: A Quasi-Experimental Study," *SAGE Open* 14, no. 1 (2024): 21582440241235024.

[76] Joshua Abah Abah, "Research Practice and Ethics in Mathematics Education" (Joshua Abah ABAH, 2020).

The study adhered to ethical standards in research. Informed consent was obtained from all participants before data collection, ensuring that they understood the purpose of the study and their voluntary participation. The anonymity and confidentiality of the participants were maintained throughout the research process, and the data was used only for academic purposes. Additionally, participants were allowed to withdraw from the study at any time without facing any negative consequences. Ethical approval was also obtained from the relevant authority at the University before the commencement of the study.

PRESENTATION OF FINDINGS

The results of this study are presented according to the research questions.

Research Question One

What is the level of utilization of statistical packages by mathematics education undergraduate?

Table 1: Level of Utilization of Statistical Packages

S/No.	Items	N	Mean	SD	Remark
1	I regularly use statistical packages to complete assignments in statistics.	150	2.98	1.090	Agree
2	I understand how to operate statistical packages such as SPSS, R, or Python for my studies.	150	2.93	1.001	Agree
3	Statistical packages make learning statistics easier and more efficient.	150	2.99	1.087	Agree
4	I rely on statistical packages to analyze data for class projects.	150	2.95	1.087	Agree
5	The university provides adequate resources for students to access statistical software.	150	2.79	1.087	Agree
6	I feel confident in my ability to use statistical packages without assistance.	150	2.88	1.090	Agree
7	My lecturers incorporate the use of statistical software in teaching statistics courses.	150	2.67	1.099	Agree
8	I have adequate time to practice using statistical software outside of class.	150	2.87	1.096	Agree
9	I use statistical packages more than traditional methods for solving statistical problems.	150	2.60	1.087	Agree
10	I actively seek opportunities to improve my skills in using statistical packages.	150	2.98	1.084	Agree
	Cluster Mean		**2.86**	**-**	**Agree**

Table 1 shows the level of utilization of statistical packages in learning by undergraduates of mathematics education. All the items in Table 1 were agreed with mean scores above the benchmark score. The cluster mean in Table 1 was found to be 2.86. This clearly shows that mathematics education students fully use statistical packages to solve statistical problems.

Research Question Two

What are the challenges mathematics education students face when using statistical software tools, and what are the suggested strategies for overcoming them?

Table 2: Challenges and Strategies

S/No.	Items	N	Mean	SD	Remark
1	Limited access to computers or the internet is a major barrier to using statistical packages.	150	3.57	1.099	Agree

2	High costs of statistical software deter students from using it effectively.	150	2.93	1.014	Agree
3	Lack of training in statistical software makes it difficult to use them.	150	2.97	1.090	Agree
4	There are insufficient workshops and tutorials on using statistical packages at the university.	150	2.99	1.099	Agree
5	Technical difficulties with statistical software discourage me from using them.	150	2.62	1.099	Agree
6	The university should prioritize statistical software as part of the curriculum.	150	2.97	1.087	Agree
7	Collaboration with peers helps me overcome challenges in using statistical packages.	150	2.88	1.084	Agree
8	Online resources and tutorials are helpful in learning statistical software.	150	2.98	1.090	Agree
9	Practical sessions in the lab improved my confidence in using statistical packages.	150	3.15	1.098	Agree
10	I believe the introduction of free or open-source statistical software can mitigate challenges.	150	2.87	1.087	Agree
	Cluster Mean		**2.90**	**-**	**Agree**

Table 2 shows the challenges students face when using statistical packages and suggests strategies to overcome them. All items in Table 1 were agreed with a mean score above the benchmark score. The cluster mean of 2.90 implies that mathematics education students accepted the stated challenges they face when using statistical packages and the suggested strategies for overcoming them.

