Integrating Excel in Statistics Instruction: A Study of Learners' 21st Century Skills and Performance

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Abstract- This study examined the effect of integrating Microsoft Excel in teaching statistics on learners' 21st century skills (21CS) and academic performance. Conducted in the Luapula province of Zambia from March to April 2023, the study followed a quasi-experimental design involving 59 Grade 11 learners at Mwense Secondary School. The experimental group received Excel-assisted instruction, while the control group was taught using conventional methods. Data collection involved a 5-point Likert scale survey and a statistics test. Prior to the intervention, both groups completed a diagnostic assessment, confirming similar levels of 21CS and statistics knowledge. After the intervention, a post-test and Likert scale were administered. Mann-Whitney and correlation tests were conducted using SPSS v27.0. Results indicated a significant improvement ($p < .001$) in the scores of learners taught with Excel ($M = 82.27\%$, $SD = 3.38$) compared to those taught conventionally ($M = 39.23\%$, $SD = 4.12$). Therefore, the experimental group demonstrated stronger 21CS than the control group. However, no significant difference was observed between the average scores of the experimental group ($M = 83.17\%$, $SD = 9.188$) and the control group ($M = 82.00\%$, $SD = 8.952$) ($p = 0.214$), suggesting that both instructional methods yielded high overall scores. No significant correlation was found between learners' performance and their 21CS ($p = 0.657$).

Index Terms- MS-Excel, Excel-assisted Statistics Instruction, Statistics, Twenty-first Century Skills, performance.

I. Introduction

The quality of teaching and learning directly influences learners' skills and academic performance, shaped by classroom activities that teachers design and facilitate. Effective mathematics instruction actively engages learners and increasingly incorporates computer technologies to enhance learning outcomes (Mulle, 2023). Research suggests that integrating technology into mathematics education can foster 21st century skills (21CS) and improve academic performance.

Zambia is one of the African nations that has recognized the importance of technology integration in education to enhance teaching and learning quality. In 2007, the Ministry of Communications and Transport launched the National ICT Policy which emphasized the role of technology in education. The policy aimed to equip learners with essential information and technology literacy skills. It involved modernizing education delivery, promoting technology literacy among teachers, and introducing computer technologies and internet access in classrooms (MoCT, 2006). Despite these objectives, the policy lacked guidelines to address implementation challenges. To address this gaps, the Ministry of Education developed a draft ICT policy specific to education and an implementation framework. In 2009, the ICT Act was enacted to establish a legal and regulatory foundation for these changes (Policy Brief, 2010). However, the act did not include initiatives to raise awareness about the importance of using technology in schools. To promote technology integration in education, the Zambian government, through the Ministry of Education, collaborated with organizations such as AfriConnect, One World Africa, UNESCO, SchoolNET, Linknet, and Computers for Zambia Schools Trust (Mtanga et al., 2012). Partnerships were also formed with mobile network providers (MTN, Airtel, and Zamtel), Multichoice, Zambia National Broadcasting Corporation (ZNBC), and Zambia Information and Communications Technology Authority (ZICTA) to facilitate the use of technologies like television, radio, computers, mobile phones, and the internet in education. These efforts provided learners and teachers with access to digital learning resources and examination results, promoting a more modernized and technology-supported educational environment.

In 2013, Zambia revised its national education curriculum from a content-based to a competency-based framework, this aimed to equip learners with skills and knowledge essential for 21st century. The revision included introduction of Creative & Technology Studies and computer studies at primary and secondary levels, respectively. Additionally, a "Computer and Calculator" topic was incorporated into the senior secondary mathematics syllabus, and ICT courses were introduced in teacher training programs. These updates aligned with the objective of National ICT Policy that is to foster 21CS (CDC, 2020). To further enhance educational quality, the Ministry of Education adopted STEM education initiatives across selected schools at national, provincial, and district levels (CDC,

2020). Supporting this effort, several key documents were published in 2020, including the Guide for Implementation of STEM School Education, Strategic Note on the Implementation of STEM Education, and National Science, Technology and Innovation Policy. The Education Technology Integration Master Plan, an updated version of the National ICT Policy, was also introduced to accelerate computer technology integration in teaching, preparing learners with 21st century skills and knowledge (National Assembly of Zambia, 2021).

