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Applicability of Microsoft Excel in Teaching Secondary School Statistics for Learners' Acquisition of Twenty-first Century Skills.

A thesis submitted to the University of Zambia in fulfillment for the requirement of
Doctor of Philosophy in Mathematics Education

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DECLARATION

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APPROVAL

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ABSTRACT

The aim of this study was to investigate whether MS Excel Software is applicable in teaching secondary school statistics for learners' acquisition of 21CS. The research was conducted with grade 11 learners at Mwense Secondary School in Luapula Province, Zambia. The grade level was purposively selected, and the two study groups, experimental and control, were randomly chosen from four grade 11 classes. An embedded quasi-experimental design was utilized, and both qualitative and quantitative data were collected. The experimental group received statistics lessons using MS Excel, while the control group was taught statistics using conventional teaching method, with scientific calculators being the only technology used. A diagnostic assessment on 21CS was conducted on the two groups before the intervention, followed by a focus group discussion interview, Likert-scale questionnaires, and a statistics test after the intervention. Qualitative data were analyzed thematically, and MS Excel was used to score and organize the quantitative data. Descriptive statistics, independent sample t-test, Mann-Whitney U test, and Spearman test were performed using SPSS V27.0 during the data analysis.

It was found that there was a statistically significant difference ($\text{sig} < .001$) in the 21CS scores between the learners who were taught with MS Excel (Mean=82.27%, SD=3.38) and learners taught by conventional teaching method (Mean=39.23%, SD=4.12). The study revealed that using MS Excel in statistics lessons enhances learners' acquisition of 21CS. The results of this study were further confirmed by themes that emerged from the interview discussion. In this regard, MS Excel is applicable in teaching secondary school statistics for learners' acquisition of 21CS. Moreover, acquiring 21CS was associated with positive learning experiences ($\text{sig.} = 0.000 < 0.01$). However, there was no significant effect of 21CS on learners' performance in statistics ($\text{sig.} = 0.657 > 0.01$). The study recommends improving computer and internet access, setting up well-equipped computer labs, and encouraging the use of MS Excel software in teaching statistics. Test and exam questions must assess both mathematical computational and reasoning. Future research could explore the influence of gender on acquiring 21CS with MS Excel, teachers' competencies in teaching with Excel, and their perceptions of its use in teaching mathematics, particularly statistics.

Key words: *Microsoft Excel, Statistics, Twenty-first Century Skills, learning experiences, performance.*

DEDICATION

This work is dedicated to my late father, Jonas Kazika, who was not only a good mentor but also a wise counsellor. He may be gone, but he will never be forgotten.

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LIST OF ACRONYMS

CAMFED	- Campaign for Female Education
CDC	- Curriculum Development Centre
CPD	-Continuous Professional Development
DEBS	-District Education Board Secretary
MoTC	- Ministry of Transport and Communications
MoGE	-Ministry of General Education
MS	-Microsoft
OECD	- Organization for Economic Co-operation and Development
PISA	- Programme for International Learner Assessment
P21	- Partnership for 21st Century Skills
SDG4	- Sustainable Development Goal number four
STEM	- Science, Technology, Engineering, and Mathematics
STEAM	- Science, Technology, Engineering, Arts, and Mathematics
SEACMEQ	- Southern and Eastern Africa Consortium for Monitoring Education Quality
SPSS	- Statistical Package for Social Sciences
TPACK	- Technological Pedagogical Content Knowledge
TPSK	- Technological Pedagogical Statistical Knowledge
ZNBC	- Zambia National Broadcasting Corporation
ZICTA	- Zambia Information and Communications Technology Authority
7NDP	-7th National Development Plan

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents an introduction to the study. It comprises the background to the study, the statement of the problem, purpose of the study, research objectives, research questions, research hypotheses, delimitations and significance of the study. The chapter also presents definitions of key terms as used in the study.

1.1 Background of the Study

The 21st century, often called the information and technology era, began in 2001 and will end in 2100 (Rosdiana et al., 2020). What sets this century apart from previous ones is the advancements in technology and the ease of accessing information. Fullan (2014) explains that to thrive in a society driven by information and technology, individuals must possess certain skills, such as critical thinking, problem-solving, communication, collaboration, efficient information retrieval, effective technology use, and statistical evaluation. These skills, known as 21st century skills (21CS) (Mills, 2002; P21, 2010; Micheals et al., 2017), are crucial in the current era of information and technology.

Today, technology is integrated into nearly every aspect of society, shaping how people think, learn, work, and live (Mtanga et al., 2012; Mulauzi et al., 2019). The prevalence of smartphones, social media, Google search, e-learning, and other electronic services exemplifies this revolution. Learning how to use technology is essential for literacy in the 21st century. Alvin Toffler's 1972 book "*Future Shock*" describes literate individuals of the 21st century as those who are proficient in technology. Tyner (1998) supports this view, stating that illiteracy in the 21st century refers to a lack of necessary technology skills.

Proficiency with technology is vital for success in the 21st century, as it underpins the development of knowledge-based societies that are crucial for social and economic progress (Masaiti et al., 2021; Policy Brief, 2010; Ministry of Transport and Communications [MoTC], 2006). Acquiring 21CS equips individuals to effectively participate in today's economies. Therefore, citizens must possess these skills in order to drive social and economic growth, as emphasized by Alismail and McGuire (2015); Bellanca and Brandt (2010). This implies that achieving Zambia's vision 2030

goal of becoming a prosperous middle-income country (7th National Development Plan [7NDP], 2017) depends on the population's technological abilities.

The educational system plays a critical role in developing the 21CS necessary for societal advancement and economic growth (Policy Brief, 2015). The curriculum establishes the path for adapting to 21st century society and emphasizes the effective incorporation of these skills (Partnership for 21st Century Skills [P21], 2010; UNESCO, 2005). The success of teaching and learning heavily relies on the pedagogy employed, aligning with the demands of a technology-driven world (Colin, 2017). The ongoing global revision of education curricula, seen in the works of Larvin & Larvin (2011), Gravemeijer et al. (2017), and Smit (2016), emphasizes the shift towards enhancing educational systems to meet current and future needs.

Research has shown that integrating computer technologies with subject knowledge is essential in implementing the 21st century curriculum and pedagogy, thereby facilitating progress towards Sustainable Development Goal number four (SDG4), which aimed to provide inclusive, equitable, quality, and lifelong education (Nyemba & Zulu, 2020).

1.1.1 Mathematics and Statistics Education in 21st Century

Mathematics Education is one of the subject areas that require attention in the 21st century due to the variety of skills it encompasses (Khalil & Alnatheer, 2020; Hysa, 2014). The emphasis in mathematics education is on critical thinking, problem-solving, hands-on learning, active participation, and the use of technology (Ministry of General Education [MoGE], 2019; Busaka & Mbewe, 2017; Hysa, 2014; Zambia Curriculum Development Centre [CDC], 2013). The goal of teaching mathematics is to develop learners who are critical thinkers, problem solvers, responsible citizens who can apply their thinking to real-life situations, and proficient in using computer technologies (CDC, 2019; Suh & Seshaiyer, 2013). The effective use of technology in teaching mathematics enhances learners' understanding of mathematical concepts, equipping them with the skills to thrive in the age of information and technology (Suh & Seshaiyer, 2013; Gravemeijer et al., 2017; Chalkiadaki, 2018). By incorporating computer technologies into mathematics instruction, learners' comprehension of the subject can be enhanced, promoting the development of 21CS (Hysa, 2014). Therefore, mathematics education is essential for fostering learners' acquisition of 21st century knowledge and skills (Khalil & Alnatheer, 2020; Gravemeijer et al., 2017; Ruiz-Primo, 2009).

Furthermore, advancements in technology have made accessing and sharing information easier (Tishkovskaya & Lancaster, 2012), resulting in an increase in statistical information (Levitin, 2016). Consequently, the ability to work with computer technologies and the internet has become a crucial skill in the 21st century (Mills, 2002). Therefore, a statistically literate population is necessary in the 21st century, with statistics playing a significant role in developing statistical literacy among citizens (Hoyles et al., 2010; Gravemeijer et al., 2017). Teaching statistics in secondary schools can help meet this demand by equipping learners with the skills to collect, present, and interpret data using technological tools such as MS Excel or statistical software like R and SPSS (CDC, 2013; Suson, 2019; MoGE, 2019). Thus, it is important for learners to have strong understanding of concepts, which can be achieved through working with computer software (Levitin, 2016; Tishkovskaya & Lancaster, 2012).

1.1.2 MS Excel as an Educational Statistical software

MS Excel is a widely-used and free spreadsheet software program (Cuadra, 2021). It offers a variety of features, formulas, and functions for organizing and presenting data, performing calculations, analyzing data, and creating visualizations. With its familiar spreadsheet layout and user-friendly menu, MS Excel makes data entry, calculations, and analysis easy for users (Mulle, 2023). Learners can input data into cells, create tables, and apply formulas for performing calculations. The software also provides a range of pre-built formulas for calculating descriptive statistics such as mean, median, mode, standard deviation, and variance. These functions allow learners to analyze datasets and obtain useful statistical information (Groebner et al., 2017). MS Excel's graphing capabilities enable learners to create visual representations of data, including charts, graphs, and plots. The formatting and customization features allow for visually appealing and informative graphs (Field, 2018). MS Excel is menu-driven, making it easy for learners to explore and use. The graphical user interface provides clear menus and options for users at all levels of proficiency and education (Gomez, 2014; Stemock & Kerns, 2019). As a result, MS Excel can be used to engage learners in real-life statistical problems and teach them relevant skills for the 21st century (Gomez, 2014; Chaamwe & Shumba, 2016). Teachers and learners can also create their own formulas in MS Excel, allowing for a more interactive learning experience and better understanding of the statistical concepts (Chaamwe & Shumba, 2016). Therefore, MS Excel is a suitable tool for teaching statistics in primary and secondary schools. By actively involving learners in statistical practice, MS Excel facilitates a deeper understanding of abstract concepts,

fosters the development of 21CS, and enhances the overall learning experience (Gasigwa et al., 2022). Its efficiency in performing calculations and creating tables and graphs allow learners to focus their attention on understanding the concepts and applying the skills (Gomez, 2014; Rahadyan et al., 2022; Borkulo et al., 2023). Researchers have argued that MS Excel improves the effectiveness of statistics teaching by promoting active learning, providing hands-on activities, encouraging cooperative learning, and enhancing conceptual understanding and skills (Lee et al., 2018; Cuadra, 2021; Gasigwa et al., 2022; Mulle, 2023). Therefore, incorporating MS Excel in the teaching of secondary school statistics provides learners with opportunities to develop essential skills.

1.1.3 Twenty-first Century Curricula

In order to integrate computer technologies such as MS Excel software into the mathematics curriculum, the introduction of STEM and STEAM curricula, as well as Education 4.0, has been implemented. The STEM curriculum focuses on equipping learners with 21st century knowledge and skills in four disciplines: science, technology, engineering, and mathematics (Clavert, 2020). In STEM, mathematics is taught by integrating science, technology, and engineering in a practical and interdisciplinary manner. The inclusion of arts in STEM to create the STEAM curriculum is another important approach to provide learners with relevant skills and knowledge for the 21st century (Taylor, 2017).

On the other hand, Education 4.0 (Edu 4.0) has been introduced to address the needs of the fourth industrial revolution, also known as Industry 4.0. Messais et al. (2018) define Industry 4.0 as the era of cyber-physical systems, where humans and technology merge, driven by advanced technologies such as programming software, big data technology, artificial intelligence, robotics, and the Internet of Things. Industry 4.0 is characterized by a preference for digital technology over physical resources to solve problems, communicate, and access information. Education 4.0, therefore, involves the use of advanced computer technologies in teaching mathematics, providing learners with practical-based learning experiences that align with STEM and STEAM curricula (Hussin, 2018; Lawrence et al., 2019).

These curricula (STEM, STEAM, and Edu 4.0) are argued to nurture learners with the necessary knowledge and skills for the modern world. It has been demonstrated that effective implementation of these curricula not only promotes the development of 21CS but also enhances the learning

experience and performance in mathematics, which has traditionally been poor (Peters et al., 2023; Lawrence et al., 2020; Messias et al., 2018; Taylor, 2017; Smit, 2016; Salas-Pilco, 2013).

To further support teachers of mathematics in effectively implementing these curricula in their classrooms, frameworks such as TPACK (Technological, Pedagogical, and Content Knowledge), 2T2C (thinking, technology, communication, and collaboration), Bridge21, and 21st century ICT models have been developed. These frameworks provide guidance on what mathematics teachers need to know and do to integrate technology into their teaching, as well as how learners should engage with technology in the 21st century classroom (Tangney et al., 2022; Bray, 2017; Ahmad et al., 2016; Warner, 2015; Zain & Balakrishnan, 2014; Mishra & Koehler, 2006).

1.1.4 Twenty-first Century Education in Zambia

Zambia is one of the countries in Africa that recognized the importance of integrating technology into the education system to ensure quality and lifelong learning. In 2007, the Ministry of Communications and Transport launched the National ICT Policy, which emphasized the need for technology integration in education. The goal was to equip learners with information and technology literacy to succeed in the 21st century. This involved modernizing the educational delivery system, incorporating technology literacy into teaching, and introducing computer technologies and the internet in classrooms (MoCT, 2006).

However, although the policy outlined these objectives, it lacked guidelines for addressing implementation challenges, and little progress was made in putting the policy into action. In response, the Ministry of Education developed a draft ICT policy specifically for education, along with an implementation framework. In 2009, the ICT Act was enacted to establish the necessary legal and regulatory framework to support these changes (Policy Brief, 2010). Unfortunately, the act was not accompanied by initiatives to raise awareness about the importance of using technologies in schools.

To raise awareness and promote the benefits of technology in schools, the government of Zambia, through the Ministry of Education, collaborated with various partners such as AfriConnect, One World Africa, UNESCO, SchoolNET, Linknet, and Computers for Zambia Schools Trust (Mtanga et al., 2012). Additionally, the ministry partnered with mobile network providers (MTN, Airtel, and Zamtel), Multichoice, ZNBC, and ZICTA to facilitate the use of technologies like television,

radio, computers, mobile phones, and the internet in the learning process, as well as accessing learning materials and examination results.

In 2013, the Zambia national education curriculum was revised. This included the introduction of Creative & Technology Studies and computer studies as subjects in primary and secondary schools respectively. Furthermore, the topic “Computer and Calculator” was incorporated into the mathematics syllabus at senior secondary school, and ICT courses were introduced in teacher training programs. These changes aligned with the goals of the National ICT Policy to promote 21CS (CDC, 2020).

To further promote the acquisition of 21CS, the Ministry of Education adopted STEM education for selected schools at national, provincial, and district levels (CDC, 2020). In 2020, documents such as the Guide for Implementation of STEM School Education, Strategic Note on the Implementation of STEM Education, Report on the Assessment of STEM Education Implementation, STEM Education Chapter Policy Document, Assessing Learning in STEM Education, and National Science, Technology and Innovation Policy were published to support and strengthen the teaching of STEM. The Ministry of Education also developed the Education Technology Integration Master Plan, an updated version of the National ICT Policy, which aimed to accelerate the integration of computer technologies in teaching and learning to prepare learners with 21CS (National Assembly of Zambia, 2021).

1.1.5 Application of MS Excel in Statistics Instruction for 21CS

Based on the information presented above, it is clear that computer technologies play a crucial role in developing 21st century skills in learners, regardless of the subject or topic being taught. These technologies can enhance critical thinking, problem-solving, collaboration, communication, digital literacy and many other skills, which are essential for academic success and future career readiness. In mathematics education, integrating technological tools can improve learners’ engagement, comprehension, computational and analytical abilities. Among these tools, MS Excel stands out as a widely accessible software, easy to use, and has data analysis and visualization functions. Learners can use in-built formulae and also create formulae on the spreadsheet, this makes it a potential resource for teaching statistical concepts. However, the extent to which MS Excel contributes to the acquisition of 21st century skills in secondary school learners remains unclear.

It is against this background that this study was conducted to investigate whether or not the application of MS Excel in teaching statistics can lead to improving learners' acquisition of 21C.

1.2 Statement of the problem

In today's rapidly changing world of information and technology, education systems should equip learners with 21st century skills (21CS) to prepare them for the modern workforce (Smit, 2016). Secondary school graduates should demonstrate proficiency in both hard and soft skills necessary for employment, entrepreneurship, and professional growth, which should enable them to contribute meaningfully to socio-economic development of the country. An effective education system should integrate innovative teaching approaches that enhance learners' ability to apply knowledge and skills in real-world situations.

However, Zambia's education system continues to fall short in achieving this goal. Many secondary school graduates exhibit low proficiency in essential 21CS, this makes it difficult for them to effectively compete in the job market, pursue entrepreneurship, or advance professionally (Mtanga et al., 2012). This has contributed to high unemployment rates and limited socio-economic engagement (Plecher, 2020; World Bank, 2017; Zambia Statistics Agency, 2022). One of the key factors behind this challenge is the continued reliance on conventional teaching methods in subjects such as mathematics (Changwe & Mwanza, 2019). These methods emphasize manual calculations and rote memorization while neglecting the integration of computer technologies in teaching practices (Musonda & Mwape, 2014). Consequently, topics such as statistics are often perceived as abstract, irrelevant, and difficult, leading to negative attitudes and poor conceptual understanding (Giesbrecht, 1996; Petocz, 2002).

To address this issue, integrating computer technologies, such as MS Excel, into constructivist teaching approaches could enhance learners' proficiency in 21CS (Barell, 2020; Suson, 2019). While previous research in Zambia and across Africa has focused on academic performance and student attitudes, there is a lack of empirical studies examining how such technological integration can improve development of 21CS such as communication skills, information literacy, technology literacy, and statistical literacy.

1.3 Purpose of the study

The purpose of this study was to investigate the applicability of Microsoft excel in teaching secondary school statistics for learners' acquisition of Twenty-first Century Skills, specifically communication skills, information literacy, technology literacy, and statistical literacy (CITS).

1.4 Research Objectives

This study was conducted to achieve the following objectives;

1. To determine whether applying MS Excel in teaching statistics can lead to the acquisition of 21CS (communication skills, information literacy, technology literacy, and statistical literacy).
2. To determine whether learners' 21CS (communication skills, information literacy, technology literacy, and statistical literacy) have an effect on their performance in statistics.
3. To determine whether learners' 21CS (communication skills, information literacy, technology literacy, and statistical literacy) have an effect on their learning experiences.