DISCUSSION

The findings of this study are promising, as the results in Table 1 show an acceptable utilization of statistical packages by the students in the sample of this study. The outcome is understandable given the fact that the students are all enrolled in the B.Sc.(Ed.) Statistics/Computer Science programme (in the Department of Mathematics Education) at the West African University was used as the study location. This implies that the fundamentally science-oriented university provides adequate resources for students to access statistical software within the academic programme. Students accepted that they have access to operate statistical packages such as SPSS, R, or Python for their studies, particularly made available through the Statistical Computing Laboratory of the university. These outcomes agree with the findings of Li and Goos, which report how the teacher's intervention promoted learning and statistical thinking of students when using IT in a statistics classroom.[77] The results of the present survey indicated that appropriate technical support mechanisms played facilitating and supporting roles in students' statistics learning to foster a learning atmosphere, restructure learning tasks and provide feedback. This outcome is unlike the earlier findings of Mazouchová *et al.*, who unfortunately observed that the teaching methods used in various statistical courses are outdated and unattractive for most students.[78] This calls for an active and modern approach. Teaching statistics with the statistical software support seems to be the right way to make statistics accessible to students. The recommendation is to take into account the notion of the students when preparing statistical courses.[79]

As shown in Table 1, the students agreed that the lecturers incorporate the use of statistical software in teaching statistics courses. This is an indication of the right pedagogical practice within Statistics Education, as also reported by Dinov *et al.*, who observed successful instructional use of

[77] Ken W Li and Merrilyn Goos, "A Study on Students' Attitudes towards Teacher's Intervention in Statistical Computing Laboratory," in *Technology in Education. Transforming Educational Practices with Technology: First International Conference, ICTE 2014, Hong Kong, China, July 2-4, 2014. Revised Selected Papers* (Springer, 2015), 116–26.
[78] Mazouchová, Jedlicková, and Hlavácová, "Statistics Teaching Practice at Czech Universities with Emphasis on Statistical Software."
[79] Mazouchová, Jedlicková, and Hlavácová, "Statistics Teaching Practice at Czech Universities with Emphasis on Statistical Software."

conceptual simulations and statistical computing interfaces, which are designed to bridge the gap between the introductory and the more advanced computational and applied probability and statistics courses.[80] The findings of the present study also agree with Theobold and Hancock, whose in-depth interviews revealed three themes in students' paths towards computational knowledge acquisition: use of peer support, seeking out a singular "consultant," and learning through independent research experiences.[81] Like the items of the current study, these themes provide rich descriptions of graduate student experiences and strategies used while developing computational skills to apply statistics in their own research, thus informing how to improve instruction, both in and out of the formal classroom.

Mathematics education students in this study acknowledged that they use statistical packages more than traditional methods for solving statistical problems. They also actively seek opportunities to improve their skills in using statistical packages. These outcomes are pointers to the fact that a blend of all these educational technologies helped to enrich student understanding and satisfaction in learning statistical concepts.[82] Integrating theory with practice has become a mandatory requirement for modern university education, which requires the use of educational technology to supplement traditional pedagogical approaches to maintain undergraduate academic success. This outcome was also supported by Neumann *et al.*, whose earlier work affirmed that the discipline of statistics seems well-suited to the integration of technology to enhance student learning and engagement.[83] Evidently, statistical packages can be used to simulate statistical concepts, create interactive learning exercises, and illustrate real-world applications of statistics.[84] The results from Neumann *et al.*, showed three global effects of deploying statistical packages on student learning and engagement, namely, an improvement in the practical application of statistics, helped in understanding statistics, and addressed negative attitudes towards statistics.[85]

The findings alluding to a high level of utilization of statistical packages are unique and reassuring for quantitative educational research. However, these findings disagree with Dani and Al Quraan, who observed that research students' choice of research approach is affected by their attitude towards Statistics.[86] In the view of Dani and Al Quraan, many research students try to avoid applying quantitative methods in their research and prefer to rely on a qualitative research approach due to a lack of interest and confidence in statistical skills.[87] However, this present study established that mathematics education undergraduates are confident in using statistical packages. If research students' choice of research approach is affected by their attitude towards Statistics, it is hoped that the cohort from this study will be more quantitatively inclined. Sampson *et al.*, affirm this line of thought in their results, which revealed that the statistical package is useful to postgraduate students and is utilized among male and female postgraduate students.[88]