Despite these resources and reforms, Zambia's education system struggles to equip high school graduates with 21CS essential for success in today's workforce (Plecher, 2020; World Bank, 2017; SEACMEQ, 2011; UNESCO, 2005). This gap in skill development contributes to high unemployment rates, as graduates often lack the competencies necessary for personal, professional, and entrepreneurial success (Larvin & Larvin, 2011; Gravemeijer et al., 2017; Policy Brief, 2010; Zambia Statistics Agency, 2022). This is partly attributed to conventional teaching methods, particularly in mathematics, where conventional approaches fail to support 21CS development (Mwape & Musonda, 2014; Changwe & Mwanza, 2019).

Incorporating tools like Microsoft Excel into mathematics instruction offers a promising solution. Excel encourages interactive, personalized, and practical learning experiences. Therefore, it can enhance learners' understanding of statistical concepts and foster positive learning outcomes. By contrast, conventional mathematics instruction often overlooks technology, focusing heavily on manual calculations with pen and scientific calculators. This conventional approach burdens learners with memorizing statistical definitions, formulas, and procedures, increasing cognitive load and making statistics challenging to understand (Larwin & Larwin, 2011; Jatnika, 2016). Consequently, the lack of 21CS proficiency can negatively impact performance in mathematics, particularly in statistics (Smit, 2016; Tishkovskaya & Lancaster, 2012).

This study aimed to investigate the effect of integrating Excel in statistics instruction on learners' academic performance and 21st century skills, specifically, communication skills, information literacy, technology literacy and statistical literacy. Additionally, it explored the relationship between learners' 21CS and their academic outcomes in statistics.

II. LITERATURE REVIEW

The integration of 21st century skills into the curriculum is a critical area of focus in education research. Voogt and Roblin (2010) analyze the definitions and implementation of 21st century curricula, they emphasized the need for these skills in modern education. However, their review falls short of providing specific guidance for mathematics, particularly in statistics instruction. Yelland, Diezmann, and Butler (2008) presented the role of technology literacy as a gateway to acquiring 21st century skills by highlighting its significance in classroom success. Similarly, Haan et al. (2020) and Viering and Lai (2012) argue for the dual role of technology as both a teaching tool and a means of learning 21st century skills.

Studies by Hysa (2014), Tan et al. (2017), and Pineida (2011) advocate for the integration of technology into subject instruction, asserting that 21st century skills cannot be developed in isolation. This perspective is supported by Suson (2019), who emphasized the interconnected nature of these skills and the reinforcement they provide when taught collectively. Alismail and McGuire (2015) expand on this notion, proposing a 21st century curriculum that incorporates critical thinking, problem-solving, and technology literacy within core subjects such as mathematics. They recommend innovative teaching methods such as problem-based and cooperative learning to enhance both subject knowledge and skill acquisition. Handajani et al. (2018) further argue for a pedagogical shift from knowledge reproduction to knowledge creation, facilitated by technology and real-life activities. Lee and Hung (2012) support the integration of real-life activities in mathematics classrooms, enabling learners to contextualize theoretical concepts. Unfortunately, traditional teaching methods often hinder such integration, as they focus primarily on abstract and textbook-based learning (Voogt et al., 2013).

Voogt et al. (2013) recommend constructivist approaches, such as problem-based and experiential learning, to implement 21st century teaching and learning. They stress embedding technology literacy within subject knowledge to bridge the gap between classroom learning and real-life application. Mikre (2011) and Moore (1997) highlighted the potential of technology in engaging learners with real-life problems, particularly in statistics. However, they caution against focusing solely on technological tools and advocated for a balanced approach where technology enhances statistical understanding without overshadowing fundamental concepts. Chalkiadaki (2018) and Rosdiana et al. (2020) proposed combining constructivist approaches like problem-based and cooperative learning to develop both mathematical knowledge and 21st century skills. Gravemeijer et al. (2017) emphasize the shift in mathematics education goals toward equipping learners with skills relevant to the global economy, yet they call for further exploration of practical applications in teaching statistics.