1.5 Research Questions

To achieve the above objectives, the study was conducted to answer the following research questions;

1. What is the effect of applying MS Excel in statistics lessons on the acquisition of 21CS (communication skills, information literacy, technology literacy, and statistical literacy)?
2. What is the effect of learners' 21CS (communication skills, information literacy, technology literacy, and statistical literacy) on their performance in statistics?
3. What is the effect of learners' 21CS (communication skills, information literacy, technology literacy, and statistical literacy) on their learning experiences?

1.6 Research Hypotheses

This study was conducted to test the following hypotheses;

1. Research Hypothesis 1 (H_{0_1}): There is no significant difference in the acquisition of 21CS between learners taught statistics with MS Excel and those taught with a conventional teaching method.

2. Research Hypothesis 2 (H_{0_2}): There is no significant difference in the median ranks of the four skills (Communication skills, and Information, technology and statistical literacy)
3. Research Hypothesis 3 (H_{0_3}): There is no statistically significant relationship between learners' 21CS and their academic performance.
4. Research Hypothesis 4 (H_{0_4}): There is no statistically significant relationship between learners' 21CS and their learning experiences.

1.7 Significance of the study

This study will contribute to filling a gap in literature by determining whether the use of MS Excel software in teaching statistics can enhance learners' acquisition of 21CS in secondary schools. It may also generate interest for further research on this topic. Therefore, it can help improve teaching and learning by providing guidance to secondary school teachers in their selection of effective teaching methods, assessment and classroom activities for teaching 21st century skills (21CS) in statistics and mathematics. This, in turn, can contribute to achieving SDG4. Curriculum designers, such as the CDC, can also utilize this study to review, develop, and select mathematics curriculum content and pedagogies that are relevant and responsive to the needs of today's society. Additionally, education policy makers, such as the Ministry of Education, can incorporate findings from this study into their planning for the overall educational needs of the 21st century society and workforce.

1.8 Scope of the study

This study aimed to investigate the use of MS Excel in teaching Secondary School Statistics and its impact on the acquisition of 21CS by learners. Additionally, the study examined the relationship between the acquisition of 21CS, learners' performance, and their learning experiences.

1.9 Delimitations of the study

Only Grade 11 Mathematics pupils from Mwense Secondary School were included in this study; school administrators and teachers were not considered. The study did not take into account the gender of pupils.

1.10 Limitations of the study

The study was faced with limited access to the computer lab and the number of computers were not adequate. Furthermore, the size of the computer laboratory could not accommodate all the

learners. In order to overcome these limitations, two sessions for each lesson were conducted to accommodate all the learners in the experimental group. SPSS software (which was the proposed intervention) expensive to access and install, and proved to be a challenge for the teacher to use, which was also a challenge to the pupils. Moreover, SPSS revealed to be a passive software as it did not actively engage learners in creating their own formulas, figures, and statistical procedures. MS Excel, a free, easier to use and interactive software was utilized in place of SPSS. Since the study was conducted in the afternoon after regular learning hours, only boarding school learners were available to participate.

1.11 Theoretical Framework

This study was guided by constructivism theory, specifically, following the experiential and cooperative learning approaches. Constructivism is a learning theory that emphasizes the active role of learners in constructing their understanding and knowledge of the world (Sadker & Sadker, 2005). It suggests that individuals construct their own knowledge and meaning through experiencing and interacting with the environment, rather than passively receiving information. Constructivism views learning as an active, social, and dynamic process influenced by personal experiences, prior knowledge, and social interactions.

Experiential Learning Approach (ELA) is based on the idea that knowledge and skills are acquired through experience or doing (Kolb, 1984). ELA is an offshoot of constructivism learning where learners construct knowledge based on their previous experiences (Singh, 2020). It has been argued that learning through experience allows learners to retain knowledge and apply it in the real world (Kolb & Boyatzis, 1999). With experiential learning approach, learners are given an opportunity to construct knowledge from their experiences. This can be promoted when learners explore and engage in mathematics with technology. Therefore, 21CS such as communication, information literacy, technology literacy, and statistical literacy skills can be developed through the process of doing and learning statistics with Excel.

Cooperative Learning Approach (CLA) postulates that effective learning takes place when learners are actively engaged in the learning process and work collaboratively with others to accomplish a shared instructional goal (Slavin, 1996; Johnson & Johnson, 1994). CLA is a social-constructivism learning approach where learners construct knowledge through interaction with their peers (Vygotsky, 1978). With CLA, learners use their own experiences and those of their peers to acquire

knowledge and skills as they engage in experiments and real-life problem solving (Johnson & Johnson, 1994). The use of technology in teaching mathematics can actively engage learners in the classroom and support collaboration among learners. Therefore, cooperative learning approach can encourage learners to think critically, solve problems, communicate, and collaborate effectively (Jones & Jones, 2008; Williams, 2007). When learners work collaboratively with their peers, they can quickly find good information and use technology effectively.

These approaches support the theoretical framework of TPASK (Technological, Pedagogical, and Statistical Knowledge). The TPASK framework developed by Lee and Hollebrands (2011) is an adaptation of the TPACK framework. According to TPACK (Technological, Pedagogical, and Content Knowledge), good teaching requires an understanding of how technology relates to pedagogy and content (Mishra & Koehler, 2009). TPACK implies effective teaching of any subject with technology. In their TPASK, Lee and Hollebrands theorized the knowledge needed by teachers of mathematics to effectively utilize technology in teaching statistics. This framework integrates statistical knowledge, technological knowledge, and pedagogical knowledge. With TPASK, effective teaching with technology requires an understanding of pedagogical techniques that can utilize technology constructively in the teaching of statistics (Prodromou, 2015).

The use of computer technologies such as MS Excel has been argued to be effective in teaching statistics, and that they can facilitate experiential and cooperative learning (Harits et al., 2019; Murphrey & Theresa, 2011). Researchers such as Basturk (2005), and Alismail and McGuire (2015) have emphasized that integrating Excel with constructivist teaching approaches, such as experiential and cooperative learning, into the teaching of statistics may improve learning and foster the development of 21CS. Figure 1.1 depicts the theoretical framework for this study.

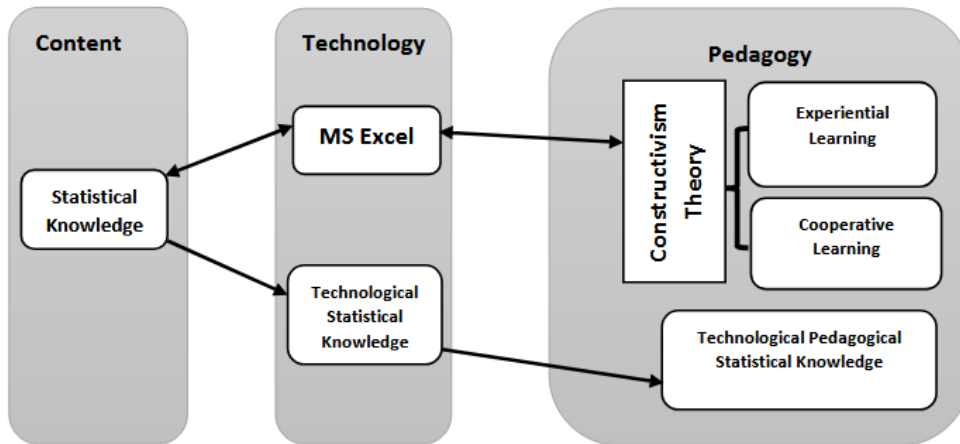


Figure 1.1: Developed by the researcher (Adapted from TPASK Theoretical Framework (Lee & Hollebrands, 2011))

Figure 1.1 presents a theoretical framework that integrates constructivism with the TPASK framework for teaching statistics using MS Excel. It illustrates how content, technology, and pedagogy interact to facilitate effective statistics instruction through a constructivist approach. On the left side of the diagram, the Content component represents Statistical Knowledge, which is fundamental for teachers in understanding and teaching statistical concepts. Teachers must possess content knowledge in statistics. This statistical knowledge serves as the foundation for effectively integrating technology and pedagogy in instruction. The middle section of the diagram focuses on Technology, specifically MS Excel, which serves as the primary tool for statistical presentations, analysis and visualization. To effectively apply technology in teaching statistics, teachers must possess Technological Statistical Knowledge, a combination of proficiency in MS Excel and understanding of statistical concepts. MS Excel provides functionalities that support statistical instruction. The Pedagogy component, shown on the right side of the figure 1.1, emphasizes the role of Constructivism Theory in teaching statistics. Constructivism advocates for active learning, where students build their understanding through experiences and social interactions. Two key instructional strategies that align with constructivism theory are Experiential Learning and Cooperative Learning. Experiential learning allows learners to explore statistical concepts hands-on using real data in MS Excel, while cooperative learning encourages collaboration among learners to present, analyze and interpret data collectively.

At the intersection of these three components is Technological Pedagogical Statistical Knowledge (TPSK), which represents the integrated knowledge required for effective instruction. A teacher

must not only understand statistical concepts (content knowledge) and be proficient in MS Excel (technological knowledge) but also be capable of implementing constructivist teaching strategies (pedagogical knowledge). The framework highlights that the effective use of MS Excel in statistics instruction depends on the teacher's ability to blend these three domains seamlessly.

Therefore, the figure 1.1 depicts that teaching statistics with MS Excel requires an interplay of statistical knowledge, technological expertise, and constructivist pedagogy. Teachers can create interactive and meaningful learning environments that enhance acquisition of knowledge and skills when experiential and cooperative learning approaches are utilized. By carefully incorporating MS Excel into the teaching process, while considering statistical concepts and teaching methods, an environment can be created which can facilitate the acquisition of 21CS (Voogt et al. (2013).

1.12 Conceptual framework

The model guiding this study is influenced by Suson (2019), Boholano (2017), Lee & Hung (2012), Gomez (2014), and Chance et al. (2007). According to these researchers, 21CS can be taught in secondary school statistics by engaging learners with computer technologies such as MS Excel and the internet. The internet is used to access real-life data. This is in agreement with Mikre (2011), who confirmed that technology can be used to bring real-world problems into the classroom, facilitate discussions of data accessed on the internet, and actively engage learners in the construction of knowledge as they do and see statistics.

Based on the theoretical literature, it has been suggested that learning with computer software such as MS Excel provides a setting in which learners can work individually and collaborate with their peers, this promotes learning by doing. Therefore, applying MS Excel in teaching statistics can engage learners in hands-on activities as they work individually and in groups, and can promote the acquisition of 21CS. The model in Figure 1.2 depicts that applying Excel in teaching secondary school statistics can foster the development of 21CS.

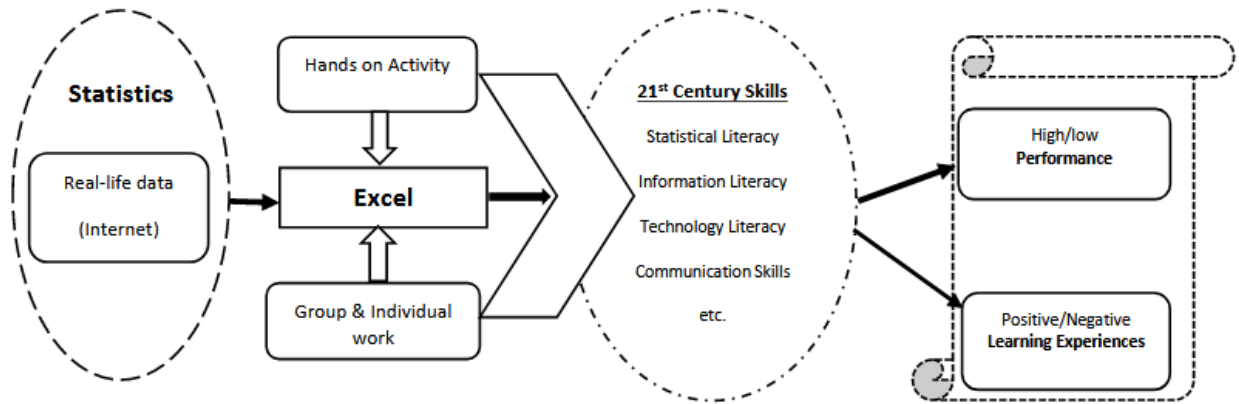


Figure 1.2: Instructional design Model (Adapted from Suson (2019); Boholano (2017); Lee & Hung (2012); Gomez, (2014); Chance et al., (2007))

According to the model in figure 1.2, the internet enables learners to access real-life data, while MS Excel can be used by learners to independently and collaboratively address real-life problems. Additionally, MS Excel engages learners through hands-on activities that involve finding, entering, analysing, and exploring data, as well as performing calculations. This model depicts that applying MS Excel into the teaching of secondary school statistics can result into learners' acquisition of 21CS, which ultimately leads to improved learning experiences and performance in statistics. The model shows that incorporating real-life data from the internet into statistics lessons may enhance relevance and engagement, this can allow learners to work with authentic datasets that reflect real-world scenarios. By utilizing MS Excel, learners can actively engage in hands-on activities such as data entry, inserting formulae, organization, analysis, and visualization, which foster deeper conceptual understanding. Through individual and group work, learners can develop 21CS, including communication, collaboration, information literacy, technology literacy, and statistical literacy. Individually, they may enhance problem-solving and self-directed learning, while group activities encourage peer learning, discussion, and knowledge-sharing. As learners manipulate real-world data, explore statistical concepts, and apply Excel functions, they can experience active learning, which strengthens their analytical thinking and decision-making skills. Ultimately, this teaching approach can improve learning experiences and performance in statistics.

1.12.1 Research Variables

According to Harmon and Morgan (2000), researchers need to determine which variable to manipulate in order to generate measurable results. A research variable is a factor that can be

changed and measured, and it can have different values and influence the outcome of a study (Harmon & Morgan, 2000). There are various types of variables, but the most important ones in the research process are the independent and dependent variables. The independent variable is the one that the researcher manipulates to measure its effect on another variable called the dependent variable (Marudhar, 2019). Whereas, a dependent variable is a variable that may change as a result of changes in the value of another (independent) variable. Therefore, it measures the effect of the independent variable on the research participants. A variable that strengthens the effect or influence of the independent variable on the dependent variable is known as a moderating variable (Shukla, 2017). In this study, the independent variable is EAI, while the main dependent variables are the 21CS. The performance of learners, as well as their learning experiences, are the other dependent variables in the study. To enhance the relationship between these variables, real-life data, hands-on activities, and individual and group work tasks were utilized.

This current study aimed to implement teaching method tailored for the 21st century to ensure mastery of essential skills. According to Katz et al. (2006), when learners are actively involved in generating their own data and applying various statistical techniques, they are more likely to retain the concepts and associated skills effectively. This supports constructivism theory. Moreover, there's a consensus among researchers (Salas-Pilco, 2013; Voogt et al., 2013; Fullan, 2014; Micheals et al., 2017) that critical thinking, collaboration, communication, problem-solving, information literacy, technology literacy, and statistical literacy are essential for navigating life and the workforce in the 21st century. Messias et al. (2018) have demonstrated that the integration of technology in the classroom plays a significant role in fostering the development of 21st century skills. This emphasize the importance of integrating technological tools such as computer software to enhance educational practices and prepare learners adequately for the challenges of the modern world. In this study, the researcher sought to apply these principles by implementing this teaching strategy focused on cultivating 21CS among learners. By incorporating active learning methods, MS Excel, and opportunities for collaborative problem-solving, the study aimed to empower learners with the competencies necessary for success in an increasingly complex and interconnected global society.

1.13 Operational definition of terms

The following are definitions of the key terms as used in this study;

- **Skill**, in this study, refers to learners' ability to perform specific tasks perform a specific task or activity effectively.
- **Literacy** refers to learners' ability to understand, interpret, and apply knowledge within a specific domain.
- In this study, **hard skills** refer to the measurable and teachable technical abilities that learners acquire through instruction and practice (e.g Information, technology and statistical literacy skills).
- In this study, **soft skills** refer to the non-technical, interpersonal, and cognitive abilities. These include critical thinking, problem-solving, collaboration, communication, and adaptability.
- **21st century skills (21CS)** means skills such as communication skills, information literacy, technology literacy, and statistical literacy.
- **Acquisition** in this study means learning or developing of 21CS.
- In this study, **applicability** refers to the effective integration of Microsoft Excel into the teaching of secondary school statistics to support learners' acquisition of 21CS.
- **Computer Technologies** in this study refers to MS Excel, PowerPoint, and internet.
- **Excel Assisted Instruction (EAI)** implies teaching of secondary school statistics with MS Excel
- **Treatment** means applying MS Excel in teaching statistics.
- **Conventional Teaching Method**- teaching statistics without Microsoft Excel, therefore, it means traditional teaching method.
- **Experimental group** means a group where MS Excel was applied in the teaching of statistics.
- **Control group** implies a group where statistics was taught using conventional teaching method.
- **Learning experiences** refer to activities, interactions, and emotions that contribute to a learner's view of statistics.
- **Views** refer to learners' attitudes, perceptions, and beliefs regarding statistics.

1.14 Chapter Summary

This chapter discussed the background of the study, problem statement, research objectives and questions, significance of the study. The chapter also presented scope and delimitations of the study, limitations of the study, and explored the theory and model that informed this study, as well as the discussion of the research variables. Lastly, operational definition of key terms were presented.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter provides an account of the review of literature related to the application of MS Excel in teaching statistics for Learners' acquisition of 21st century skills. This chapter presents previous literature reviewed on the use of computer software in teaching mathematics. The literature reviewed is presented in three main parts. It begins with an introduction, followed by the theoretical literature and the last section presents empirical literature. The empirical literature has been presented from Zambian, African and global perspectives. This Chapter also presents the theoretical and conceptual frameworks.

2.1 Introduction

The main objective of this literature review was to gather information on how various researchers have approached the use of computer technologies in mathematics education, specifically focusing on the application of MS Excel for teaching statistics to develop 21st century skills. It was discovered that there are numerous research studies conducted on the use of computer technologies in mathematics education. However, few studies have been conducted on the use of computer technologies for teaching mathematics to develop 21st century skills, as well as the impact of utilizing MS Excel in teaching college or university statistics on learners' achievement and attitudes towards statistics. Additionally, no empirical studies have been conducted on the application of MS Excel in teaching secondary school statistics to enhance learners' acquisition of 21st century skills. To identify this research gap, a search for articles and documents was conducted using academic databases such as African Journals Online (AJOL), Google Scholar, Eric, Sage publications, and ResearchGate. The key terms used in this search included twenty-first (21st) century skills, technology, Microsoft Excel, and mathematics and statistics education. For this review, the majority of the selected articles were published between 2000 and 2024.