The results in Table 2 show the challenges mathematics education students face when using these software tools and suggest strategies for overcoming them. Just like Bromage *et al.*, these findings suggest that many of the key challenges stem from negative attitudes towards statistics coupled with poor motivation to study the subject, factors which are exacerbated by statistics anxiety.[89] Fortunately, because these challenges are so widespread and have attracted the attention of innovative educators across broad

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[80] Ivo D Dinov, Juana Sanchez, and Nicolas Christou, "Pedagogical Utilization and Assessment of the Statistic Online Computational Resource in Introductory Probability and Statistics Courses," *Computers & Education* 50, no. 1 (2008): 284–300.

[81] Allison Theobold and Stacey Hancock, "How Environmental Science Graduate Students Acquire Statistical Computing Skills," *Statistics Education Research Journal* 18, no. 2 (2019): 68–85.

[82] Verena Nolan and James Swart, "Undergraduate Student Perceptions Regarding the Use of Educational Technology–A Case Study in a Statistics Service Course," *EURASIA Journal of Mathematics, Science and Technology Education* 11, no. 4 (2015): 817–25.

[83] David L Neumann, Michelle M Neumann, and Michelle Hood, "Evaluating Computer-Based Simulations, Multimedia and Animations That Help Integrate Blended Learning with Lectures in First Year Statistics," *Australasian Journal of Educational Technology* 27, no. 2 (2011).

[84] Yarhands Dissou Arthur, Samuel Asiedu Addo, and Emmanuel Harris, "Statistical Software Packages (SSPs) Integration in Teaching and Learning of Statistics in Ghanaian Tertiary Institution," *Journal of Scientific Research and Reports* 7, no. 4 (2015): 257–65.

[85] Neumann, Neumann, and Hood, "Evaluating Computer-Based Simulations, Multimedia and Animations That Help Integrate Blended Learning with Lectures in First Year Statistics."

[86] Anita Dani and Elaine Al Quraan, "Investigating Research Students' Perceptions about Statistics and Its Impact on Their Choice of Research Approach," *Heliyon* 9, no. 10 (2023).

[87] Dani and Al Quraan, "Investigating Research Students' Perceptions about Statistics and Its Impact on Their Choice of Research Approach."

[88] Anayorchi Stanley Sampson, Banke Morufat Mutiu, and Afred Usenmfon Udoh, "Utilisation of Statistical Packages for Data Analysis among Post-Graduate Students in Universities in Rivers State," *Journal of Education in Developing Areas* 31, no. 2 (2023): 352–66.

[89] Bromage et al., "Teaching Statistics to Non-Specialists: Challenges and Strategies for Success."

disciplines, there is a wealth of good ideas and resources available to statistics teachers seeking ways to create effective learning experiences.[90] These challenges highlight the importance of providing thorough training and support for both students and educators to fully leverage the advantages of statistical packages in educational settings.[91]

As seen in Table 2, the respondents in this study believe that collaboration with peers helps them overcome the challenges in using statistical packages. Conducting a cooperative lesson typically involves making pre-instructional decisions about the lesson, explaining the task and cooperative structure to students, monitoring and, if necessary, intervening with each learning group, and, after the lesson, processing and evaluating student achievement.[92] In this regard, Ben-Zvi made a strong case for the use of Wiki to support collaborative learning experiences for students in the statistics classroom.[93] In the era of Industrial Revolution 4.0, teachers are required to facilitate learning that provides opportunities for students to develop essential skills needed in the real working world.[94] Employees need strong collaboration skills to work productively as a team to accomplish complex assignments. Project-Based Learning (PBL) is one of the learning models that gives opportunities for students to develop collaboration skills. Safarini describes how students' collaboration skills develop through PBL in statistics, enabling them to make substantive decisions based on group agreement, take an important role in implementing the project, and depend on each other to complete the project.[95]