Chance et al. (2007) demonstrate the benefits of using computer technologies for statistical education, including data visualization, analysis, and interpretation. Katz et al. (2006) argue for incorporating cognitive theory into software design to enhance statistical concept understanding. In low- and middle-income countries, study by Bakaye and Ehren (2021) identifies factors for successful Computer-Assisted Instruction (CAI), such as technological trust and teacher capacity. Studies by Basturk (2005) and Higazi (2002) compared traditional and technology-based teaching methods, advocating for a hybrid approach. Chaamwe and Shumba (2016) investigated versatility of MS Excel as an e-learning tool for teaching statistics, they highlighted its interactive and exploratory capabilities.

The studies reviewed shows the significance of integrating technology into mathematics education. However, specific strategies for applying tools such as MS Excel in developing 21st century skills in secondary school statistics remain underexplored. While studies emphasize innovative pedagogies and the role of technology, practical guidance on balancing traditional and technology-based methods in statistics instruction is limited.

III. METHODS

This article presents partial findings from a broader study titled "Applicability of Microsoft Excel in Teaching Secondary School Statistics for Learners' Acquisition of 21st Century Skills." The study was conducted at Mwense Secondary School in Luapula Province, Zambia, it involved Grade 11 learners of 2023 academic year. Grade level was purposefully chosen, and two groups, experimental and control, were randomly selected from four classes. The study used a quasi-experimental design. The experimental group was taught statistics with MS Excel, while the control group used conventional teaching method with scientific calculators as the only technology.

For the experimental group, lessons covered frequency tables, histograms, and descriptive statistics, with Excel facilitating tasks such as creating bar charts, pie charts, and histograms, calculating statistical measures (mode, median, mean, variance, standard deviation), and determining quartiles. The functions of Excel also enabled learners to generate class intervals, use formulas, and collaborate in individual and group tasks. In contrast, the control group was taught through conventional teaching method, where the teacher used a blackboard, chalk, and scientific calculator to explain concepts. Lessons followed tasks from the Grade 11 Progress Mathematics textbook by Chiyaka et al. (2016), with no Excel involvement; learners completed exercises manually.

A diagnostic assessment on 21CS and statistics knowledge was given to both groups before the intervention. Following the intervention, data was gathered through Likert-scale questionnaires, and a statistics test. Data analysis involved scoring with MS Excel and statistical analysis using SPSS V27.0, including descriptive statistics, the Mann-Whitney U test, and Spearman correlation. This article reports on the findings related to learners' performance, 21CS, and their relationship.

IV. RESULTS

A pre-test was administered and it was found that learners were at the same level in terms of 21CS and statistics knowledge before the intervention and that MS-Excel had fostered the acquisition of 21CS after the learning process (results have been published in another article (Kazika & Malambo, 2025)), a statistics test was administered to the two groups to determine learners' performance after the intervention.

Normality Test

Normality test was conducted to determine a reliable test for 21st Century and statistics test scores. One of the assumptions for parametric tests to be reliable is that the data must be approximately normally distributed. The results are presented in table 1.

Table 1. Normality Test Results

	Statistic	df	Sig	Normally Distributed
Performance	.137	59	.008	No
21st Century Skills	.253	59	<.001	No

The p-values of the results in table 1 were less than the alpha value (α=0.05), suggesting that the results were significant. Based on the results, it was concluded that the scores for performance and 21st century skills were not normally distributed. Since the data set for the scores did not achieve normality, Mann-Whitney and Spearman's correlation tests were performed.

Effect of applying MS-Excel on performance

A Mann-whitney U-test was performed on the test scores to determine the effect of applying Excel on the academic performance of learners in statistics. The results are presented in table 2.

Table 2. Man-whitney U test results

	test	Sig	Decision
The distribution of the post-test scores is the same across the two groups	Mann-whitney u test	.214	Retain null hypothesis

Since P-value is 0.214 in table 2, which is greater than 0.05, we do not reject the null hypothesis that the groups are not significantly different and conclude that at $\alpha = 0.05$ level of significance there is no significant difference between the experimental and control group. This means that the two groups of learners were same level in terms of academic performance after the learning process. Additionally, the descriptive statistics were also used to determine the level of in between the two groups. The mean scores are presented in table 3.