2.2 Theoretical Literature

Countries have undertaken curriculum reviews in response to the demands of the modern world of information and technology. Education now places emphasis on both mastering subject knowledge and developing 21st century skills (Alismail & McGuire, 2015). To promote this, international

organizations have created frameworks for 21st century curricula, such as the Partnership for 21st Century Skills (P21), the EnGauge Framework, and the Educational Testing Service for ICT Literacy (Dede, 2009). These frameworks outline the knowledge and skills that are relevant in the 21st century. Rosdiana et al (2020) state that 21st century curricula should be developed in accordance with the 21st century education standards set by P21. Therefore, this study focused on the 21st century skills discussed by P21, which emphasize the integration of subject knowledge and technology in teaching and learning.

2.2.1 Twenty first Century Skills

The concept of 21st century skills (21CS) emerged as a response to the evolving demands of modern education and the workforce, which emphasizes competencies that go beyond traditional academic knowledge. Rooted in educational reform movements, the idea gained prominence in the late 20th and early 21st centuries, driven by rapid technological advancements and globalization (Trilling & Fadel, 2009). Various organizations, including the Partnership for 21st Century Learning (P21) and the Organisation for Economic Co-operation and Development (OECD), have developed frameworks outlining the essential skills learners need to thrive in contemporary society (Ananiadou & Claro, 2009; Griffin et al., 2012). While there is a broad consensus on the importance of these skills, their conceptualization and classification remain subjects of debate.

One of the major discussions revolve around the scope and definition of 21CS. Some scholars categorize them into cognitive, intrapersonal, and interpersonal domains (Pellegrino & Hilton, 2012), while others emphasize competencies in creativity, critical thinking, collaboration, and communication, the “4Cs” model (Partnership for 21st Century Learning, 2015). Additionally, there is debate on whether 21CS should be treated as distinct from traditional subject knowledge or integrated within disciplinary learning (Voogt & Roblin, 2012). Critics argue that the broad nature of 21CS makes them difficult to assess and implement effectively in curricula (Greiff et al., 2014).

Voogt and Roblin (2010) conducted a review of 21CS frameworks, they analysed 32 documents on teaching, learning, and assessment in the 21st century. Their study identified nine cross-cutting skills that is creativity, innovation, critical thinking, problem-solving, communication, collaboration, technology and information literacy, social responsibility, and citizenship.

Chalkiadaki (2018) confirmed these findings in a literature review, this reinforces the consensus on the necessity of these skills in modern education. It is widely agreed that critical thinking, collaboration, communication, problem-solving, information literacy, technology literacy, and statistical literacy are essential for success in the 21st century workforce and daily life (Salas-Pilco, 2013; Voogt et al., 2013; Fullan, 2014; Michaels et al., 2017).

Therefore, this study focused on developing communication, information literacy, technology literacy, and statistical literacy, as these skills are directly relevant to the teaching and learning of statistics. Jones and Jones (2008) and Williams (2007) highlight these competencies as crucial components of 21CS. Given that the study involved the use of MS Excel as an intervention, emphasis was placed on technology literacy for proficiency in spreadsheet tools, statistical literacy for interpreting and analyzing data, information literacy for sourcing and evaluating information, and communication skills for effectively presenting and explaining results.

Effective communication is fundamental in the 21st century, as it enables individuals to interpret and convey statistical insights clearly. The key aspects of communication skills include verbal communication, non-verbal communication, listening skills, written communication, interpersonal communication, public speaking, digital communication, emotional intelligence in communication, persuasion and negotiation, and cultural and contextual awareness (Sutama et al., 2019). Verbal communication involves expressing ideas, thoughts, and emotions through spoken words with clarity and articulation. Non-verbal communication uses body language, gestures, and facial expressions to reinforce verbal messages. Listening skills require actively engaging to understand, interpret, and respond to spoken messages, while written communication focuses on effectively conveying information through reports, emails, and messages (Hayati et al., 2020). Interpersonal communication involves engaging in meaningful discussions and understanding social cues, whereas public speaking is the ability to present ideas persuasively to an audience. Digital communication is crucial for using online tools for professional and academic discourse, and emotional intelligence in communication ensures effective management of personal emotions while understanding others' perspectives (Muslim et al., 2019). Persuasion and negotiation skills involve convincing others using logical reasoning, and cultural and contextual awareness allows for adapting communication styles to different audiences (Qohar, 2011).

Within the context of applying computer technologies in teaching mathematics topics such as statistics, verbal communication, listening skills, and interpersonal communication were particularly relevant (Rohid & Rusmawati, 2019). Verbal communication is essential for discussing statistical findings, presenting data-driven arguments, and collaborating with peers. Listening skills facilitate comprehension of statistical problems, ensuring accurate interpretation of data analysis processes. Interpersonal communication plays a significant role in teamwork, peer discussions, and professional statistical reporting. These skills support the ability to explain statistical concepts, justify analytical approaches, and share information effectively, which are critical in statistics instruction and modern society (Yerizon et al., 2020).

Information literacy is crucial for identifying, evaluating, and using data effectively in statistical analysis (Firmanto et al., 2018). The key aspects of information literacy include identifying information needs, locating information, evaluating information, organizing and managing information, synthesizing and applying information, ethical and legal use of information, and communicating information effectively (Marilyn et al., 2016). Identifying information needs involves recognizing when information is required and defining the scope of an inquiry. Locating information refers to searching for and accessing relevant data from books, academic journals, databases, and the internet. Evaluating information ensures the credibility, reliability, and relevance of sources, distinguishing between factual data and biased information. Organizing and managing information allows for efficient structuring and storage of datasets to facilitate easy retrieval and use. Synthesizing and applying information involves integrating new knowledge to solve problems and draw meaningful conclusions. Ethical and legal use of information focuses on understanding copyright laws, intellectual property rights, and proper citation practices to avoid plagiarism. Finally, communicating information effectively ensures that statistical data is presented clearly through various formats such as reports, presentations, or digital media.

In the context of the application of Computer software such as MS Excel in teaching statistics, locating information, evaluating information, and organizing and managing information are particularly essential (Erickson, 2018). Locating information enables learners and researchers to source accurate datasets, ensuring the integrity of statistical analysis. Evaluating information is crucial in verifying the reliability and validity of statistical sources, this prevents the use of misleading or inaccurate data (Wijaya, 2016; Fairuz et al., 2019). Organizing and managing information is fundamental when working with datasets in MS Excel which allows for efficient

data arrangement, filtering, and retrieval. These skills collectively enhance the ability to analyse data, generate meaningful information or data, and present statistical findings effectively (Wijaya, 2016).

Technology literacy involves the ability to use digital tools efficiently, enabling individuals to navigate and apply technological resources for statistical analysis (Nocar et al., 2019). It encompasses several major aspects which includes understanding technology concepts, accessing and using technology, evaluating digital information, problem-solving with technology, digital communication and collaboration, ethical and responsible technology use, and adapting to technological changes (Kim et al., 2022). Understanding technology concepts involves gaining knowledge of digital tools and emerging technologies. Accessing and using technology requires proficiency in computers, software, and cloud-based services for various tasks, such as data processing and visualization. Evaluating digital information ensures the credibility of online sources, which is critical in statistical research. Problem-solving with technology involves utilizing digital tools to analyse problems and develop effective solutions. Digital communication and collaboration facilitate professional and academic discourse through digital platforms. Ethical and responsible technology use focuses on understanding cybersecurity, digital privacy, and ethical considerations related to data management. Additionally, adapting to technological changes is essential for maintaining flexibility in learning new statistical tools and technologies (Ezziane, 2007).

For the application of technology in statistics instruction, the most relevant aspects of technology literacy for this study include accessing and using technology, evaluating digital information, and problem-solving with technology (Garcia, 2022). Proficiency in spreadsheet tools ensures that users can efficiently perform statistical operations, such as data entry, analysis, and visualization. Evaluating digital information is crucial for verifying the accuracy and reliability of statistical data sources, preventing misinformation and errors in analysis (Erwin & Mohammed, 2022). Problem-solving with technology enables users to apply Excel functions for statistical modelling, hypothesis testing, and decision-making, ultimately enhancing the quality and efficiency of statistical analysis (Smith et al., 2024).

Statistical literacy involves understanding and applying statistical concepts to analyse data effectively (Kurnia et al., 2022). It encompasses essential skills such as literacy in interpreting

statistical information across different contexts, knowledge of statistical principles like variability, probability, correlation, and distributions, and mathematical skills necessary for solving statistical problems (Watson, 2010). Contextual understanding is also crucial, as it allows individuals to recognize the relevance of data in real-world scenarios. Critical thinking plays a vital role in assessing the validity of statistical claims and identifying potential biases in data interpretation (Doyle, 2008). Additionally, strong communication skills are necessary to explain statistical findings through written, verbal, and visual representations, while an appropriate disposition and confidence in working with statistical data further enhance statistical literacy (Callingham & Watson, 2017).

In the context of applying statistical software such as MS Excel in teaching statistics, major aspects include statistical knowledge, mathematical skills, contextual understanding, critical thinking, and communication skills (Dijke-Droogers et al., 2016). Built-in functions of MS Excel enhance statistical knowledge by enabling users to perform analyses efficiently (Risqi & Setianingsih, 2021). Mathematical skills are reinforced through the application of formulas, computations, and numerical operations within the spreadsheet of MS Excel. Contextual understanding is developed by analyzing real-world datasets, this is achieved by applying statistical methods to practical scenarios, and drawing meaningful conclusions (Gordon & Nicholas, 2010). Critical thinking is fostered by evaluating data quality, identifying patterns, and interpreting statistical trends. Communication skills are strengthened through the creation of charts, tables, and reports, which allow users to present statistical findings clearly and effectively (Yuniawatika, 2018).

Communication Skills

Communication skills are the set of abilities that enable individuals to effectively convey thoughts, ideas, and emotions to others through various mediums such as verbal, non-verbal, and written communication (Asemanyi, 2015). These skills are fundamental not only within the classroom but also in all aspects of life, including personal relationships, career development, and societal interactions. According to Gordon et al. (2005), communication skills encompass a broad range of capabilities, including active listening, clear articulation, empathy, non-verbal communication, and conflict resolution. These skills are essential for fostering understanding, collaboration, and mutual respect in interpersonal interactions. In the classroom, communication skills are crucial for effective participation, comprehension, and collaboration among learners and teachers (Hayati et

al., 2020). As noted by Muslim et al. (2019), effective communication skills are foundational for academic success, facilitating learning, collaboration, and critical thinking in the classroom. Advancements in technology offer innovative methods for teaching and practicing communication skills. Computer software can provide interactive and immersive experiences that engage learners and facilitate skill development in realistic contexts.

According to Rohid and Rusmawati (2019), technology-enhanced communication tools provide opportunities for learners to engage in authentic communication scenarios, receive immediate feedback, and develop proficiency in diverse communication modalities. Computer software, such as Excel, video conferencing platforms, presentation software, and collaboration tools, can play a significant role in fostering the development of communication skills. These tools enable learners to practice public speaking, collaborate on activities, and receive feedback from peers and instructors. As highlighted by Yerizon et al. (2020), computer software offers interactive platforms where learners can practice communication skills, such as active listening, articulation, and empathy, in a safe and supportive environment. Therefore, Communication skills are essential competencies for learners in mathematics lesson, supporting academic success, interpersonal relationships, and professional growth. By integrating technology and computer software tools such as Excel, teachers can create dynamic learning environments that engage learners and facilitate the development of effective communication skills, preparing them for success in an increasingly interconnected world.

Information literacy

Information literacy is the ability to recognize when information is needed, locate relevant sources, evaluate their credibility, and effectively use information to solve problems and make informed decisions (Dreisiebner & Schlögl, 2019). In 21st century, an era characterized by an abundance of information, possessing information literacy skills is essential for learners to thrive both within school and in their personal and professional lives. Information literacy goes beyond simply accessing information; it involves critical thinking, analysis, and synthesis of information from various sources (Fairuz et al., 2019). Learners' proficient in information literacy can discern between reliable and unreliable information, understand ethical issues surrounding information use, and apply information effectively in different contexts. In mathematics classroom, information literacy enables learners to find good information quickly and to critically evaluate

sources. As noted by Firmanto et al. (2018), Information literacy equips learners with the skills necessary to explore huge amounts of information, discern credible sources, and make informed decisions, fostering lifelong learning. Technology such as computer software plays a crucial role in teaching and enhancing information literacy skills (Funmi & Olufemi, 2019).

According to Wijaya (2016), technology-enabled learning environments provide interactive experiences where learners can develop information literacy skills through hands-on exploration of digital resources and collaborative activities. Computer software such as Excel enables learners to critically evaluate and interpret data, enhancing their ability to analyse information effectively. As emphasized by Zinn et al. (2016), computer software tools provide learners with practical skills for exploring information, including data analysis, and information visualization whereby empowering them to engage with information critically. Therefore, Information literacy is a foundational skill for learners today.

Technology literacy

Technology literacy refers to the ability to effectively use and understand technology to solve problems (Erwin & Mohammed, 2022). In 21st century, technology literacy is essential for learners, both within educational settings and outside, as it equips learners with the skills needed to thrive in a technology-driven society. Technology literacy encompasses a wide range of competencies, including digital fluency, proficiency with digital tools and platforms, and the ability to critically evaluate digital information (Ezziane, 2007). Individuals who are technologically literate can adapt to new technologies, utilize digital resources effectively, and engage responsibly in technology-driven environments. In mathematics classroom, technology literacy enables learners to access educational resources, use technology, collaborate with peers, and develop digital skills necessary for future academic and professional success. According to Nocar et al. (2019), technology literacy is vital for learners to effectively access information, explore technological tools, and communicate in a technology-driven world. Technology serves as a powerful tool for teaching and enhancing technology literacy skills. Technological tools such MS Excel provide opportunities for hands-on learning and skill development. As highlighted by Smith et al. (2023), technology-enabled learning environments facilitate the development of technology literacy skills through interactive experiences, adaptive learning tools, and real-world applications, promoting digital competence and confidence. According to Garcia (2022), computer

software can offer practical ways for developing technology literacy skills, including digital creation, problem-solving, and computational thinking, and preparing learners for success in an increasingly technology-driven world. Therefore, MS Excel software can play a crucial role in fostering the development of technology literacy skills.

Statistical literacy

Statistical literacy is the ability to understand, interpret, and critically evaluate statistical information encountered in various contexts (Doyle, 2008). In 21st century, an era where data permeates every aspect of society, statistical literacy is essential for learners to make informed decisions, solve problems, and engage meaningfully with quantitative information. Statistical literacy involves comprehension of basic statistical concepts, such as averages, as well as the ability to interpret data and draw conclusions from data (Gordon & Nicholas, 2010). Individuals who are statistically literate can explore numerical information effectively, distinguish between reliable and misleading statistics, and apply statistical reasoning in decision-making processes. In mathematics classroom, statistical literacy empowers learners to analyse data, evaluate findings, and draw evidence-based conclusions. As stated by Pamungkas and Khaerunnisa (2020), statistical literacy equips learners with the skills necessary to analyse and interpret data, enabling them to make informed decisions, evaluate claimed, and participate in evidence-based reasoning. Technology such as computer software provides innovative ways for teaching and enhancing statistical literacy skills. Computer software such as MS Excel can offer engaging ways to introduce statistical concepts, calculate figures, generate curves, demonstrate data analysis techniques, and provide opportunities for hands-on exploration of real-world datasets (Risqi & Setianingsih, 2021). According to Sharma et al. (2012), computer software plays a vital role in fostering the development of statistical literacy skills. Statistical software packages, such as SPSS, R, and Excel, enable learners to analyse data, generate descriptive statistics, and create visual representations of data. Additionally, spreadsheet software can be utilized for data manipulation, hypothesis testing, and regression analysis, providing practical experience in statistical analysis. As emphasized by Utomo (2021), computer software tools offer practical ways for developing statistical literacy skills, including data analysis, interpretation of results, and communication of findings, preparing learners for data-driven decision-making. Therefore, Statistical literacy is a critical competency for learners.

2.2.2 Twenty first century teaching and learning

The review by Voogt and Roblin (2010) addresses the analysis, definitions, and implementation of 21st century curriculum, however, it does not provide guidance on teaching or learning these skills in mathematics, specifically statistics. Yelland et al. (2008) argue that learners need to develop technology literacy in order to acquire 21st century skills and succeed in the classroom. Technology plays a central role in acquiring other 21st century skills, as supported by Haan et al. (2020) and Viering & Lai (2012). Technology can be used both as a tool for teaching these skills and as a means of learning them. Since 21st century skills cannot develop in isolation and require subject knowledge, they should be taught by integrating technology into the teaching and learning of subjects like mathematics (Hysa, 2014; Tan et al., 2024; Pineida, 2011). Suson (2019) adds that these skills are interconnected, and teaching one skill reinforces others. All of these authors argue that incorporating technology into mathematics education is an effective way to teach 21st century skills. Therefore, teaching 21st century skills is closely linked to both mathematics and the use of technology.

Alismail and McGuire (2015) describe how a 21st century curriculum and instruction can be designed. According to Piaget's view in Alismail and McGuire (2015), a 21st century curriculum should incorporate critical thinking, problem-solving skills, communication, collaboration, innovation, technology and information literacy, media, and real-life experiences within core subjects like mathematics. The authors recommend the use of innovative and modern teaching methods that enhance both skills and subject knowledge while engaging learners in real-life activities. They emphasize the use of technological tools and teaching strategies such as problem-based and cooperative learning. However, the study does not discuss how technology can be applied specifically in teaching mathematics topics like statistics to develop 21st century skills.

Handajani et al. (2018) argue that the recommended pedagogy for the 21st century is one that integrates subject knowledge and skills. They believe that the emphasis in a 21st century classroom should shift from reproducing knowledge to creating knowledge and moving away from simply knowing to doing. The activities given to learners should elicit 21st century skills and can be achieved with the use of technology in teaching. They suggest that technology and real-life activities can help learners acquire and apply 21st century skills.

Lee and Hung (2012) assert that utilizing real-life activities in the mathematics classroom provides learners with opportunities to contextualize and apply theoretical learning. Therefore, concepts presented to learners should be connected to their real-life experiences. However, integrating technology with mathematics and 21st century skills can be challenging within traditional teaching methods, as traditionally classrooms tend to focus on abstract and textbook-based activities.