Another strategy accepted by mathematics education students to overcome challenges to using statistical packages is the use of online resources and tutorials. This outcome agrees with DeVaney, who describes the evaluation of video tutorials used in a graduate-level online statistics course, with results suggesting that video presentations used as supplemental materials may provide instructional designers with a tool to create online courses that are as effective as traditional face-to-face courses.[96] Similar outcomes were earlier reported by Dinov *et al.*[97] Additionally, Yang presented outcomes favouring strategies such as case studies, video demonstrations, mini-projects and discussion forums.[98] Video demonstrations of statistical tests and procedures using SPSS were reported to be a helpful and effective instructional strategy in the online statistics class. Video demonstrations successfully achieved their intended purpose, teaching students how to perform different statistical procedures in SPSS, effectively replacing a face-to-face, hands-on lab session.[99] Similarly, Bliwise developed interactive Web-based tutorials as a supplement to lectures in an introductory statistics class, reporting findings that suggest Web-based tutorials can be an effective supplement to class lectures for enhancing student learning.[100]

Similarly, the respondents in this study applauded the availability of free or open-source statistical software for teaching and learning. Open-source statistical software addresses concerns about both cost and accessibility. Such programs are free to download and use across various operating platforms, avoiding recurring licensing costs. Secondly, open-source software may increase accessibility by allowing students to use their own devices. This potentially expands opportunities for students who are otherwise

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[90] Garfield and Ben-Zvi, *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice*; Mills and Raju, "Teaching Statistics Online: A Decade's Review of the Literature about What Works"; Joo and Spies, "Aligning Many Campuses and Instructors around a Common Adaptive Learning Courseware in Introductory Statistics"; Horton and Hardin, "Teaching the next Generation of Statistics Students to 'Think with Data': Special Issue on Statistics and the Undergraduate Curriculum."

[91] Tishkovskaya and Lancaster, "Statistical Education in the 21st Century: A Review of Challenges, Teaching Innovations and Strategies for Reform."

[92] Cary J Roseth, Joan B Garfield, and Dani Ben-Zvi, "Collaboration in Learning and Teaching Statistics," *Journal of Statistics Education* 16, no. 1 (2008).

[93] Dani Ben-Zvi, "Using Wiki to Promote Collaborative Learning in Statistics Education," *Technology Innovations in Statistics Education* 1, no. 1 (2007).

[94] T.L.S Desyarti Safarini, "Developing Students' Collaboration Skills through Project-Based Learning in Statistics," in *Journal of Physics: Conference Series*, vol. 1265 (IOP Publishing, 2019), 012011.

[95] Safarini, "Developing Students' Collaboration Skills through Project-Based Learning in Statistics."

[96] Thomas A DeVaney, "Impact of Video Tutorials in an Online Educational Statistics Course," *Journal of Online Learning and Teaching* 5, no. 4 (2009): 600–608.

[97] Dinov, Sanchez, and Christou, "Pedagogical Utilization and Assessment of the Statistic Online Computational Resource in Introductory Probability and Statistics Courses."

[98] Yang, "Instructional Strategies and Course Design for Teaching Statistics Online: Perspectives from Online Students."

[99] Yang, "Instructional Strategies and Course Design for Teaching Statistics Online: Perspectives from Online Students."