Table 3. Descriptive statistics Results (N=59)

Scores	Group	N	Mean	SD
Learner Performance	Experimental	29	83.17	9.188
	Control	30	82.00	8.952

Table 3 presents the descriptive statistics results, and it reveals that, on average, the learners in control group scored 82.00% (with a standard deviation of 8.952), whereas the learners in the experimental group scored slightly higher, at 83.17% (with a standard deviation of 9.188). The means for the two groups are almost the same. Therefore, the results of this test indicate that after the learning process, the average scores of the experimental group and the control group were not different. However, the two groups had higher scores, learners' performance was good for the experimental and control groups despite using Excel and conventional teaching approaches, respectively.

Effect of applying MS-Excel on 21st century Skills

Mann-Whitney U-test was performed on the learners' scores to confirm whether there is no significant difference in acquisition of 21CS between learners taught with Excel-assisted Statistics Instruction and those taught using conventional method. The results are presented in Table 4 below.

Table 4. Man-Whitney U test results

	Test	Sig	Decision
The distribution of the post-test scores is the same across the two groups	Mann-Whitney U test	<.001	Reject null hypothesis

Since the computed p-value is less than 0.001 (Table 4) which is also less than 0.05, the null hypothesis was rejected. It was therefore concluded that at $\alpha = 0.05$ level of significance there was a significant difference between the experimental and control groups. This means that the two groups of learners were not at the same level in terms of 21CS after the learning process. Descriptive statistics were also calculated to determine the difference in post-test questionnaire scores between the control and experimental groups. The mean and standard deviation scores relative to the two groups are presented in Table 5 below.

Table 5. Descriptive Statistics Results (N=59)

	Group	N	Mean	SD
Post-test	Experimental	29	82.28	3.378
	Control	30	39.23	4.122

Table 5 reveals that learners in the control group had a mean score of 39.23% (standard deviation 4.12) whereas those in the experimental group had a higher mean score (82.28%) and standard deviation 3.38. These statistics indicate that after the treatment and in the context of 21CS, learners in the experimental group had higher scores than those in the control group.

Relationship between Learner 21CS and Academic Performance

In order to determine the relationship between acquisition of 21CS and learners' performance, a non-parametric correlation test; Spearman rank test, was performed to assess the strength and direction of the relationship between learners' acquisition of 21CS and their performance in statistics. The results are shown in table 6.

Table 6. Correlations between 21st Century Skills and Performance (N=59).

		21st Century Skills	Academic Performance
21st Century Skills	Spearman's correlation	1	.060
	Sig. (2-tailed)		.657
Academic Performance	Spearman's correlation	.060	1
	Sig. (2-tailed)	.657	

The results in table 6 of a correlation test performed at α=0.01 showed that there was no significant relationship between the acquisition of 21CS and their performance in statistics test (sig. =0.657 > 0.01). The result of Spearman's rho correlation coefficient was 0.060, meaning that there was a positive but very weak relationship between the acquisition of 21CS and their academic performance. The results shows that there was no relationship between acquisition of 21CS and performance of learners in statistics.

V. DISCUSSION

Effect of applying Excel-Assisted Instruction on performance

The results showed no statistically significant difference in performance between the experimental group, which used MS Excel, and the control group, which relied on conventional teaching methods with calculators. Both groups performed well, with the experimental group slightly outperforming the control group. These results align with Gasigwa et al. (2022) and Chance et al. (2007), who recognized the supportive role of technology in teaching statistics but contrast with studies (e.g., Simutenda & Musonda, 2018) that found significant performance advantages with technology-enhanced learning.