Voogt et al. (2013) describe how 21st century teaching and learning can be implemented in relation to digital technology. They recommend the use of new teaching methods and assessments to implement a 21st century curriculum, with a focus on using technology within real-life contexts. They emphasize the importance of constructivist approaches, such as problem-based, cooperative, and experiential learning, to support the development of 21st century skills. The authors also suggest the need to investigate how subject knowledge can be related to 21st century skills and how these skills can be taught and assessed. They stress the need to embed technology literacy within subject knowledge and 21st century skills, using technology to bridge the gap between learning in the classroom and outside of it. They argued that teachers must be competent in 21st century skills to effectively facilitate 21st century learning.

Mikre (2011) claimed that technology can be used to bring real-life problems into the classroom and facilitate discussions and data exploration. It can actively engage learners in the construction of knowledge, particularly in the field of statistics. However, Moore (1997) cautions teachers to focus on teaching mathematics rather than the technological tools themselves. The instructional focus should remain on statistics and not solely on software. Computer software should be used to enhance understanding and explore concepts, rather than using it for the sake of computing numbers. This is in agreement with Chance et al. (2007). Teachers should guide and scaffold learners' interaction with the software. Mikre (2011) and Moore (1997) suggest the need for a well-structured instructional plan to effectively apply technology, such as statistical software, in teaching statistics. Assessment tasks should evaluate learners' ability to explain and justify conclusions, rather than focusing solely on rote calculations. However, this paper does not suggest a specific software or provide guidance on how it can be applied for teaching high school statistics to develop 21st century skills.

Chalkiadaki (2018) argues that teaching approaches in today's classrooms must foster technology and information literacy, as well as other essential skills in today's global economy. The

development of 21st century skills cannot be achieved with a single teaching approach. Chalkiadaki recommends combining constructivist teaching approaches, such as problem-based teaching and experiential and cooperative learning, to support the development of 21st century skills. In this approach, learners should take center stage in the learning process. This teaching approach is also recommended by Rosdiana et al (2020), Barell (2020), Lapek (2018), Fulan (2014), Voogt & Roblin (2012), and Conneely (2013) as the most appropriate way to engage learners in meaningful learning to develop mathematical knowledge and 21st century skills. They conclude that combining cooperative and experiential learning is the central element in implementing a 21st century curriculum. Thus, the teaching of 21st century skills can only be accomplished by adopting innovative pedagogical approaches that foster the development of both mathematical knowledge and 21st century skills. Therefore, it is the responsibility of teachers to create a learning environment that nurtures these skills and knowledge.

A discussion paper by Gravemeijer et al (2017) points out the meaning of mathematical proficiency in today's society. They argue that calculations taught in the classroom can be performed by computers. This international study proposes that the goal of mathematics education should be to teach 21st century skills to prepare learners for the future. However, most countries are currently not preparing learners for the demands of today's life and workforce, as confirmed by the findings of Voogt et al. (2013). However, the study only discusses the goals of mathematics education in terms of curriculum, assessment, and pedagogy in the 21st century. It does not propose specific ways to teach 21st century skills using computers in the mathematics classroom.

2.2.3 Computer Software for teaching and Learning Mathematics

Research by Suh and Seshaiyer (2013) has revealed that technology can be applied in the teaching of Mathematics to develop 21st century skills. In response, countries have adopted STEM, STEAM, and education 4.0, where learners engage with computer technologies to foster skill development (Peters et al., 2019; Lawrence et al., 2019; Messias et al., 2018; Taylor, 2017). Frameworks such as TPACK, 2T2C, Bridge21, and the 21st Century ICT model have been developed to guide teachers in effectively implementing these curricula (Tangney et al., 2018; Bray, 2017; Ahmad et al., 2016; Warner, 2015; Zain & balackrishnan, 2014; Mishra & Koehler, 2006). However, these frameworks do not depict how computer technologies like MS Excel can

be integrated into topics like statistics in secondary schools to foster learners' acquisition of 21st century skills.

To effectively apply statistical software in teaching statistics at secondary school, researchers such as Barell (2020), Boholano (2017), Bray and Tanglely (2015), and Suson (2019) recommend integrating it into constructivist teaching approaches. These approaches support collaborative, problem and project-based, and experiential learning, allowing learners to work with real-life data and solve realistic problems. Integrating technology, particularly the TPACK framework, in mathematics education is stressed by Prodromou (2015), with a specific focus on teaching statistics.

The TPACK framework, developed by Mishra and Koehler, emphasizes the relationships between technology, pedagogy, and content knowledge. The TPSK framework, an extension of TPACK, refines this framework for statistics instruction, exploring Statistical Knowledge (SK), Technological Statistical Knowledge (TSK), and Technological Pedagogical Statistical Knowledge (TPSK). The need for technology in statistics education is supported by international research, including the work of Lee and Hollebrands. Australian literature, specifically studies involving TinkerPlots, exemplify the practical application of TPSK. This sets the stage for further exploration of TPSK, providing a foundation for integrating technology into statistics teaching.

Chance et al. (2007) conducted a study demonstrating the impact of technology on teaching statistics. They argue that computer technologies, such as Microsoft software and the internet, can help high school learners understand statistical concepts. These technologies allow access to real-life data sets, analysis and interpretation, graph generation, and visualization of abstract concepts. Using these software tools saves time, reduces cognitive load, and enhances learners' performance in statistics.

Katz, Poorten, and Linton (2006) review computer-based teaching tools in the statistics classroom. They highlight the importance of theoretical models and instructional design in educational software. Incorporating cognitive theory and educational research in the use of software tools can enhance the conveyance of statistical concepts. However, the study did not implement these instructional ideas with computer software in the secondary school statistics classroom.

Low and middle-income countries have faced challenges in achieving learning outcomes. Mathematics educators have been searching for innovative teaching approaches, and applying

technology has been recommended to improve learning outcomes. Studies conducted in these countries to investigate the effect of computer technologies on learning outcomes have shown mixed results. Bakaye and Ehren (2021) conducted a study to identify factors that can contribute to improving this intervention. They analysed 21 resources from around the world and found key factors to consider when designing Computer-Assisted Instruction (CAI) interventions, including technological trust, content curation/creation, CAI tool design, learner engagement, teacher capacity, and classroom integration.

Studies by Basturk (2005); Jatnika (2015); Gomez (2010); Morris (2013); Simutenda and Musonda (2017) concluded that teaching statistics using computer software like Excel can save cognitive load and time for learners to explore, understand, and apply statistics. Excel can perform computations quickly and efficiently, allowing learners to focus on interpreting results. However, Basturk (2005) and Higazi (2002) argue that teaching statistics with traditional methods can promote mathematical and logical thinking and enhance problem-solving skills. Therefore, incorporating both Excel and traditional teaching methods can be beneficial. Traditional methods can be used to teach statistical definitions, formulas, and calculation procedures, while Excel can be used to explore, display, and explain concepts in an additional session.

2.3 Empirical Literature

To further explore related literature on the use MS Excel in teaching statistics for learners' acquisition of 21st century skills, empirical literature was reviewed.

2.3.1 Zambian perspective

Chaamwe and Shumba (2016) argue for the effective use of MS Excel (MS Excel) as a versatile and widely available tool for teaching statistics in secondary schools. The study highlights the advantages of using spreadsheets, particularly MS Excel, as an e-learning tool in the teaching and learning of mathematics and statistics. The authors emphasize the interactive and exploratory nature of spreadsheets, which can enhance learners' understanding of abstract mathematical concepts. The study goes on to discuss how MS Excel can be employed to create frequency tables, histograms, frequency polygons, cumulative frequency curves, and conduct various statistical analyses. The authors provide step-by-step instructions on how to perform these tasks using MS Excel. The study concludes by asserting that MS Excel can be an effective tool for teaching basic statistics in secondary schools due to its widespread availability and ease of use. However, the

study does not address the context of 21st century skills acquisition. The current study aimed to fill this gap by specifically investigating the application of MS Excel in teaching statistics for the acquisition of these skills.

Masaiti et al. (2021) examined the availability and usage of technology facilities in selected secondary schools in Zambia. The data was collected from Luapula, Eastern, Lusaka, and Copperbelt provinces where a survey design and a sample of 360 teachers was used. Data was collected from teachers using a questionnaire and analysed quantitatively, where Kruskal Wallis test and a Mann Whitney U test were performed. The study revealed that there was low access to technology facilities, low usage of the available technology facilities by pupils, teachers, and administrators, and high challenges in technology facilities especially in government schools. The study recommended government to invest more in technology and to partner with other stakeholders to improve input in investing in technology infrastructure for enhanced outcomes in our education system. However, this study did not probe further on the issue by examining teachers views on the availability and usage of technology. Also, the study did not focus on how teachers were using the available technology in teaching mathematics in secondary schools. Thus, it is hoped that this study will add to the body of knowledge by establishing how technology such as statistical software (Excel) can be applied in teaching statistics for learners' acquisition of 21st century skills in secondary schools in Zambia.

Mtanga et al. (2012) investigated how urban based secondary schools in Lusaka, Zambia were using technology. The case study was carried out in seven (7) selected high schools with 70 participants (teachers and pupils) who were purposively selected. The study revealed that all participating schools had computers, Internet access, telephones, and faxes whereas computer and the internet were found to be the most used technology by both pupils and teachers. It was also revealed that pupils and teachers used computers for storing materials, school projects and used the Internet to access resources online. However, teachers used technology more than pupils. Low technology literacy among pupils was found to be one of the reasons. According to the pupils, integrating technology in teaching and learning can improve learning process. Unfortunately, few teachers saw the benefits of using technology in their teaching process. The study did not investigate how technology can be applied in the teaching of mathematics topics such as statistics and did not focus on the development of 21st century skills, hence, the need to conduct this current study.

Bvute (2017) conducted a study on “the application of technology and its relationship with improvement of teaching and learning” in six selected secondary schools in Mumbwa District of Zambia. The case study was conducted on 58 teachers to collect qualitative and quantitative data using questionnaires and focus group discussion. The study revealed that computers, mobile phones, printers, television sets and desktops were some of the technologies used in secondary schools in Mumbwa District. The study also revealed that the use of technology such as computers and the internet can help transform learning into one that is learner-centred as it makes it possible for learners to access information on their own which may be left out by teachers but relevant to the subject. It was further revealed that the use of technology can prepare learners to be self-reliant after school because skills acquired by learners whilst in schools can help them survive outside school. In addition, it was found that the use of technology can raise education quality and connect learning to real life situation, therefore, the quality of teaching and learning in some schools that did not have technologies was affected. The study did not focus on learners, statistics topic, and it did not investigate the use of technology on learners’ acquisition of skills, hence, this study investigated the applicability of Excel in teaching statistics to foster the development of 21st century skills at secondary school.

The use of technology in mathematics by teachers and learners has increased in recent years, and much research has been conducted. It is for this reason that Phiri and Mulenga (2018) conducted a study to identify secondary school teachers’ profiles of technology use, skills, beliefs, and attitudes in Mathematics Pedagogy in Kabwe district of Central Province in Zambia. In the quantitative study, the authors used a descriptive survey design to collect data from 92 teachers with questionnaires where ANOVA was performed to analyse data using SPSS. The analysis revealed that teachers possessed technology literacy and showed positive attitudes towards technology integration in mathematics classrooms. However, teachers had low profiles of technology integration in general and there was a significant difference between teachers’ gender and their overall technology mathematics profiles. The study focused on the technology use of teachers, it did not investigate the impact of applying technology in mathematics pedagogy on pupils’ acquisition of 21st century knowledge and skills.

Simutenda & Musonda (2018) investigated the effect of instruction with SPSS on learners’ achievement and attitude towards inferential statistics at Catholic University in Zambia. The study used a randomized pre-test, post-test control group design where second year learners were

randomly assigned to the experimental and control group. The experimental group used the instruction with SPSS as an intervention which involved teaching hypothesis testing with a computer and SPSS software. The results of independent samples t-test showed that learners in the experimental group had better achievement in hypothesis testing at the end of the intervention. It was also found that learners in experimental group showed better attitudes towards learning hypothesis testing in terms of their intellectual knowledge and skill when applying hypothesis testing, this is similar to findings of Jatnika (2016). The authors pointed out that the use of SPSS had a positive impact on learners' performance. It was also revealed that Instruction with SPSS is a sure way to improve performance in statistics (Mwingirwa, 2016). However, there was no statistically significant difference between male and female learners in experimental group in terms of performance. The study concluded that SPSS learning environment gives equal chances of learning to both male and female learners (Petrocz, 2001). The study adopted a quantitative research methodology, therefore, it lacked provision for in-depth insight into the effect of SPSS on achievement and attitudes towards statistics. The study was done with University learners while this study 'was conducted at secondary school. In addition, this study is different as it will look at the application of Excel in teaching Statistics for the development of 21st century skills.

Similarities and Variations of the studies: Research Gap

The Zambian studies reviewed share common themes while also presenting unique perspectives on the integration of technology in education. A central similarity across the works is their emphasis on the potential of technology to enhance teaching and learning. For Instance, Chaamwe and Shumba (2016), Mtanga et al. (2012), Bvute (2017), and Phiri and Mulenga (2018) reveal how tools such as MS Excel, computers, and the internet can transform teaching practices and outcomes. Similarly, Simutenda and Musonda (2018) and Jatnika (2016), explored the specific use of SPSS for statistical instruction, they emphasized its positive impact on learners' achievement and attitudes. These studies collectively highlighted the value of technology in fostering learner engagement and improving educational outcomes.

Many of the studies also explore the role of technology at the secondary school level. Chaamwe and Shumba (2016), Mtanga et al. (2012), and Phiri and Mulenga (2018) focus on technology integration in secondary schools. They examined how technology supports subject-specific teaching. Although Simutenda and Musonda (2018) investigated university learners, their findings align with the study at secondary school level as they demonstrate how technology can enhance

statistical learning. Across these studies, the emphasis on skill development emerges strongly. For instance, Bvute (2017) and Simutenda and Musonda (2018) highlighted the acquisition of technology literacy and problem-solving skills among learners, themes that align with the focus of the current study.

Another commonality is the recognition of barriers to technology integration. Masaiti et al. (2021) and Mtanga et al. (2012) identify challenges such as limited access to technology and low usage by both teachers and learners. These findings emphasize broader issues in technology adoption, which are acknowledged in other studies as well. Additionally, many of the studies employed quantitative and descriptive methodologies to analyse the role of technology in education. Research studies by Masaiti et al. (2021), Phiri and Mulenga (2018), and Simutenda and Musonda (2018) used surveys and statistical analyses to assess the impact of technology which provided empirical outcomes on the benefits and challenges.

Despite these similarities, the studies vary in their focus and approach. Chaamwe and Shumba (2016) concentrate on MS Excel as an e-learning tool for teaching statistics, while Simutenda and Musonda (2018) and Jatnika (2016) focused on SPSS. In contrast, Bvute (2017) and Mtanga et al. (2012) adopt a broader perspective, they examined multiple technologies such as mobile phones, printers, and the internet. Educational contexts also differ, with Simutenda and Musonda targeting university learners, unlike the other studies, which focused primarily on secondary education. This distinction reveals a research gap that the current study aimed to address by specifically investigating the use of MS Excel at the secondary school level.

The current study also stands out for its emphasis on 21CS acquisition, a theme that is only implicitly addressed in previous works. While studies such as Bvute (2017), Masaiti et al. (2021), and Phiri and Mulenga (2018) discuss the potential of technology to enhance education, they do not explicitly focus on how these tools foster skills such as critical thinking, problem-solving, communication, and information, statistical and digital literacy. The current research sought to fill this gap by exploring how MS Excel can be applied in teaching statistics to equip learners with these essential competencies.

Differences also emerged in the depth of analysis. Simutenda and Musonda (2018) employed a quantitative approach to measure learners' performance and attitudes. In contrast, Bvute (2017) and Mtanga et al. (2012) incorporate qualitative data for a more in-depth understanding of

technology use. While several studies focus broadly on the role of technology across subjects, Chaamwe and Shumba (2016) and Simutenda and Musonda (2018) narrow their scope to the application of specific tools for teaching statistics. These variations in focus, methodology, and context illustrate the diversity of research on technology in education in Zambia. This highlighted the unique contribution of the current study.

2.3.2 African perspective

Mathematics educators in sub-Saharan Africa have suggested that teachers in secondary schools must adopt modern teaching pedagogies that integrate technology, are learner-centred, and can foster the development of relevant skills. In this regard, Benning and Agyei (2016) conducted a quasi-experimental study on the effectiveness of Spreadsheet Instructional Method in teaching quadratic functions to senior high school learners in Ghana. The research highlights the positive impact of this method on learners' performance and emphasizes the potential for enhancing mathematics education in a context traditionally rooted in teacher-centred approaches. The use of guided discovery, a combination of direct instruction and hands-on activities, was found to be particularly beneficial. While their study sheds light on the advantages of integrating spreadsheet tools in teaching, it does not address 21st century skills, such as communication skills, information literacy, technology literacy, and statistical literacy. The current study examines how Excel can contribute to the acquisition of these essential skills, providing an understanding of the educational benefits associated with technology integration in the classroom.

Gasigwa et al. (2022) address the specific challenge of learners excelling in various areas of mathematics but facing difficulties in statistics. Focusing on the integration of Excel software in teaching statistics, the study conducted in Kigali, Rwanda, shows a significant advantage for the experimental group using Excel over the control group using scientific calculators. The findings emphasize the positive impact of incorporating technology in statistical education. While Gasigwa et al.'s work provides understanding of the effectiveness of Excel in enhancing learners' statistical performance, it primarily concentrates on academic outcomes. In contrast, the current study aimed to extend the exploration by examining its broader implications for learners' acquisition of 21st century skills, encompassing communication skills, information literacy, technology literacy, and statistical literacy. The current study sought to provide a more comprehensive understanding of the role of Excel in fostering a holistic skill set, preparing learners for the challenges of the modern learning.

Ogunmakin's (2018) study addresses the limited integration of ICT, particularly Microsoft Excel, in teaching and learning within secondary schools in Lagos State, Nigeria. The research sheds light on the prevailing challenges associated with the conventional, teacher-centered methods dominating classrooms in the region. The findings reveal the relatively low popularity of MS Excel in the teaching and learning processes. While Ogunmakin's work lays the groundwork by identifying the current state of ICT utilization in secondary schools, it primarily focuses on general perceptions and utilization without a specific emphasis on the application of MS Excel for teaching statistics. The current study, however, aimed to extend this understanding by focusing specifically on the use of MS Excel in teaching statistics, a critical component in the development of 21st century skills.