[100] Nancy Gourash Bliwise, "Web-Based Tutorials for Teaching Introductory Statistics," *Journal of Educational Computing Research* 33, no. 3 (2005): 309–25.

limited to campus computer lab sessions.[101] In this respect, the findings of this study support earlier work of Stemock and Kerns, who observe that students taught using R (open-free source) earned slightly higher grades overall than those in the SPSS (commercial) class, with the software R being recommended more strongly for future use in a statistics course than the software SPSS.[102] Evidently, these findings provided some insights into the use of different software packages in statistics education, which might support the use of free software in teaching statistics at the higher education level.[103] Similar outcomes were reported by Sidou and Borges, who provided a series of examples that students used to carry out Principal Component Analysis (PCA) in R-Project, a free and open-source software program.[104] Paura and Arhipova provide further details on the advantages and disadvantages of professional and free software for teaching statistics.[105] Shepherd and Richardson pointed to ease of download, quality of online instructions, availability of instructor resources, sophistication of analyses available, ease of use, operating system requirements, whether it uses point-and-click or code, and whether a VPAT (Voluntary Product Accessibility Template) is available as useful criteria for making decisions on the choice of statistical packages.[106]

Implications for Curriculum in the Era of the Fourth Industrial Revolution

In an era where data analysis skills are essential across numerous disciplines, statistical literacy has become a crucial component of Mathematics education. Statistical packages, such as SPSS, R, and Python, play a significant role in enhancing students' ability to analyze, interpret, and visualize data effectively. However, despite the integration of these tools into many educational programs, there appears to be a gap in their utilization across many academic institutions.[107] Although the findings of this study support a positive level of utilization, many other studies confirm a gross lack of statistical skills among undergraduates being prepared for the 21st century workforce.[108] Observations suggest that students may lack the skills, interest, or adequate support needed to use statistical software effectively in their study of statistics.[109]

As Slootmaeckers *et al.* observed, quantitative skills are important for studying and understanding social reality. Fear of statistics has often been listed among the major causes of this problem.[110] This present study joins an ongoing effort to advocate the integration of quantitative material into non-methodological courses to tackle the influence of dispositional, course-related and person-related factors on the attitudes towards statistics among students, to improve the learning and retention of statistics skills.[111] This advocacy pushes for a curriculum-wide approach to normalise the use of quantitative methods that will not only foster interest in statistics but also foster retention of the acquired skills. Moore has recommended that Statistics can serve as a model for teaching that builds on applications and applies technology, and as a model for outreach via consulting services, campus connections, and joint appointments. Technology in the saddle, as canvassed in the present study.[112] It is, of course, technology that is driving all the trends we are watching. Technology has changed statistics, so the field has moved

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[101] Melissa A Shepherd and Elizabeth J Richardson, "Opting for Open-source? A Review of Free Statistical Software Programs," *Teaching Statistics* 46, no. 1 (2024): 53–63.
[102] Stemock and Kerns, "Use of Commercial and Free Software for Teaching Statistics."
[103] Stemock and Kerns, "Use of Commercial and Free Software for Teaching Statistics."
[104] Laís Feltrin Sidou and Endler Marcel Borges, "Teaching Principal Component Analysis Using a Free and Open Source Software Program and Exercises Applying PCA to Real-World Examples," *Journal of Chemical Education* 97, no. 6 (2020): 1666–76.
[105] Liga Paura and Irina Arhipova, "Advantages and Disadvantages of Professional and Free Software for Teaching Statistics," *Information Technology and Management Science* 15, no. 1 (2012): 9–64.
[106] Shepherd and Richardson, "Opting for Open-source? A Review of Free Statistical Software Programs."
[107] Ben-Zvi, "Using Wiki to Promote Collaborative Learning in Statistics Education"; Roseth, Garfield, and Ben-Zvi, "Collaboration in Learning and Teaching Statistics."
[108] Koen Slootmaeckers, Bart Kerremans, and Johan Adriaensen, "Too Afraid to Learn: Attitudes towards Statistics as a Barrier to Learning Statistics and to Acquiring Quantitative Skills," *Politics* 34, no. 2 (2014): 191–200.
[109] Eva G Makwakwa, David Mogari, and Ugorji I Ogbonnaya, "First-year Undergraduate Students' Statistical Problem-solving Skills," *Teaching Statistics* 46, no. 1 (2024): 8–23; Garfield and Ben-Zvi, *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice*.
[110] Slootmaeckers, Kerremans, and Adriaensen, "Too Afraid to Learn: Attitudes towards Statistics as a Barrier to Learning Statistics and to Acquiring Quantitative Skills."
[111] Slootmaeckers, Kerremans, and Adriaensen, "Too Afraid to Learn: Attitudes towards Statistics as a Barrier to Learning Statistics and to Acquiring Quantitative Skills."
[112] David S Moore, "Undergraduate Programs and the Future of Academic Statistics," *The American Statistician* 55, no. 1 (2001): 1–6.