However, a significant observation emerged when examining the performance on questions that required conceptual understanding. Notably, the control group struggled with a question related to interpreting the meaning of a small standard deviation. This indicates a limitation of the conventional approach in fostering conceptual understanding among learners, as evidenced by the lower performance of control group on this question. The results suggest that while conventional teaching methods may be suitable for mastering formulae and calculation procedures of statistics, they fall short in promoting a deeper understanding of underlying concept (Wiggins & McTighe, 2005; International Society for Technology in Education (ISTE), 2008). Applying MS-Excel positively influenced conceptual understanding among learners in the experimental group, as evidenced by high mean score and their performance on the question that required understanding and application of statistics concepts. Additionally, possible contamination between the groups may have influenced the results, as both were from the same boarding school, this may have allowed opportunities for the exchange of information. This factor could have contributed to the similarity in performance outcomes.

The study demonstrates that both MS Excel and conventional teaching methods can be effective in delivering statistical content. However, the role of technology in fostering conceptual understanding and practical application highlights its potential as an important instructional tool. These findings emphasize the need for assessments that go beyond procedural knowledge to evaluate deeper learning and application of statistical concepts. These findings support the results by Organization for Economic Co-operation and Development [OECD] (2019), which revealed that the 21st century brings new demands to educational assessment. While computational skills remain important, focusing solely on memorizing formulas and procedures is no longer enough (Partnership for 21st Century Skills [P21], 2009). The results confirm Pellegrino and Hilton's (2013) emphasis on the need for a broader approach to assessment, which must aim to measure not just how well learners can perform calculations, but also how they understand concepts and can apply their knowledge in various situations.

Effect of applying MS-Excel on Learners' acquisition of 21CS

The findings revealed a significant difference in scores between learners taught with MS Excel and those taught with conventional method. This suggests that after the learning process, the experimental group achieved a higher level of 21st century skills (21CS) than the control group. These results align with studies by Gravemeijer et al. (2017) and Suh and Seshaiyer (2013), which emphasize the effectiveness of technology in enhancing mathematics learning and skill acquisition.

Supported by findings from Changwe and Mwanza (2019), Cuadra (2021), Mulle (2023), Basturk (2005), Voogt et al. (2013), and Alismail and McGuire (2015), this study has emphasized the role of MS Excel in fostering 21CS. It was found that MS Excel engaged learners through real-life statistical problems, encouraged active and collaborative learning, and deepened their understanding of statistical concepts and skills. In addition, the constructivist learning which was supported by MS Excel facilitated 21CS development as learners actively participated in problem-solving and built knowledge through hands-on experience. Overall, integrating Excel into statistics instruction actively engaged learners and promoted essential 21CS.

Relationship between Learner 21CS and Academic Performance

The correlation test revealed no significant relationship between learners' 21CS and their performance in the statistics test. Additionally, the Spearman's rho correlation coefficient indicated a very weak positive relationship between 21CS acquisition and academic performance. These findings suggest no substantial connection between the two variables.

These result aligns with the findings of Bircan and Akman (2023), who similarly reported no significant relationship between 21CS and academic performance. However, it contrasts with the work of Smit (2016) and Tishkovskaya and Lancaster (2012), who found that a lack of 21CS could negatively affect performance in statistics. In contrast, studies by Rabi et al. (2022) and Onur and Kozikoglu (2020) demonstrated a positive correlation between subject knowledge and 21CS skills when computer software was integrated into learning.

VI. CONCLUSION

The study showed that there was a substantial difference in 21st century skills (21CS) between learners who were taught with MS Excel and those taught using conventional teaching method. The learners in the experimental group obtained higher scores than those in the control group. Findings of this study have also shown that there was no significant difference in terms of performance between learners who were taught with MS-Excel and those taught with conventional method. Results revealed that using MS-Excel in teaching secondary school statistics has no effect on learners' performance. Both groups performed well. The study proved that the learners' performance in statistics is high weather MS-Excel is used or not.

Although both groups performed well, the study did not find a significant difference in performance between the experimental and control groups, this indicate that both MS-Excel and conventional teaching methods can yield similar outcomes. However, the similarity in scores has been attributed to the type of test questions utilized in the statistics test. It was revealed that most questions in the test instrument assessed ability to recall formulae and statistical procedures and not understanding or application of statistical concepts. It was further noticed that learners in the experimental group performed well on the question which required understanding of the concepts. Furthermore, the relationship between learners' 21CS and their performance was found to be not significantly related. The results showed that learners' 21CS have no bearing on performance of learners in statistics.

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