Akpoveta et al. (2016) investigated the impact of conventional lecture methods and computer software, particularly MS Excel Spreadsheet Package, on learners' performance in Numerical Methods course. The authors highlight the evolving field of teaching and learning processes in the 21st century. The study, conducted with Nigerian Certificate in Education learners, presents understanding of the effectiveness of incorporating technology into mathematical education. While their focus is on numerical methods, the study provides a foundation for understanding the role of software tools like MS Excel in enhancing learners' problem-solving skills. However, the research primarily centres on performance outcomes and the comparison between conventional methods and Excel usage, neglecting an exploration of broader 21st century skills. The current study on the application of MS Excel in teaching statistics seeks to expand this perspective by specifically addressing communication skills, information literacy, technology literacy, and statistical literacy. By concentrating on statistics education, the present study aimed to bridge the gap and offer a more comprehensive understanding of the software's potential contributions to diverse skill sets crucial in the 21st century.

The study by Seyram et al. (2021) study explores the effectiveness of utilizing MS Excel spreadsheet software to enhance the performance of senior secondary school learners in statistical charts, specifically in Port Harcourt local government area of Rivers state, Nigeria. The research employs a quasi-experimental design with an experimental group taught using Excel and a control group using traditional paper and pencil methods. The findings reveal a significant difference in the performance of learners taught statistical charts with Excel, indicating its potential as an effective teaching tool. While the study makes valuable contributions to the field of statistical

education, it primarily focuses on academic performance outcomes. The current study on the application of MS Excel in teaching statistics seeks to complement this research by addressing skills aligned with 21st century learning objectives. Specifically, it aimed to investigate the impact of Excel on learners' 21st century skills, providing an understanding of the software's educational implications beyond traditional academic achievement.

Abdullahi et al. (2022) explored the perceptions of science teachers in senior secondary schools in the Federal Capital Territory, Nigeria, regarding the use of Microsoft products for teaching and learning. The study focused on the effectiveness of Microsoft tools, such as computers, smartphones, tablets, and internet devices, in engaging learners in digital classrooms. The research revealed a disparity in the utilization of Microsoft products between public and private schools, with private schools effectively incorporating these tools into the teaching and learning processes. The findings emphasized the positive impact of Microsoft products in addressing challenges faced by teachers during education delivery. The study concluded by advocating for Microsoft's support in providing affordable products to enhance classroom organization and facilitate teaching and learning processes. However, the study did not explicitly investigate the application of MS Excel in teaching statistics or its contribution to the acquisition of 21st century skills. The current research sought to address this gap by specifically examining how the integration of MS Excel in statistics education contributes to the development of these essential skills. By focusing on a specialized context, teaching statistics, the present study aimed to provide a more understanding of the role of MS Excel in fostering a set of competencies crucial for learners in the 21st century.

Singh and Siddiqui (2009) focuses on the utilization of MS Excel for teaching science and engineering curriculum at college and university levels. The study presents interactive applications of Excel in computational physics, physics education, computer science, and medical sciences. It highlights the computational power of MS Excel in simulating complex scenarios, such as projectile motion and dice rolling simulations. While Singh and Siddiqui's work showcases the versatility of Excel in scientific applications, it primarily emphasizes physics and computational aspects. In contrast, the current study on the application of MS Excel in teaching statistics aimed to extend this exploration into the field of statistical education, specifically targeting learners' acquisition of 21CS. The study examined the potential Excel in enhancing communication skills, information literacy, technology literacy, and statistical literacy, providing a different perspective on the software's educational applications beyond physics and computational sciences.

Kamodi and Garegae (2019) contribute to the literature by investigating the perceptions of junior secondary mathematics teachers regarding the use of MS Excel in teaching specific concepts related to graphs. The study, employing a quantitative survey approach with 85 mathematics teachers, aimed to provide understanding of teachers' attitudes towards incorporating Excel into their teaching practices. The data was collected using a Likert scale questionnaire with thirty items, analysed through descriptive statistics. Findings of the study indicate that, on the whole, mathematics teachers hold positive perceptions about the use of Microsoft Excel. These positive attitudes, as suggested by the theory of planned behaviour, may potentially translate into actual implementation in the classroom. Additionally, the study reveals that factors such as teachers' competence in using Excel, computer availability, and time constraints influence their perceptions of integrating Excel into their teaching methodologies. However, it's essential to note that the study did not investigate how the application of MS Excel in teaching statistics can lead to learners' acquisition of 21st century skills. In contrast, the current study aimed to examine the role of MS Excel in teaching statistics, not only as a tool for enhancing mathematical understanding but also as a means to cultivate essential 21st century skills among learners. Therefore, the current study sought to extend the understanding of the role of Excel in education beyond the mere perceptions of teachers, focusing on its impact on learners' holistic development in the context of 21st century skills.

Hussaini et al. (2017) conducted a study on the effect of computer-assisted instruction on secondary school mathematics learners' spatial visualization ability, achievement and attitude in Niger State, Nigeria. The study used a quasi-experimental design where Geometry Achievement Test (GAT), Spatial Ability Test (SAT), and Mathematics and Technology Attitude Scale (MTAS) were used to collect data from 330 learners (152 females and 178 males) selected from nine secondary schools. The results of the study revealed that the male learners performed better than female learners in spatial ability tasks. It was also found that males had higher positive attitude towards learning mathematics with technology. However, the study did not focus on secondary school statistics and on skills for 21st century.

In another quasi-experimental study conducted in Nigeria, Yusuf and Afolabi (2010) investigated the performance of secondary school learners when computer assisted instruction (CAI) is applied in teaching biology in Oyo State. The study also examined the influence of gender on the performance of learners exposed to CAI in individualised or cooperative learning settings. A 3 x

2 factorial design was used on 120 learners selected from three private secondary schools. According to the results of ANCOVA, learners exposed to CAI either individually or cooperatively performed better than learners taught with traditional instruction. However, the study revealed no significant difference in the performance between male and female learners taught with CAI in either individual or cooperative settings. Nevertheless, study was not 21st century skills, Excel and mathematics specific. It did however investigate the effect of technology on performance by gender.

Usman and Madudili (2020) assessed the impact of computer-assisted instruction (CAI) on teaching and learning in Nigeria. The study was a literature review conducted using the secondary data analysis approach. The assessment showed that CAI is a powerful tool that can be used in teaching to improve the academic achievement of learners and the performance of teachers in Nigeria and thus can transform the education system. Unfortunately, factors such as teachers' attitudes, policy inconsistencies, inadequate funding of the education sector, poor maintenance culture, and lack of relevant software, computer knowledge by teachers and constant power supply were identified to militate against the efficient use and adoption of CAI in Nigeria. These factors affecting the efficient use of computers in teaching may not be the same in Zambia.

Malekani (2018) established the status of technology in terms of access, use and challenges of technology. This was in a cross section survey where self-administered questionnaires were given to learners and teachers in selected secondary schools in Morogoro municipality, Tanzania. The findings indicated that the status of technology use is not good in secondary schools in Tanzania. However, learners and teachers were aware of the importance of applying technology in teaching practice, unfortunately, technology was not being utilized adequately. The results of a quantitative study by Tarimo and Kavishe (2017) which was also conducted in Morogoro municipality in Tanzania on access and usage of the internet by secondary school learners revealed that that majority of learners did not have enough internet browsing skills for information literacy. The study used a survey research design conducted with 120 randomly selected learners from six schools. These studies did not focus on the application of technology in teaching mathematics topics such as statistics for development of 21st century knowledge and skills.

The application of technology in teaching has been found to have a positive impact on the learners' achievement and attitudes. For instance, Chebotib and Kering (2021) examined how Computer-

Assisted Instruction (CAI) can realign the learner's achievement and attitudes towards learning mutations in a selected secondary school in Uasin-Gishu County, Kenya. The experimental study used a Pre/Post-test control group design to compare the computer-assisted learning with conventional teaching methods. 54 learners were randomly sampled and assigned to the two groups. Data was collected with an achievement test and attitude questionnaire which showed that there was a significant differences in the attitudes of the learners from the two groups with higher positive attitudes towards the use of technology. The study also revealed that learners taught with CAI showed higher positive mental attitudes and performed better in the subject. However, the study did not focus on development of 21st century skills, mathematics discipline, Excel and on Zambian context.

Netsianda and Ramaila (2012) investigated the use of technology in teaching mathematics in secondary schools in the Vhembe East District in the Limpopo Province, South Africa. The study used a mixed methods approach and an exploratory descriptive survey design which was conducted with 60 teachers of mathematics who were purposively selected. A survey questionnaire and observations were used to collect quantitative and qualitative data, respectively. The results revealed that teachers had inadequate competence to effectively integrate technology in mathematics teaching. The study did not establish how technology can be applied in teaching mathematics topics such as statistics.

Teaching mathematics today demands the use of technology by teachers, working in technology-rich classrooms and using technology creatively to support a constructive teaching and learning environment. In this regard, the use, access, and integration of technology in teaching mathematics was investigated by Umugiraneza et al. (2018) in KwaZulu-Natal schools in South Africa. The quantitative study was conducted with a questionnaire which contained closed and Likert scale items about the use of technology, this was administered to 75 teachers of mathematics. It was found that calculators were the most used technology and that most teachers never use computers in their teaching. However, 80% of the teachers were positive that the use of technology in teaching can improve understanding of mathematics concepts. The study of Umugiraneza et al. (2018) also revealed that confidence levels in teaching mathematics were high for teachers who have access to internet instructional resources.

Similarities and Variations of the studies

The reviewed studies demonstrate several similarities and variations in the use of technology in teaching mathematics and other subjects in Africa, particularly the integration of spreadsheet tools such as MS Excel. Studies by Singh and Siddiqui (2009) and Kamodi and Garegae (2019) emphasized the use of MS Excel in different educational contexts. While Singh and Siddiqui focused on its application in computational physics and scientific education at higher learning levels, Kamodi and Garegae explored its role in teaching graph-related concepts in junior secondary mathematics classrooms. Despite the varied focus areas, both studies highlighted positive attitudes toward potential of Excel to enhance teaching practices, although they differed in their emphasis on learner outcomes.

Similarly, research from South Africa, including studies by Umugiraneza et al. (2018) and Netsianda and Ramaila (2012), indicated positive teacher perceptions toward technology use in mathematics instruction. However, these studies revealed varying levels of teacher competence and technology usage which emphasizes the importance of teacher preparedness and resource availability for effective technology integration. In contrast, studies by Hussaini et al. (2017), Yusuf and Afolabi (2010), and Chebotib and Kering (2021) focused on the impact of computer-assisted instruction (CAI) on learners' achievement and attitudes across various subjects. Although their emphasis was not specifically on MS Excel or the development of 21st-century skills, these studies consistently highlighted the positive influence of technology-assisted learning on learner outcomes. Other research studies conducted across different African countries further supports these observations. Benning and Agyei (2016), Gasigwa et al. (2022), and Seyram et al. (2021) emphasized the effectiveness of MS Excel in improving mathematics and statistical education, they demonstrated that integrating spreadsheet software yields better academic outcomes compared to traditional teaching methods. While Benning and Agyei (2016) and Akpoveta et al. (2016) focused on learner performance in mathematical functions and numerical methods, Gasigwa et al. (2022) and Seyram et al. (2021) concentrated on teaching statistical concepts. Despite these successes, broader challenges remain. Studies such as those by Ogunmakin (2018) and Abdullahi et al. (2022) highlighted disparities in technology adoption between public and private institutions and emphasized general ICT tool adoption rather than Excel-specific interventions.

The current study builds upon these findings by shifting the focus beyond academic performance to explore how the application of MS Excel in teaching statistics can foster the development of 21CS, Specifically communication, information literacy, technology literacy, and statistical literacy. Unlike previous studies that primarily concentrated on teacher perspectives or educational outcomes, this research emphasizes learners' holistic development and addresses a critical research gap by examining the broader implications of technology-driven pedagogy. Through this approach, the study positions MS Excel as a vital tool for fostering competencies necessary for learners' adaptation to modern educational and professional environments in Zambia.

2.3.3 Global perspective

Communication, Information Literacy, Technology Literacy, and Statistical Literacy

Kurnia et al. (2022) conducted a study to explore the differences in statistical literacy (SL) among Indonesian year 9 and year 12 learners, as well as between female and male learners. The focus was on learners' capacity to critically interrogate data, including interpreting, communicating, evaluating, and decision-making. These skills were found to be strongly influenced by learners' understanding of three interconnected knowledge components: text and context, representation, and statistical-mathematical knowledge. The study administered the same test to 48 year 9 learners (50% females) and 48 year 12 learners (50% females) from 16 different schools in Indonesia. The findings revealed that a significant percentage of both year 9 and year 12 learners demonstrated consistent but non-critical thinking (level 4), showcasing their statistical knowledge without a critical approach. Importantly, a higher proportion of year 9 learners exhibited limited statistical thinking (levels 1 to 3) compared to year 12 learners. While no significant gender differences were observed in SL and its skills, the study revealed substantial grade-level variations in overall SL, excluding interpreting. The implications of the study suggest the need for a framework that provides a comprehensive assessment of learners' SL from a data consumers' perspective, along with recommendations for classroom teaching strategies.

Callingham and Watson (2017) address the growing importance of statistical literacy in education and the need for clear expectations at different schooling stages. Building on Watson and Callingham's 2005 study, the authors establish a 6-level hierarchy of statistical literacy using a new dataset from over 7000 middle-years learners across Australia during 2007-2009. This research confirms the existence of the hierarchy and employs longitudinal analysis to track

learners' performance over time. The study, set against the background of statistics and probability becoming a recognized strand in the Australian mathematics curriculum, provides understanding of realistic expectations for middle-years learners and outlines potential curriculum challenges. The findings offer guidance for education systems and teachers in fostering statistical literacy among learners, contributing to the ongoing discourse on statistical education.

Risqi and Setianingsih's (2021) study addresses the need for statistical literacy in the 21st century, emphasizing its role in reading data, critical thinking, and decision-making. The qualitative research explores the statistical literacy abilities of three female grade XII high school learners with varying initial statistical abilities. The study employed indicators categorized into Tier 1 (reading and explaining data), Tier 2 (analyzing, interpreting critically, and making conclusions), and Tier 3 (presenting data and predicting). Results indicate that learners with high initial statistical abilities perform well across all three tiers, demonstrating critical mathematical thinking (level 5 to 6). Conversely, those with medium and low abilities exhibit varying degrees of proficiency, falling within levels 3 to 5 (consistent non-critical to critical) and levels 1 to 3 (idiosyncratic to consistent non-critical), respectively. The study presents the importance of cultivating statistical literacy skills among learners and highlights the need for teachers to focus on enhancing learners' understanding and decision-making abilities in addressing daily challenges.

The study by Wijaya (2016) provides an investigation of information literacy by examining it within the framework of mathematical literacy, diverging from traditional perspectives found in library science or information and communication technology. The study involved 381 eighth and ninth graders from nine junior high schools in the Province of Yogyakarta, Indonesia who were subjected to a test based on PISA mathematics tasks. These tasks were selected for their specific information processing characteristics, such as superfluous information, missing information, and the need for connecting information across sources. The study employed error analysis to explore learners' incorrect responses, revealing that learners struggled with three key aspects of information literacy: recognizing information needs, locating and evaluating information quality, and making effective and ethical use of information. The findings expose a general deficiency in learners' information literacy skills.

Kim et al. (2022) conducted a study to identify teaching styles and challenges faced by teachers in imparting digital literacy skills specifically for the topic of quadratic equations. The research aimed

to address and refine shortcomings in the process of integrating digital literacy skills into quadratic equations. Using a qualitative approach, the study employed structured interviews with four participants from three districts in Malaysia. The interview data underwent analysis using ATLAS.ti 8 software, employing thematic analysis to categorize transcripts into small codes. The findings highlighted the significance of digital literacy skills in quadratic equations, encompassing motivation, space efficiency, conducive environments, development of thinking skills, and diversity of resources. Teachers predominantly relied on existing hardware and software, including MS Excel software, Google software, teaching aids, internet resources, and mobile applications. The study identified constraints faced by teachers, such as challenges in utilizing technology for calculations, communication of information, exploring diverse information, issues in mathematical modeling, and technical limitations. The research's implications include serving as a catalyst for cultivating digital literacy, especially among Generation Z, suggesting the use of TI-Nspire software for solving mathematical problems.

Erickson (2018) addressed the relationship between information literacy and mathematics instruction in mathematics education. He highlighted the importance of numeracy skills and the ability to critically engage with quantitative concepts in various contexts. While quantitative literacy has often been associated with financial mathematics and data-driven approaches, Erickson emphasizes the need for learners to explore an information environment filled with diverse sources. The study builds on the theoretical framework of quantitative literacy and statistical literacy, particularly Iddo Gal's model, to explore the roles of mathematical content in information-based problems. Erickson's study addresses a significant gap in the literature by conducting a cross-case analysis of three mathematics instructors who integrate information problem-solving tasks into their classrooms, revealing the challenges, tensions, and potential benefits of such integration.

Dijke-Droogers et al. (2016) conducted a study to address the shortcomings of current secondary school statistics curricula. These curricula tend to emphasize procedural knowledge over statistical reasoning, making it challenging for learners to apply their knowledge to practical situations. The study also aimed to address the issue of neglecting gifted learners in educational approaches. For grade 8 learners, the researchers implemented a differentiated learning trajectory that focused on statistical reasoning with visual representations. The intervention involved using TinkerPlots software in a digital mathematics environment (DME) with differentiated modules and

investigation activities. The results indicated that the differentiated approach increased learners' statistical literacy. This was demonstrated through improved scores on statistical tests and enhanced performance in investigation tasks. The findings of the study highlight the potential of integrating technology and differentiation strategies to address the limitations of traditional statistics education and better meet the diverse needs of learners.

Marilyn et al. (2016) advocated for the integration of information literacy skills in STEM undergraduate courses. They emphasized the crucial role these skills play in enhancing learners' research capabilities. The study addresses the gap in information literacy integration in mathematics education within STEM disciplines. Practical strategies such as evaluating internet-based resources, utilizing scientific databases, and information literacy tutorials are proposed to bridge existing gaps and prepare learners for the demands of the 21st century. Marilyn et al. acknowledge the need for targeted pedagogical support for faculty and emphasize the importance of collaboration between STEM educators and library professionals. The study concludes by highlighting the significance of future research to explore learner and faculty perceptions, contributing to a comprehensive understanding of information literacy in STEM education. This study aligns with the broader theme of investigating the application of technology.