somewhat away from mathematics back toward its roots in data analysis and scientific inference.[113] Technology is driving demand for quantitative skills, including statistical skills. Technology is now the most important tool for all sciences and applied sciences, displacing both mathematics and statistics from traditional roles. Mathematics advances largely from within and will survive. Statistics is inherently methodological, and so is under threat if students do not master statistical computing.

The findings of this study argue for the strong pedagogical advantages of using statistical software packages in improving the teaching and learning of statistics-related courses at the undergraduate level.[114] The Fourth Industrial Revolution (Industry 4.0 or 4IR) has given educators what might be the greatest responsibility of our time: to evolve teaching strategies so that they can unlock individual student potential and prepare students with the skills needed to shape the future through innovation supported by technology. This implies that research supervisors develop their own background, experience, perceptions of their own statistical knowledge, the capabilities of their students, and their own attitudes towards the provision of statistical support for students.[115] According to Baglin *et al.*, most supervisors described themselves as having an intermediate or advanced level of statistical experience and were moderately to very confident supervising students in relation to statistical matters.[116] In contrast, supervisors identified a substantial discordance, or gap, between research students' statistical knowledge, which they rated at an overall introductory or lower level, and the requirement to have at least an intermediate level of statistical knowledge to complete their degree.[117] The findings of Baglin *et al.* suggest that supervisors perceive research students' statistical knowledge to be underdeveloped, that both students and supervisors are likely to benefit from the provision of formal statistics training and that supervisors value access to statistical consultancy services.[118]

When thinking of preceding industrial revolutions, it's important to note the correlation of workplace needs with education. The First Industrial Revolution used power generated by water and steam to produce goods that required of physical labour. The Second Industrial Revolution used electricity and assembly lines for mass production run by skilled labour educated with higher-learning techniques. The Third Industrial Revolution used computers, data, and information technology (IT) to automate production through the rise of smart machines and the people who could program them. The advent of the Fourth Industrial Revolution (4IR), characterized by the fusion of technologies that blur the lines between the physical, digital, and biological spheres, has profound implications for education. One significant area affected is the integration of statistical packages into academic curricula. As data becomes central to decision-making in fields ranging from health, finance to engineering, the ability to process, analyze, and interpret data through statistical software is no longer a niche skill but a core competency.[119] Consequently, educational institutions must re-evaluate their curricula to embed these tools early and effectively.

Statistical packages such as R, SPSS, SAS, Python (with libraries like pandas and NumPy), and even Excel are essential for handling large datasets and conducting complex analyses. In the context of the 4IR, where data science, machine learning, and artificial intelligence are dominant, students need hands-on experience with these tools to remain competitive.[120] Integrating such software into the curriculum not only enhances students' technical proficiency but also prepares them for interdisciplinary applications of statistics in real-world scenarios.[121]

[113] Moore, "Undergraduate Programs and the Future of Academic Statistics."
[114] Babagana Mala Musti and Ahmed Mallum, "Impact Of Statistical Software Application In Teaching Econometrics On Students'learning Achievements," *Journal of Arid Zone Economy* 1, no. 2 (2023): 162–71.
[115] James Baglin, Claire Hart, and Sarah Stow, "The Statistical Knowledge Gap in Higher Degree by Research Students: The Supervisors' Perspective," *Higher Education Research & Development* 36, no. 5 (2017): 875–89.
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[121] Enriqueta Reston, "An Outcome-Based Framework for Technology Integration in Higher Education Statistics Curricula for Non-Majors," *Technology Innovations in Statistics Education* 7, no. 2 (2013).