Nocar et al. (2019) discuss the changing field of digital literacy in the context of ongoing curricular reforms in the Czech Republic, with a particular focus on its integration into mathematics education. The study highlights the necessity for teachers to possess digital competencies and emphasizes the shift in educational goals towards the development of both mathematical and digital literacy. The authors outline the transformation of the perception of digital literacy, its planned incorporation into mathematical teaching, and the underlying documents guiding the reform. Digital literacy is positioned as a key objective in the teaching of specialized subjects, such as mathematics, alongside the traditional goal of developing mathematical literacy. The study responds to evolving trends in Czech education, where digital technologies are no longer merely supportive tools but integral components of teaching, requiring active learner involvement in developing digital literacy. The theoretical basis draws on international assessments like PISA and TIMSS, emphasizing the importance of mathematical literacy and the changing role of digital literacy. The study emphasize the need for an approach to digital literacy development, encompassing competencies in information and data literacy, communication, collaboration, problem-solving, and technological skills. The authors propose thematic units within mathematics

education to achieve these competencies, aligning with broader national initiatives and frameworks. The study concludes by highlighting the significant role of mathematics education in nurturing learners' digital literacy, positioning it as a pivotal aspect of the ongoing educational reforms in the Czech Republic.

Watson (2010) emphasizes the significance of fostering statistical literacy skills among learners at the school level. This is driven by the evolving information and data-driven environment. The author identifies two crucial components of adult statistical literacy: the ability to critically interpret statistical information and the capability to communicate such understanding effectively for informed decision-making. The integration of statistics and probability into the school curriculum, initiated by curriculum reforms in the 1990s, serves as a foundation for statistical literacy development. The author acknowledges that traditional subject divisions hinder the integration of statistical concepts across various subjects and limit critical thinking development. However, new curriculum reforms in some countries are moving towards holistic and integrated approaches that foster quantitative literacy across subjects. This shift further presents the importance of statistical literacy as a contributor to broader quantitative literacy. The study discusses Australian research conducted since 1993, examining learners' understanding of statistical topics. The study employed hierarchical models, including a three-tiered hierarchy of statistical literacy.

The work by Qohar (2011) presents the importance of communication skills in learning mathematics. It asserts that mathematics is a language of symbols, and individuals studying mathematics need the ability to communicate effectively using these symbols. Developing communication skills not only allows individuals to use mathematics for its own sake but also enhances positive attitudes toward the subject. The study suggests that these communication skills are crucial for problem-solving abilities, as effective communication can lead to a more accurate representation and resolution of problems. The national curriculum and standards in mathematics education stresses the objective of fostering learners' ability to communicate mathematical ideas using various mediums. The study discusses different ways to develop mathematical communication skills, such as group discussions and contextualized problem-solving. The new paradigm of learning mathematics is described, where teachers facilitate active communication in the classroom, helping learners understand mathematical concepts accurately.

The study conducted by Firmanto et al. (2018) investigated the integration of information literacy, class culture, and learning outcomes in the educational context. Information literacy is identified as a fundamental skill for learners, it facilitates their comprehension of academic materials and promoting accurate knowledge acquisition. The study emphasises the necessity of establishing typical behaviours in response to information and highlights the positive impact of learners' active involvement in the classroom on academic performance. Emphasizing the role of class culture, the research contends that a positive and conducive classroom atmosphere contributes to improved learner behaviour, motivation, curiosity, and enthusiasm for learning. Furthermore, the study aligns with the idea that cultural aspects integrated into the learning environment foster meaningful understanding and engagement, promoting a shift from teacher-centered to learner-focused learning. The study posits that a culture-based learning approach, rooted in local cultural contexts, enhances learner participation and information literacy skills. The dimensions of class culture, including involvement, consistency, adaptability, and mission, are explored as key factors influencing learners' academic behaviour and information literacy. Furthermore, the study asserts that class culture-based learning is integral to creating effective learning behaviours, ultimately enhancing learners' information literacy and academic achievements.

The work by Qohar (2011) emphasizes the importance of mathematical communication skills in learning mathematics. It asserts that mathematics is a language of symbols and individuals studying mathematics need the ability to communicate effectively using these symbols. Developing mathematical communication skills not only allows individuals to use mathematics for its own sake but also enhances positive attitudes toward the subject. The study suggests that these communication skills are crucial for problem-solving abilities, as effective communication can lead to a more accurate representation and resolution of problems. The national curriculum and standards in mathematics education stress the objective of fostering learners' ability to communicate mathematical ideas using various mediums. The study highlighted different ways to develop mathematical communication skills, such as group discussions and contextualized problem-solving. The new paradigm of learning mathematics was described, as where teachers facilitate active communication in the classroom to help learners understand mathematical concepts accurately.

Yuniawatika's (2018) study addressed the importance of statistical literacy, particularly in the context of the Fourth Industrial Revolution. The Author argued that statistical literacy is a key skill

for individuals in the 21st century by posing fundamental questions about the simplicity and understanding of this skill. The study explored the meaning of statistical literacy and queries whether possessing statistical knowledge equates to having statistical literacy skills. Central to the discussion is the inquiry into methods for developing statistical literacy skills among learners. The study established the significance of statistics in the mathematics curriculum across educational levels and emphasized its role in shaping informed and literate individuals. The author contends that statistical literacy is pivotal in addressing complex problems in the rapidly advancing fields of information and technology. The study highlighted the importance of educators, including not only observers of education but also producers and pioneers, in enhancing statistical literacy. Ultimately, the study emphasizes the need for a comprehensive approach to statistical literacy, encompassing knowledge, critical thinking, and communication skills.

Gordon and Nicholas (2010) emphasized the essential role of statistical literacy for learners in both their professional lives and as responsible citizens. The study revealed challenges in teaching statistics and highlighted the importance of making the subject meaningful and relevant. Drawing on Gal's (2002) model of statistical literacy, which includes five interrelated knowledge bases (literacy, statistical, mathematical, context, and critical) and essential supporting dispositions, the authors proposed a framework for enhancing statistical instruction. The study categorizes three ways educators use examples to promote statistical literacy: (1) educator developed examples for basic instruction, (2) learner generated examples under teacher direction, and (3) examples linking statistics to learners' future professional work. Interviews with university statistics educators highlighted strategies for fostering engagement and reducing learner anxiety about statistics. The study offers understanding of improving statistics pedagogy and advancing statistical literacy development among learners.

Sharma et al. (2012) presented the significance of statistical literacy in statistics education research. The author revealed that statistical literacy demands particular attention, especially as efforts are made to refine the teaching, learning, and assessment of this domain. The study investigated the challenges associated with teaching and assessing statistical literacy through two teaching experiment cycles in year 9 classes. The research incorporates a diverse dataset, including audio and video recordings, learners' written work, interviews, and field notes. The outcomes reveal instrumental tools and techniques in cultivating critical statistical literacy skills among learners. The authors contend that statistical literacy extends beyond mere calculations,

emphasizing the importance of interpretation, critical evaluation, and effective communication of statistical information. They emphasized the role of teachers in fostering a conducive classroom environment and addressing literacy skills as integral components of statistical literacy. The study advocates for an enriched pedagogical approach, positioning statistical literacy as a vital skill for exploring information-rich society and fostering collaboration between educational research and teaching practice.

Gordon et al. (2005) conducted an exploration of what statistics teachers perceive as the attributes of a proficient statistics learner and the role that communication skills play in this evaluation. Conducting e-mail interviews with members of the International Association for Statistics Education (IASE) worldwide, the study revealed a diversity of opinions among statistics educators regarding the importance of communication skills in statistics learning. While some educators assert that communication skills are fundamental to university-level statistics education, others do not emphasize this aspect. The study argues that understanding the array of perspectives held by statistics educators is crucial for comprehending the messages conveyed to learners through teaching. The authors revealed that communication skills are integral to statistics education but questioned whether statistics teachers explicitly communicate this importance to their learners. The study explores the views of statistics educators on what constitutes a 'good' statistics learner, considering factors such as critical thinking, curiosity, and work ethic. The study suggests that communication skills serve various roles, including expressing statistical ideas, facilitating peer discussions, and addressing challenges faced by learners less confident in mathematics. Therefore, the study stressed the need to recognize and address diverse perspectives among statistics educators to enhance the effectiveness of statistics education.

Nartani et al. (2015) contribute to the literature by investigating the impact of contextual learning on learners' mathematical communication skills at Taman Muda Yogyakarta Elementary School, Indonesia. The study aligns with the broader educational discourse as it emphasizes the significance of effective communication in mathematics education. The researchers build upon the foundations of constructivism and contextual teaching to create a learning environment that integrates real-life scenarios into mathematics instruction. The study highlighted the idea regarding the importance of learners constructing their own knowledge. The findings demonstrated the success of contextual learning in enhancing mathematical communication and supporting the assertion that this approach can address challenges posed by traditional teaching methods. The

study contributes to the literature on mathematics education, and offers a practical application of contextual learning that positively influence learners' communication skills in the subject.

Sutama et al. (2019) addressed the persistent issue of the importance of communication skills among Indonesian learners. They attributed poor communication skills to the teacher-dominated learning process. Their research aimed to develop a Lesson Learned Plan for mathematics that integrates communication skills, utilizing a research and development approach. The study involved mathematics teachers, principals, and learners from 65 Junior High Schools in Sukoharjo, Central Java. Data collection methods included questionnaires, interviews, documentation, and Focus Group Discussions (FGD). The Lesson Plans developed through this approach focus on integrating communication skills by specifying competencies, developing indicators, formulating clear learning objectives, creating relevant lessons and activities, and implementing scoring tools. The study also emphasizes literacy planning within the learning process. The authors argue for a shift towards double loop learning to guide learners in enhancing their communication skills, aligning with the 2013 curriculum's emphasis on 21CS. Therefore, the study highlights the importance of active learner participation, variety in teaching methods, and the need for higher-order thinking skills to improve communication abilities in the context of mathematics education.

The study conducted by Pamungkas and Khaerunnisa (2020) investigated the statistical literacy of learners in basic statistics courses. They focused on early knowledge and mathematical self-esteem. Utilizing descriptive quantitative research methods, the researchers employed tests of statistical literacy, early knowledge, and mathematical self-esteem scales for data collection. The findings reveal that learners exhibit a moderate level of statistical literacy, with variations in prior knowledge and mathematical self-esteem. Learners with high initial knowledge and self-esteem tend to demonstrate higher statistical literacy scores, highlighting the influence of these factors. The study stresses the significance of considering learners' prior knowledge and self-esteem in designing effective statistics courses and teaching strategies. Therefore, the research provides understanding of the factors shaping learners' statistical literacy abilities and offers implications for enhancing statistics education.

The study by Muslim et al. (2019) focused on exploring the effectiveness of problem-based learning (PBL) in enhancing the communication skills and mathematical problem-solving abilities of seventh-grade learners. Involving 120 learners, the research reveals that PBL significantly

outperformed conventional learning in improving mathematical communication skills and problem-solving abilities. Regardless of school qualification factors, PBL demonstrated a more substantial impact on enhancing these skills. The study also highlights the positive influence of PBL on both male and female learners, they emphasized its efficacy in fostering positive attitudes toward mathematics. Despite some challenges related to question difficulty and time factors, the findings revealed the potential of problem-based learning to positively impact learners' cognitive flexibility, adaptability, and overall mathematical abilities.

Computer Software in Teaching and Learning Mathematics

Georgieva (2015) focused on incorporating technology, specifically Microsoft Excel, into mathematical education. The study aimed to enhance learners' critical and analytical thinking about mathematical concepts through the use of electronic spreadsheets. The study drew on educational theories such as social constructivism, scaffolding, and activity approaches, along with the principles of connectivism, to propose a new approach to teaching mathematics. The study emphasized the importance of learners understanding the practical applications of mathematics and highlighted the benefits of using MS Excel in developing mathematical skills. Through examples and activities, the study demonstrated how electronic spreadsheets could be employed to engage learners, encourage collaboration, and facilitate problem-solving. The study encouraged educators to leverage available resources, such as computer labs with widespread software like Microsoft Excel, to enhance learners' mathematical literacy. While Georgieva's study provided understanding of the integration of technology in mathematical education, it primarily focused on MS Excel and its application in solving mathematical problems. The study did not specifically address the application of MS Excel in teaching statistics or the acquisition of 21CS.

Giles (2002) contributed significantly to the integration of technology in New Zealand secondary schools, particularly through the development of OG Statistics, a Visual Basic software package designed to enhance the teaching of Year 13 Mathematics with Statistics using Microsoft Excel. The study highlighted the challenges and slow adoption of technology in New Zealand schools, emphasizing the importance of tools like Excel for statistical problem-solving. While Giles discussed the benefits of Excel in teaching statistics, the study did not explicitly address 21st century skills such as communication skills, information literacy, technology literacy, and statistical literacy. The current study aimed to extend Giles' work by specifically examining how

the application of MS Excel in teaching statistics contributes to the acquisition of these essential 21CS. By focusing on a skill set, the present research sought to provide an understanding of the impact of Excel on learners' overall proficiency and preparedness for the modern era of information and technology.

Marley-Payne and Dituri (2019) investigates the role of technology in delivering high-quality mathematics education, they emphasized the need for appropriateness in its application for effectiveness. Their research advocates for the use of spreadsheet software as a particularly valuable technological tool in the mathematics classroom, facilitating a deeper understanding of algebra and modelling. The study asserts that purposeful integration of technology into the mathematics curriculum is essential for learners to recognize its utility. To contribute to this understanding, the study focuses on elucidating the role of spreadsheets in mathematics education, drawing explicit connections to best practices supported by research. Furthermore, the research outlines a strategic approach for incorporating spreadsheets into high school mathematics through a lesson series on retirement savings, illustrating the diverse educational benefits that spreadsheets can bring. While this study enriches the discourse on the integration of technology in mathematics, it does not address the dimensions of the current study, specifically, the application of MS Excel in teaching statistics for learners' acquisition of 21CS. The current study aimed to fill this gap by exploring how MS Excel can foster communication skills, information literacy, technology literacy, and statistical literacy in the context of modern education.

Rabi et al. (2022) focus on investigating the relationship between academic skills and Microsoft Mathematics Visualization in the classroom, treating the latter as an independent variable influencing the former. Employing a quantitative research approach, the study collected and analysed approximately 300 responses, revealing that Microsoft Mathematics Visualization serves as a significant predictor for academic skills, explaining a substantial percentage of the variance in the model. The findings highlight a positive correlation between learner caliber and Microsoft Mathematics Visualization, indicating the impact of the tool on formal schooling. Despite this findings provided by Rabi et al., their study does not explore the application of MS Excel in teaching statistics or its role in fostering 21CS, including communication skills, information literacy, technology literacy, and statistical literacy. Therefore, the current study aimed to explore how MS Excel can enhance the acquisition of these crucial skills in the context of modern

education, offering a comprehensive perspective on the broader implications of technology in the learning process.

Cobcobo and Capua (2022) contribute to the understanding of ICT integration in mathematics education, particularly focusing on teachers' expectations, attitudes, and the readiness of mathematics teachers in the Paracelis district, Philippines. The study employs a questionnaire to evaluate ICT integration readiness, revealing that mathematics teachers in the district are confident and willing to use ICT, with an average rating of 4.06. The research stresses the positive impact of MS Excel in integrating machine data for statistics, enhancing learners' performance. However, the study does not address 21CS, which are crucial for learners in the modern educational. The current study aimed to build upon this foundation by specifically exploring how the application of MS Excel in teaching statistics can contribute to the acquisition of these essential 21CS, providing a more comprehensive perspective on the varied role of technology in mathematics education.

Cuadra's (2021) research focuses on evaluating the impact of Information and Communication Technologies (ICT), specifically Microsoft Excel, on the academic performance of first-grade secondary learners in mathematics. The study highlights the motivational aspect influenced by learners' interaction with ICT, emphasizing its role in enhancing academic outcomes. While the research provides valuable information on the positive effects of ICT, particularly Excel, on academic performance in mathematics, it primarily focuses on general academic improvement and motivation. However, it does not address the acquisition of 21CS. The current study on the application of MS Excel in teaching statistics aimed to fill this gap by examining how Excel usage contributes to the development of these skills, providing a more comprehensive understanding of its educational impact.

Lee et al.'s (2018) study explores the significance of spreadsheet skills for accountants, aiming to identify the specific skills deemed crucial for success in the field. The study emphasizes the scarcity of research that discerns the relative importance of distinct spreadsheet skills, providing understanding of spreadsheet proficiency. While the study contributes to understanding the importance of skills like 'Lookup and Pivot Table,' 'Data entry, format and calculations,' and 'Logic' for practicing and newly hired accountants, it primarily focuses on the accounting domain. The study however shows that spreadsheet proficiency is essential not only in schools but also in professional life. The current study aimed to broaden the scope by exploring the development of

21CS, including communication skills, information literacy, technology literacy, and statistical literacy. By doing so, the current study extends the research beyond the accounting profession, offering insights applicable to a broader educational context and addressing a more comprehensive set of skills essential for the modern era.

The study by Patron and Smith (2022) investigated the impact of class attendance and Microsoft Excel intensive lab sessions on learner performance in business statistics courses. The research, conducted in two sections; a hybrid class and a traditional class, reveals that attendance at both regular lectures and Excel lab sessions positively influences learner performance. The study emphasizes the importance of attendance, highlighting that each lecture and lab session attended contributes significantly to higher test scores. Interestingly, the results indicate that the effect of attendance remains significant even when controlling for other factors such as age, gender, race, GPA, and workload. This emphasizes the relevance of actively engaging in both traditional and technology-intensive learning environments. However, while Patron and Smith focus on the impact of attendance on test scores, the current study extends this research by examining the acquisition of 21CS. Specifically, it explored how the use of Excel contributes to learners' development of communication skills, information literacy, technology literacy, and statistical literacy.

Bernard et al.'s (2019) study emphasizes the significance of basic math proficiency as a foundational requirement for learners in mathematics education. Their research investigates the efficacy of an Open-Ended approach, coupled with Information and Communication Technology (ICT), particularly Visual Basic for Applications (VBA) in Microsoft Excel, to enhance learners' problem-solving skills and cultivate a disposition for creative mathematical thinking. The experiments conducted on three groups of learners revealed that those utilizing the Open-Ended approach supported by VBA for MS Excel outperformed their counterparts who did not use VBA. The study establishes VBA for MS Excel as a valuable tool for creating and explaining mathematical concepts. While this research provides understanding of enhancing mathematical learning, it primarily focuses on basic math proficiency and problem-solving. In contrast, the current study on the application of MS Excel in teaching statistics for learners sought to extend this understanding to encompass the acquisition of essential 21CS, including communication skills, information literacy, technology literacy, and statistical literacy.

Borkulo et al. (2023) contribute to the discourse on integrating computational thinking (CT) into education, particularly focusing on upper-secondary statistics lessons using spreadsheets. The study highlights the successful engagement of learners in computational concepts, data practices, and the demonstrated awareness of the relevance of CT in their lives. While Borkulo et al.'s work sheds light on the potential of spreadsheets for developing computational thinking skills in secondary school, it primarily explores the technical aspects of CT within the field of statistics. In contrast, the current study sought to extend this exploration to a broader context, encompassing 21CS.

Mulle (2023) contributes significantly by investigating the influence of spreadsheet applications on the instruction of Data Management in Mathematics of the Modern World to first-year college learners. Through the utilization of a quasi-experimental design and statistical analyses, valuable insights are derived regarding the efficacy of these tools in augmenting learner achievements. While Mulle's research establishes a groundwork for elucidating the beneficial impacts of spreadsheet applications, it predominantly concentrates on scholastic performance within a defined mathematical sphere. Conversely, the present study endeavoured to broaden this examination to include 21CS.

Agyei (2013) provides understanding of the development of reform-oriented teaching practices among pre-service teachers through the use of interactive spreadsheets in the context of secondary school mathematics. The qualitative analysis of various data sources highlights the positive impact on participants' understanding, pedagogies, and classroom management, ultimately enhancing learners' higher-order thinking and conceptual formation. While the work by Agyei (2013) lays a foundation for understanding the benefits of spreadsheet applications in mathematics education, it primarily focuses on general mathematics concepts. The current study on the application of MS Excel in teaching statistics aimed to bridging this gap by specifically addressing the acquisition of 21CS. By focusing on communication skills, information literacy, technology literacy, and statistical literacy, the current study sought to extend the inquiry beyond traditional mathematical concepts, providing a more comprehensive perspective on the potential of MS Excel as an educational tool.

In his study, Gomez (2014) proposed an innovative teaching approach for University Statistics. He argued that emphasis while teaching statistics should shift from formulae and computations to

a deeper discussion of concepts and their application to real-life which can be facilitated with the appropriate use of technology. The paper suggested that innovative teaching of statistics must constitute an interactive method involving the use of presentation technology such as PowerPoint, and SPSS software for calculations of real-life data. This teaching approach was implemented at Florida International University in USA, it was found that the learners taught using a technology-based interactive approach had higher passing and retention rates compared to those taught with a traditional teaching method. The study indicated that the integration of SPSS into an interactive teaching approach while teaching introductory statistics course provides a highly effective teaching method for undergraduate learners. Nevertheless, the results of the study are not indicative of what might pertain at secondary school level and development of 21CS when Excel is utilized. Therefore, this study 'was conducted to investigate the application of Excel in teaching statistics at secondary schools, focusing on learners' acquisition 21st century skills.

Larwin and Larwin (2011) carried out a meta-analysis to investigate the impact of Computer-Assisted Instruction (CAI) on learner achievement in postsecondary statistics education across a 40 year period of time. The study was conducted from 70 studies, for a total of 219 effect-size measures from a sample of 40,125 participants. They calculated an overall effect size of 0.566, indicating that the use of CAI can have a moderate impact on learner achievement in postsecondary statistics education. It was found that a learner moved from the 50th percentile to the 73rd percentile when technology was used as part of the curriculum. The study suggests that the average learner participating in a computer-assisted statistics instruction exceeded the academic achievement of approximately 73% of the learners in traditional statistics instruction. Larwin and Larwin argued that the mean effect-size measures consistently increased across the four decades, the impact of CAI on statistics education has been growing. However, the study concluded that learner performance and understanding cannot be achieved with CAI alone but if properly utilized as an enhancement or supplement it can be very beneficial to learner achievement. They concluded that incorporating technology with innovative teaching approaches such as activity-based, experiential and cooperative learning can further maximize the understanding of statistics. Nevertheless, this study did not focus on the effect of using computer-Assisted Instruction on learners' acquisition of 21CS.

Technology play a vital role in our every-day lives and in the teaching and learning practices. The role of mathematics has entered the field of technology. Das (2019), in his paper highlighted the

importance of the integrating technology into the teaching and learning of mathematics in India. The study involved an observation, conservation, interpretative, and study of secondary materials such as journals, articles, books, thesis, and websites. Literature displayed that applying technology in Mathematics has a positive impact on teaching and learning process. According to the study, statistics is one of the areas in mathematics that can benefit from the opportunities technology offers. The study did not however suggest how technology can be applied in teaching statistics for 21CS.

The study of Smit (2016) suggest that the use of problem-based task can foster the development of the four 21CS, namely; creativity, critical thinking, communication and collaboration (aka 4-Cs). This was in an explorative study conducted with three different classes at two different schools in Netherlands to investigate how to develop 21CS in mathematics classroom. From smit's (2016) stand point, the use of problem-based tasks can elicit 21CS compared to regular tasks. Bray and Tanglely (2015); Suson (2019) adds that the tasks must be contextual scenarios lined with real-life experiences of the learners. Hiong and Osman (2013) proposed conceptual framework (BTEM) for the integration of 21CS in biology education, they depicted the use of problem-based learning and inquiry-based learning in a 21st century classroom to coordinate both knowledge and skills simultaneously in Malasyian context. Smit (2016); Hiong and Osman (2013), concluded that the development of 21st century skills cannot be achieved with one specific teaching approach, different constructivist approaches must be utilized to teach these skills. However, the study did not investigate how technology such as computer software can be applied in problem-based task to foster the development of 21CS in statistics classroom.

Rosdiana et al (2020) conducted a qualitative study on "Implementation of 21st Century learning through lesson study", the study used a descriptive approach and was conducted on University learners of materials science course. The study was conducted in Indonesia. According to Rosdiana and other scholars, combining a lesson study learning model with a variety of learning approaches such as blended learning, group discussion, problem-based learning etc. can help to develop the relevant competencies in the learners. The researchers found that the use of lesson study can foster the development 21CS namely; critical thinking and problem solving, creativity and innovation, media and ICT Skills. However, the study does not provide a description for integrating lesson study model with Excel. Furthermore, the study is not statistics specific.

Ware and Chastain (1989) investigated the effect of using computer technology in teaching introductory statistics on academic success of university learners of Creighton University, Nebraska, USA. The study was conducted with 103 learners. The results did not reveal any difference in mathematical success and showed no difference between females and males on their success in statistics, when exposed to computer-assisted learning. These findings are in agreement with the studies conducted by Wang and Newlin (2000); Maltby (2001); Spinelli (2001) which showed that understanding statistical concepts cannot be achieved with the use of statistical software and that there is no difference in achievement between boys and girls when statistics is taught with statistical software. However, these studies concluded that the use of statistical software in teaching statistics can improve learning outcomes if properly or effectively utilized. So, this current study was conducted to investigate whether effective application of Excel in teaching statistics can foster the development of 21st century skills.

According to Jatnika (2015), Introducing SPSS course to Learners can increase their knowledge and ability to apply statistics. This was in an experimental study conducted at Padjadjaran University in Indonesia. In order to answer the research questions, the study utilized a one group pre/post-test design. The results of Wilcoxon test and t-test performed with SPSS version 18.0 showed a significant increase in cognitive aspects and a decrease in achievement after using SPSS course. He concluded that the decrease in achievement was as the result of learners being anxious when using computer. Nevertheless, it was argued that learning statistics is not about getting a good score but to produce learners who can use statistical concepts appropriately (Jatnika, 2015).

Researchers have been trying alternative teaching approaches to improve learning of Mathematics in Universities and Colleges with the aim to foster the development of skills and knowledge necessary for 21st century life and work force. Spradlin (2009) posited that computers and the internet makes it possible to effectively teach and learn mathematics. This was in a quasi-experimental study which he conducted to compare learners' academic achievement in Intermediate Algebra when taught using traditional instruction and with traditional instruction plus computer-assisted instruction. ANCOVA was performed with SPSS to determine the difference in mathematics performance between the two groups. The findings revealed that there was no statistically significant difference in the two groups. However, there was a significant difference in mathematics scores in relation to gender, whereby females performed better than males in both

teaching and learning modes. The study was not secondary school, Excel, statistics topic, and 21CS focused. Hence, the need to conduct this study.

A quantitative study conducted by Basturk (2005) on the “effectiveness of Computer-Assisted Instruction (CAI) in teaching introductory statistics course” at Carnegie I Research University in Turkey suggests that learning capacity is improved when CAI is used as a supplement to regular teaching approach and that SPSS is a useful tool for teaching statistics. Basturk employed a quasi-experiment design which made use of two groups comprising of 205 learners. The control group was taught introductory statistics using Lecture-only approach while the experimental group was taught with Lecture plus CAI approach where SPSS was used during an extra session in the computer laboratory. The results of independent sample t-test showed that learners in the experimental group scored significantly higher than learners in the control group. It was discovered that the learning gap between the two groups increased from descriptive to inferential statistics. The results further showed that additional time spent in computer lab did not account for better performance by the experimental group but it interpreted into gains in learning statistics, this was in line with the conclusion made by Higazi (2002). The study was conducted at tertiary level with Masters and PhD learners of introductory statistics course and it did not focus on Excel, and the development of 21CS, therefore, this study ‘was conducted to fill this gap in literature.

In Malaysia, It has been acknowledged that technology is key in transforming the country to future development and that this can be achieved by integrating technology in teaching which is to use technology-based teaching facilities and tools where computers serve as teaching aids. Indeed, applying technology in teaching gives learners an opportunity to learn and apply the required 21CS. Hence, Ghavifekr and Rosdy (2015) analysed teachers’ perceptions on effectiveness of technology application in supporting the teaching and learning process in classroom. The study used a survey questionnaire which were administered to 101 teachers who were randomly selected from 10 public secondary schools in Kuala Lumpur in Malaysia. The findings were quantitatively analysed with SPSS v21.0 and the results indicated that applying technology in subjects such as mathematics is effective for both learners and teachers. It was also revealed that teachers’ well-equipped preparation with technological tools is one of the main factors for success of technology-based teaching. Unfortunately, limited technical support, limited accessibility and network connection, lack of effective training, lack of teachers’ competency, and limited time were among challenges faced in using technology in classrooms in Malaysia. However, this study did not

establish how teachers were applying technology in order to foster the development of 21CS in mathematics classroom.

Handajani et al. (2018) refers 21st century teaching to teaching that integrates attitudes, skills, mastery of technology and content knowledge. Handajani et al (2018), conducted a study to determine whether there was a difference in the effectiveness of applying a Model-eliciting activities (MEAs) Model that integrates 21CS and traditional teaching in terms of learning outcomes. They used an experimental method which was conducted at a vocational high school. The findings showed that integrating the 4Cs (communication, collaboration, Critical thinking & Problem solving, and Creativity & Innovation skills) in MEAs can provide better learning outcomes than traditional teaching. However, the study did not reveal how technology can be applied in MEAs to engage learners with 4Cs in the teaching of statistics.

According to Harits et al. (2019) stated that pedagogy ability, mastery of technology and content knowledge of teachers of mathematics is vital in the implementation of the TPACK framework for developing 21CS, this was in agreement with Mishra, Koehler, and Henriksen (2011). The study was a qualitative study conducted with a case study approach on four teachers of mathematics. According to the TPACK framework, effective implementation of technology into learning requires considering the integration of pedagogy, and content in a creative and integrated manner. It was found that the TPACK ability of the four teachers was at medium level. The data emanating from the study shows that the use of interactive media, High Order Thinking problems, drill and scaffolding method, class discussions and cooperative learning models can foster the development of 21CS through TPACK. Unfortunately, the study only describes the TPACK abilities of four teachers and how TPACK framework can help to develop 21CS in mathematics classroom.

Warner & Kaurb (2017) describes how the four 21CS, thinking, communication, collaboration, technology, and confidence can be developed in a mathematics classroom using 2T2C model. These authors investigated the perceptions of teachers and learners on the effectiveness of a 21st century mathematics instructional model (2T2C). The findings of this qualitative research revealed that learners took responsibility of their learning and thinking. On the same note, the interviews indicated that thinking, communication, collaboration skills, use of technology and confidence improved. The study revealed that the use of 2T2C model can foster the development of some 21CS. Since this is a qualitative study, the results cannot be generalized. Moreover, the study did

not investigate the application of 2T2C model in teaching statistics to foster the development of 21st century skills.

Lee & Hung (2012) proposed an instructional framework for 21st century learning which they called the D.A.S.K. The model depicts the five zones of learning, namely; zone of instruction, interaction, tinkering; and meta-cognition. The argument here is that effective learning is about the interplay between 21CS and content knowledge (Gravemeijer et al, 2017; Alismail & McGuire, 2015). The study proposed the framework for learning science in the context of Singapore, however, the proposed framework does not depict the practical application of technology and mathematics knowledge basing on a concrete topic such as statistics. Furthermore, the study did not examine the effectiveness of the framework.

The empirical literature search brought to the fore more studies; Peters, Burton & Stehle (2019), conducted a study in the USA to investigate the extent to which teachers in STEM schools implemented the 21st century teaching methods. Lesson plans from seven (7) sampled STEM schools were collected for the study. It was found and concluded that STEM schools provided environments that supported the development of 21st Century skills. The researchers suggested the use of a rubric for 21st century learning as the best way for teachers to assess the level of 21CS in their lessons (Peters-Burton & Stehle, 2019). They also found that lesson plans that lasted three or more days had higher levels of 21CS. On the contrary, the study did not look at how these 21st Century skills could be nurtured or developed in statistics classroom.

Taylor (2017) argued that, STEAM as opposed to STEM education could foster the development of 21CS. In attempt to obtain in depth appreciation of the concept, Hadinugrahaningsih et al. (2017) conducted a two year study on the effect of using STEAM approach on learners' acquisition of 21st century skills by modifying the project-based learning model. However, their qualitative study was conducted in two secondary schools with chemistry learners. The study showed that project based approach could be integrated in STEAM schools to improve learning of chemistry and to foster the development of 21st century skills.

Messias et al., (2018) performed a case study on Education 4.0 with high school learners where robotic activities were used to foster the development of 21st century skills. The results showed that that using robotic activities in classroom helped learners to develop some skills. They stated that education 4.0 can nurture the important skills which can develop solutions for real world

problems. Lawrence, Ching, and Abdullah, (2019) argue that education 4.0 can engage learners with new technology tools and enhance their knowledge and usage of technology. It can also promote the development of 21CS. Therefore, education 4.0 can build competencies and develop skills for the new era of digital technology (Mourtzis et al, 2018). According to Hussin (2018) teachers should welcome the new wave of Education 4.0 as this promotes the development of knowledge and skills as well as helps learners to identify the source of these skills and knowledge. Hussin (2018) suggests the use of flipped classroom, Bring Your Own Device (BYOD) and blended learning approach where learners are exposed to project-based learning are the most appropriate methods of teaching education 4.0. He further encouraged the use of e-learning tools for effective implementation of education 4.0 and development of 21st century skills. So, it is imperative for teachers to integrate technologies in their pedagogy.

2.3.4 Integration of Curricula, Teaching and Learning Models, and Approaches

Since the beginning of the 21st century, there have been rapid changes in education systems worldwide, including reforms in curricula such as STEM, STEAM, and Education 4.0. These changes fall under the umbrella of 21st century education, as they all require the use of computer technologies in teaching core subjects like mathematics. Literature has emphasized the importance of integrating technology into the education curriculum and has proposed various teaching methods, frameworks, and models for 21st century teaching and learning. Studies have shown that incorporating computer technologies into mathematics instruction can enhance understanding of the subject and skills. However, the successful implementation of these curricula requires structured teaching and learning models such as TPACK, TPASK, 2T2C, Bridge21, and DASK, along with effective teaching approaches like flipped classrooms, project-based learning, and blended learning. The interplay between these elements determines the effectiveness of contemporary education strategies.

Curricula such as STEM and STEAM focus on interdisciplinary learning and problem-solving, they necessitates pedagogical frameworks that guide teachers in the integration of technology and subject knowledge. For instance, the TPACK framework (Mishra & Koehler, 2006) provides a structured way for teachers to blend technological, pedagogical, and content knowledge to enhance instruction. The TPASK model, an extension of TPACK, tailors this integration specifically for

statistical education (Harits et al., 2019). Similarly, the 2T2C model (Warner & Kaurb, 2017) can foster collaboration, communication, and critical thinking in STEM classrooms.

Despite the theoretical strength of these frameworks, research has highlighted gaps in their practical implementation. Studies by Lee and Hung (2012); Gravemeijer et al. (2017), suggest that these models do not fully address how specific computer technologies, such as Microsoft Excel or statistical software, can be integrated into curricula for effective learning outcomes. Furthermore, the DASK framework emphasizes an interactive learning environment but lacks empirical evidence on its efficacy in different subject domains.

The successful implementation of curricula and teaching models requires effective pedagogical approaches. Problem-based learning, project-based learning, and collaborative learning approaches are widely recognized for fostering student engagement and deep learning (Hussin, 2018; Smit, 2016). Studies indicate that integrating these approaches with digital tools enhances students' conceptual understanding and skill development (Muslim et al., 2019).

For instance, flipped classrooms and blended learning approaches align well with Education 4.0, which emphasizes personalized and technology-enhanced learning (Hussin, 2018). Bring Your Own Device (BYOD) approach further support this by allowing learners to engage with digital tools both inside and outside the classroom. However, research by Georgieva (2015) highlights that the effectiveness of these approaches depends on structured guidance and scaffolding to ensure meaningful learning experiences.

Although curricula, teaching and learning models, and instructional approaches are often studied separately, empirical evidence suggests that they are interconnected and work most effectively when implemented in a complementary manner. STEM and STEAM curricula provide the overarching framework, while models such as TPACK and 2T2C offer theoretical guidelines for integrating technology. Teaching approaches like PBL and blended learning serve as the practical tools for executing these models in the classroom.

However, studies reveal that gaps still exist in the integration of these elements. For example, while project-based learning has been successfully implemented in STEAM education (Hadinugrahaningsih et al., 2017), it is often applied independently rather than as part of a structured model like TPACK or Bridge21. Similarly, while BYOD support Education 4.0, their

effectiveness depends on pedagogical frameworks that guide technology use (Alismail & McGuire, 2015).

Therefore, curricula, teaching and learning models, and learning approaches in 21st century education are interconnected rather than isolated components. Their effectiveness depends on their integration, where curricula set the foundation, teaching and learning models provide instructional structure, and learning approaches facilitate practical engagement. However, Literature indicate that while theoretical connections exist, there is a need for more an empirical study on their implementation in specific educational contexts, such as mathematics instruction.