Moreover, the inclusion of statistical packages in the curriculum supports a shift from rote learning to experiential and inquiry-based learning. Students can engage in projects that involve real-time data collection, processing, and visualization. This practical approach fosters critical thinking, problem-solving, and decision-making skills, which are highly valued in the 4IR workforce.[122] Additionally, learning through statistical packages cultivates adaptability, as students become familiar with tools that are frequently updated and require continuous learning.

However, the implementation of statistical software in curricula also presents challenges. These include the need for adequately trained educators, access to technological infrastructure, and the risk of over-reliance on software without a solid understanding of statistical theory.[123] Institutions must therefore balance teaching tool-based competencies with foundational knowledge. Professional development programs for instructors and investments in digital infrastructure are crucial to bridge this gap. Industrial cooperation and educational partnership are important to establish trust in future employability and the best education for the fourth industrial revolution will be delivered in partnership with society, industry, employers and the government.[124]

This study has demonstrated that the implications of statistical packages for curriculum development in the Fourth Industrial Revolution are far-reaching. They signal a necessary transformation in education, aligning it with the demands of a data-driven world.[125] By equipping students with statistical software skills, educators empower them to navigate complex systems, drive innovation, and contribute meaningfully to the digital economy.[126] However, to fully realize these benefits, systemic support and thoughtful curriculum design are essential.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proffered. To ensure optimal utilization of statistical packages by undergraduates, institutions should prioritize early and consistent exposure through their curriculum. Introducing students to statistical software such as SPSS, R, Python, or Stata in the first or second year of study allows them to build familiarity over time. Courses should integrate practical assignments that require students to use these tools for data analysis, helping to reinforce theoretical concepts with hands-on experience. Providing access to licensed software or open-source alternatives along with instructional support encourages frequent use and skill development.

Faculty should incorporate blended teaching methods that combine traditional instruction with technology-enhanced learning. Workshops, tutorials, and lab sessions tailored to specific statistical packages can bridge the gap between conceptual understanding and technical proficiency. Instructors should emphasize real-world applications, allowing students to analyse datasets relevant to their field of study. Additionally, assessments should evaluate both the correctness of statistical outputs and the interpretation of results to promote critical thinking.

Support structures such as peer-led study groups, tutoring, and online forums can further enhance learning outcomes. Encouraging collaborative projects where students use statistical packages to solve research questions promotes teamwork and shared learning. Furthermore, universities should provide access to online resources, such as video tutorials and manuals, and maintain up-to-date software labs. With these strategies, undergraduates can gain confidence and competency in using statistical tools, preparing them for academic research and professional careers.

To overcome challenges in using statistical packages, universities must address the common barriers faced by undergraduates, such as a lack of prior exposure, limited technical skills, and fear of complex software. This can be mitigated by integrating foundational training in statistical software early in academic programs, accompanied by user-friendly guides and step-by-step tutorials. Instructors should adopt a

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[122] Hardin et al., "Data Science in Statistics Curricula: Preparing Students to 'Think with Data.'"

[123] Mine Çetinkaya-Rundel and Colin Rundel, "Infrastructure and Tools for Teaching Computing throughout the Statistical Curriculum," *The American Statistician* 72, no. 1 (2018): 58–65.

[124] Kehdinga George Fomunyam, "Education and the Fourth Industrial Revolution: Challenges and Possibilities for Engineering Education," *International Journal of Mechanical Engineering and Technology* 10, no. 8 (2019): 271–84.

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[126] Georg Spöttl and Lars Windelband, "The 4th Industrial Revolution–Its Impact on Vocational Skills," *Journal of Education and Work* 34, no. 1 (2021): 29–52.

gradual learning approach, starting with basic operations and gradually introducing more complex analyses. Providing access to practice datasets and encouraging experimentation in a low-pressure environment can help students build confidence and reduce anxiety around using statistical tools.

In addition to curriculum enhancements, institutions should invest in support systems such as help desks, tutoring services, and peer mentoring programs focused on statistical software. Encouraging collaborative learning and group projects allows students to learn from one another and troubleshoot challenges collectively. Regular workshops and refresher courses can also help students stay engaged and improve their proficiency. Moreover, ensuring that students have access to free or institutionally licensed software reduces financial barriers and promotes equal opportunity for skill development. By addressing both technical and psychological obstacles, students are more likely to engage meaningfully with statistical tools in their academic work.

In the context of the Fourth Industrial Revolution, curricula must evolve to emphasize data literacy and digital proficiency, with statistical packages playing a central role. Undergraduate programs should integrate statistical software training across disciplines – not just in mathematics or statistics courses, but also in fields like business, health sciences, and social sciences. This ensures that all students, regardless of their major, develop the analytical skills needed to navigate data-driven environments. The curriculum should balance theoretical instruction with practical, technology-based applications, enabling students to use statistical packages for tasks such as predictive modelling, data visualization, and real-time data analysis.

Furthermore, the curriculum should promote interdisciplinary learning by combining statistics with areas such as artificial intelligence, machine learning, and big data analytics. Incorporating project-based learning that leverages real-world datasets allows students to solve complex problems using modern tools, preparing them for the demands of the digital workforce. Educators must be trained and equipped to teach these evolving technologies, and institutions should collaborate with industry partners to ensure that curricula remain aligned with emerging trends and technologies. These adjustments will ensure that graduates are not only statistically competent but also adaptable and competitive in the rapidly changing technological landscape.

CONCLUSION

This study focused on the use of statistical packages in learning by undergraduate mathematics education students from a West African university. The research discovered from existing works that statistical packages are widely used in various academic fields, including social sciences, business, engineering and natural sciences. They offer a range of tools and functions for data analysis, visualization, and interpretation, making it easier for students to work with complex datasets and produce meaningful results.

The findings of the study indicate that mathematics education students fully use statistical packages in solving statistical problems while accepting the prevalence of certain challenges they face when using statistical packages. Undergraduates overcome the challenges of using statistical packages through a combination of structured learning, peer collaboration, and practical application. Many institutions, such as the one used in this study, now incorporate hands-on workshops, tutorials, and blended learning approaches that break down complex functions into manageable tasks, allowing students to gradually build confidence. Peer support and group projects encourage knowledge sharing and problem-solving, while access to online resources such as forums, video tutorials, and open-source documentation helps students troubleshoot issues independently. Additionally, integrating statistical packages into real-world research assignments motivates students to persist through difficulties, as they see the relevance and impact of their analytical skills in action, within the context of the Fourth Industrial Revolution.

In the Fourth Industrial Revolution, statistical packages are crucial for curriculum development, as they enable data-driven decision-making, improve analytical skills, and prepare students for future jobs requiring advanced data handling. This is important because 4IR emphasizes data analytics, machine learning, and artificial intelligence, making statistical proficiency a key asset. Statistical packages help educators understand student performance, identify learning gaps, and tailor instruction. This data-driven approach allows for more effective curriculum design and assessment, ensuring alignment with emerging industry needs. Incorporating the use of quantitative statistical packages across the curriculum helps students gain proficiency in data analysis, interpretation, and visualization, essential skills for the 4IR workforce. This prepares them to solve complex problems, make informed decisions, and contribute to innovation. This also translates into a future-ready workforce. The ability to analyse and interpret data is highly sought after in various industries, from manufacturing to healthcare. Statistical packages equip students with the skills needed for data-driven roles in the 4IR economy.

The deliberations of this study highlight the need to address the existing skills gap. The 4IR demands a workforce that can not only operate technology but also understand and interpret the data it generates. Statistical packages help bridge the skill gap by providing practical training in data analysis and interpretation.

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