2.3.5 Research Gap

While empirical studies in Zambia, Africa, and other parts of the world have explored the impact of using computer software such as MS Excel in teaching statistics at the college and university levels, none have specifically focused on fostering the development of 21CS among secondary school learners (Lee et al., 2018; Akpoveta et al., 2016; Chaamwe & Shumba, 2016; Boachie, 2016; Georgieva, 2015; Agyei, 2013). Some empirical investigations have demonstrated that employing Excel can improve performance and attitudes (Mulle, 2023; Abdullahi & Moham, 2022; Rabi et al., 2021; Marley-Payne & Dituri, 2019), while others have found no significant enhancements in performance or skill development when using statistical software (Ware & Chastain, 1989; Wang & Newlin, 2000; Maltby, 2001; Spinelli, 2001). Despite these mixed findings, all these studies agree on the conclusion that computer software can enhance learning if properly and effectively applied. These empirical studies have been instrumental in shaping the current study's methodology, guiding the selection of the software, and adapting research instruments.

The greatest contribution to the understanding and development of the current study, however, came from the theoretical literature. Theoretical perspectives have emphasized that to effectively employ computer software such as MS Excel in teaching secondary school statistics, it should be integrated with constructivist teaching methods that promote experiential, problem-based, project-based, and cooperative learning approaches (Barell, 2020; Boholano, 2017; Bray & Tanglely, 2015; Suson, 2019). These approaches engage learners in hands-on activities utilize real-life data to solve practical problems, thereby laying the foundation for developing 21CS such as communication skills, information literacy, technology literacy, and statistical literacy. Moreover, the theoretical

literature has informed the selection of the study topic, the design and application of the intervention, selection of the five 21CS, and the overall teaching approach adopted in this research. By bridging the gap between empirical evidence and instructional design challenges which has been highlighted by the scarcity of resources on applying computer software in teaching statistics for 21CS development (Barrett et al., 2019), the current study is uniquely positioned to extend beyond academic performance and contribute a holistic understanding of technology-driven pedagogy in secondary schools in Zambia.

Given the absence of empirical studies at the secondary school level and the lack of focus on the development of 21CS, there was need for research that directly investigates the use of Excel in teaching secondary school statistics to promote learners' acquisition of these skills. Therefore, this study investigated the applicability of Excel in teaching secondary school statistics and its impact on learners' acquisition of 21CS, addressing the existing research gap in mathematics education.

2.4 Chapter Summary

This chapter consists of the theoretical and empirical literature concerning the utilization of MS Excel in enhancing the teaching of secondary school statistics, with a focus on fostering the development of 21CS. The empirical literature has been discussed from Zambian, African and Global perspectives. Additionally, the chapter explored similarities and variations of the studies, as well as the discussion of the research gap.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter focuses on the research methodology employed in the study. To begin with, the philosophical orientation that underpinned the chosen methodological approach is outlined, including the researcher's philosophical standpoint and the rationale behind selecting the particular research approach. The research strategy, method, and design are also presented. Additionally, the research site, study population, sampling techniques, and research instruments are discussed. Moreover, the procedures for data collection and analysis are described. Finally, the chapter concludes with a discussion on the validity and reliability of mixed methods research, and control of extraneous variables, as well as ethical considerations.

3.1 Philosophical Orientation

The methodology of a research study is a general strategy that informs how the study should be conducted. It encompasses the philosophical assumptions of the study, which outline the understanding of the research questions and the choice of approaches that underpin the research process (Melnikovas, 2018). According to Kaushik & Walsh (2019), Sahay (2016), and Schwaferts (2014), research must be conducted based on philosophical assumptions to ensure the trustworthiness of the study. These assumptions determine what is considered a valid study and which research approaches are appropriate for knowledge development.

A research paradigm is a collection of philosophical assumptions held by researchers regarding the nature and conduct of the research study (Johnson et al., 2007). On the other hand, research philosophy can be described as the basis of research, which delineates the nature of reality (ontology), sources of knowledge (epistemology), and values or ethics of research (axiology) (Melnikovas, 2018; Saunders, Lewis & Thornhill, 2016).

After reviewing various research paradigms for educational research, pragmatism was chosen for this study. Therefore, the philosophical position of pragmatists was followed.

Pragmatism; Philosophical underpinning for the study

Pragmatism originated in the United States of America and was developed by Dewey, James, and Pierce between 1860 and 1930 (Cameron, 2009). The main philosophical idea behind pragmatism is that knowledge should be acquired through problem-solving (Schwaferts, 2014). Therefore, when conducting a research study, the choice of research paradigm should be based on the research problem (Kaushi & Walsh, 2019). Pragmatism allows for the use of research strategies that are best suited to the specific research questions being investigated. This means that there can be multiple realities that contribute to holistic and valid knowledge. Researchers who adopt a pragmatic stance choose to work with different types of knowledge and approaches, resulting in the use of a variety of research approaches, data collection methods, and analysis procedures.

From an **epistemological perspective**, pragmatists assume that the relationship between the knower and the known in a research study should be determined by what the researcher deems appropriate for that particular study (Creswell, 2013). From an **ontological standpoint**, pragmatists believe that individuals have different ways of interpreting reality, and therefore, research should be conducted using different approaches (Saunders, 2012; Creswell & Clark, 2011). The ontology of pragmatism aims to reconcile the gap between facts and values. In this particular study, a mixed methods approach was adopted, combining both quantitative and qualitative research methods to provide a deeper understanding of the phenomenon (Creswell, 2013; Saunders, 2012).

From an **axiological perspective**, pragmatists acknowledge the role of values and ethics in the research process. They advocate for research studies that contribute to knowledge and benefit research participants (Johnson & Onwuegbuzie, 2004). In the case of this study, the goal was to improve learning of statistics and fill a gap in the literature. It is important to note that neither positivism nor interpretivism alone can determine the truth about a phenomenon. Scholars argue that choosing one or the other position is unrealistic and that complete objectivity or subjectivity cannot be achieved (Kaushik & Walsh, 2019; Kivunja & Kuyini, 2017; Gafoor & Haskar, 2013; Kelemen & Rumens 2008). Instead, research paradigms should provide appropriate research methods for the phenomenon being studied (Biesta, 2010; Teddlie & Tashakkori, 2009). Pragmatism is considered appropriate for research studies because it allows for a combination of

research strategies that can capture the actual behavior of participants, the beliefs behind these behaviors, and the consequences of different behaviors (Gafoor & Haskar, 2013).

Pragmatism is particularly suitable for educational research studies as it allows for the use of multiple strategies to improve classroom practices. The choice of research strategies is influenced by the nature of specific research problems and the purpose of the study (Kelemen & Rumens, 2008). Using multiple strategies ensures that the results of the research study are trustworthy, credible, reliable, and valid. Education problems can be solved by adopting a pragmatic philosophical approach that allows for a combination of interpretivist and positivist positions, depending on the research question (Kaushik & Walsh, 2019). Pragmatism is based on experience, experimentation, and action. It provides the flexibility to choose various strategies and perspectives to observe, investigate, understand, and improve the teaching and learning process (Saunders et al., 2016). By bringing together scientific and humanistic understanding, it offers understanding of the context and nature of the problem, as well as the effectiveness and value of interventions in learners' lives. Pragmatism is not concerned with abstract distinctions but with practical actions that can solve real-world problems (Masadeh, 2012; Kelemen & Rumens, 2008). These arguments clearly establish pragmatism as an appropriate paradigm for this study. The researcher shares the same philosophical sentiment that it is important to focus on understanding and finding practical solutions to problems, rather than adhering to specific paradigms or research approaches. This study followed a pragmatic philosophical orientation and used a mixed methods approach to answer the three research questions.

3.2 Research Approach

This research study utilized a mixed methods approach, which combines quantitative and qualitative approaches within a single study (Tashakkori & Teddlie, 2011). This approach was introduced in the 1980s as the third research approach (Creswell, 2013). With this approach, the researcher collected and analysed data and interpreted the findings using both quantitative and qualitative approaches within the same study. Greene (in Doyle et al., 2009) identified five major justifications for adopting a mixed methods approach. These included triangulation, which involves converging and corroborating results from different research approaches; complementarity, which allows for illustrating and clarifying results from one approach with the results from another; initiation, which involves discovering contradictions or inconsistencies

within the data sets that can lead to the reformulation of questions or the raising of additional questions; development, which entails using findings from one approach to inform the other approach; and expansion, which involves clarifying or elaborating on the knowledge gained from the previous approach. However, some researchers such as Cameron (2009), Johnson and Onwuegbuzie (2004), and Tashakkori & Teddlie (2003) have argued that the mixed methods approach is guided by the philosophical orientation of pragmatism. Pragmatism enables the mixing of qualitative and quantitative approaches throughout the research process, and this is influenced by the research questions that the researchers seek to answer. Therefore, pragmatism offers researchers the opportunity to use the mixed methods approach to answer research questions. Creswell (2012) stated that the mixed methods approach helps to answer research questions that cannot be answered by either the quantitative or qualitative approach alone. Combining the two approaches provides a more enhanced insight into the research questions than using one approach in isolation. Therefore, research approaches should be mixed in ways that offer the best opportunities for answering research questions. The relationship between research questions, pragmatism, and the mixed methods approach is depicted in Figure 3.1.

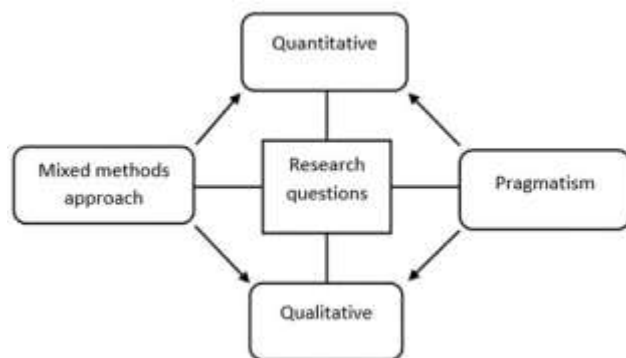


Figure 3.1: Developed by the researcher (Relationship between mixed methods approach and pragmatism).

Figure 3.1 illustrates that a mixed methods approach can be used to address both qualitative and quantitative questions, and that pragmatism supports the investigation of research questions that combine qualitative and quantitative approaches. Additionally, a mixed methods approach allows researchers to leverage the strengths and compensate for the weaknesses of both approaches (Johnson & Onwuegbuzie, 2004). The purpose of employing this approach is to integrate the strengths and mitigate the limitations of each method. Moreover, a mixed methods approach offers the potential to gather more comprehensive and in-depth information compared to using one

approach alone. Consequently, this approach enables a more detailed and understanding of phenomena which facilitates the capture of information that may be overlooked by strictly employing a quantitative or qualitative approach (Doyle, 2015; Creswell & Clark, 2011). By using words, pictures, narratives, and numbers, researchers can gain a broader perspective on educational issues, enriching the field as a whole (Almalki, 2016). This combination of methods allows words, pictures, and narratives to provide contextual meaning to numbers, while numbers add precision to words, pictures, and narratives. The integration of these approaches enhances the usefulness and validity of research results by offering diverse viewpoints on the same phenomenon and promoting understanding of the topic. A mixed methods approach facilitates a deeper comprehension, increased objectivity, and improved generalizability of the study, ultimately ensuring the validity of the research findings. Although employing a mixed methods approach can be expensive and time-consuming, the researcher agrees with Almalki (2016) that mixed methods approach can enhance the quality of research findings.

Therefore, a mixed-method approach was utilized in this study, following an **explanatory sequential approach**. According to Creswell and Clark (2011), the explanatory sequential approach is a type of mixed-method that consists of two distinct phases. The first phase is the collection and analysis of quantitative data, which dominates the study, followed by a second phase which is qualitative phase. In this approach, the initial quantitative results primarily shape the study findings of the study, while the qualitative phase plays a supplemental role which serves to refine and provide deeper understanding of specific aspects of the quantitative data (Creswell, 2012).

The explanatory sequential approach is particularly useful in studies where researchers seek to clarify quantitative results through qualitative insights (Cohen et al., 2008). It is often applied when the researcher aims to identify trends or patterns from a broad dataset and then further interpret these findings through qualitative inquiry (Johnson & Onwuegbuzie, 2004). This approach is most appropriate in contexts where numerical data forms the foundation of the analysis, but qualitative data is necessary to provide additional context and meaning to the statistical outcomes (Cameron, 2009). One of the key strengths of the explanatory sequential approach is that it allows for a structured and systematic integration of quantitative and qualitative data, which ensures that the qualitative phase supplements rather than overshadows the primary quantitative analysis (Creswell, 2012). It enhances the depth of understanding by enabling researchers to explore the “why” behind statistical trends observed in the quantitative phase (Cohen et al., 2008).

Additionally, this approach is advantageous because it helps mitigate some of the limitations of relying solely on quantitative or qualitative methods, thereby increasing the overall validity and reliability of the study (Johnson & Onwuegbuzie, 2004). The sequential nature of this approach also makes it adaptable, as researchers can refine qualitative data collection based on the initial quantitative results, leading to more targeted and meaningful insights (Cameron, 2009).

3.3 Research Strategy

A research strategy determines the choice of research methods. It is described based on the way data is collected and analysed. Data can be collected and analysed quantitatively and/or qualitatively (Saunders et al., 2007). The logic of inquiry in a mixed methods approach includes the use of both quantitative and qualitative strategies. One basic difference between these two strategies is that the aim of the quantitative strategy is to test hypotheses, while the goal of the qualitative strategy is to produce hypotheses (Cronholm & Hjalmarsson, 2011). The quantitative strategy can be concluded as an objective process of deductive reasoning, whereas the qualitative strategy is seen as a subjective process of inductive reasoning. Reasoning from both deductive and inductive reasoning is referred to as abductive reasoning (Neuman, 1997). Therefore, the mixed methods approach entails reasoning from abduction. In abductive reasoning, a hypothesis is developed, which is then tested by further investigations resulting in either the rejection or non-rejection of the hypothesis. Realities are constructed inductively from the data, and explanations are generated deductively from the data. Therefore, this study made use of an abductive reasoning strategy.

3.4 Research Design

Tshuma (2003) describes a research design as a systematic arrangement of strategies used to collect data and sets the logic by which researchers make interpretations at the end of the study. However, the researcher endorses Maree's (2007) definition that a research design is simply a plan developed or adopted to seek and discover answers to research questions. The study made use of an Embedded Quasi-experimental Design (EQD). This design involves the collection of both quantitative and qualitative data, with quantitative data being dominant and qualitative data playing a supplemental role (Johnson et al., 2007). In EQD, follow-up interviews are conducted to better understand and explain the quantitative results. The two data sets are then combined during

the analysis to provide an interpretation from both data sets. The research design used in this study is presented in Figure 3.2. Both qualitative and quantitative data were collected for this study.

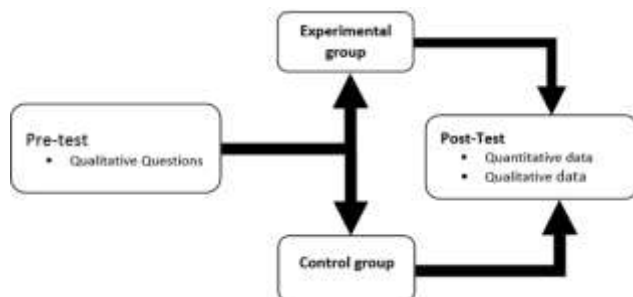


Figure 3.2: Developed by researcher (Adapted from Johnson et al. (2007); Creswell & Clark (2003))

The two groups; experimental and control groups differed in their teaching methods, with the experimental group being taught statistics with Excel, while the control group was taught using a conventional teaching method. As a result, the participants in this study were divided into two classes: the control group and the experimental group. A CITS-diagnostic test was administered as a pre-test to both groups to evaluate their basic demonstration of 21CS. For the post-test, a different assessment was used, designed with higher demands for demonstrating these skills compared to the pre-test. This approach aimed to minimize the potential effects of repeated testing. According to Cohen et al. (2008), administering the same test for both pre-test and post-test can influence results, as prior exposure may affect outcome on the second attempt.

To ensure that the post-test did not favour the experimental group, an adapted instrument was used which was designed to measure 21CS competencies without bias. The test content aligned with general skill development rather than specific training given only to the experimental group. Standardized scoring criteria were applied, and independent raters were used to maintain objectivity. Additionally, the pre-test results helped establish baseline similarity between groups, this ensured that any differences observed in the post-test were due to the intervention rather than test design bias.

Learners in both groups received instruction three times a week for two months, with each lesson lasting 80 minutes. The instruction was provided by two different teachers who were purposively selected. To minimize disruption to normal learning, the study took place in the afternoon, from 14:00hrs to 15:20hrs. After the learning process, post-tests were given to both groups. The effect of using MS Excel to teach Statistics on the acquisition of 21CS by learners was assessed using a CITS-questionnaire administered to both groups. A follow-up Focused Group Discussion (FGD)

interview was conducted with selected participants from the Experimental group to gain insights into their 21st Century Skills (21CS) development and learning experiences. The FGD was exclusively conducted with the Experimental group because the primary aim was to gather qualitative data on the skills acquired through the intervention, which the Control group did not experience. This qualitative data served to supplement the quantitative results by providing a more comprehensive understanding of the effect of the intervention. Additionally, a Likert-scale questionnaire was administered to both the control and experimental groups to assess their learning experiences. In order to determine learners' academic performance after the learning process, a statistics test was also administered. This procedure is summarized in Table 3.1.

Table 3.1: Research Design for Data collection with EQD

Group	Pre-test	Intervention	Post-Test		
Experimental	Test	EAI	Likert-Scale	Interview	Likert-Scale Test
Control	Test	Conventional	Likert-Scale		Likert-Scale Test

As shown in Table 3.1, a pre-test was conducted in both groups. The experimental group was taught using Excel Assisted Instruction (EAI), while the control group was taught using conventional teaching methods. After the instruction, a post-test was administered to both groups. Likert scale questionnaires (for 21CS and Learning Experiences-LE), interviews, and tests were then administered to both groups.

3.4.1 Experimental group

The experimental group comprised learners who were taught statistics with Excel-Assisted Instruction. In this group, the teacher used chalk, a blackboard and a projector, and the lessons were conducted in the computer lab. The concepts, formulae and procedures were introduced using black board and chalk. Therefore, the teaching approach used was an integrated instructional approach that blended traditional teaching methods with technological tools, specifically MS Excel. The lessons were structured to ensure that learners first acquired a solid understanding of fundamental statistical concepts before transitioning to digital applications. The teacher initially used chalk and a blackboard to introduce statistical principles and formulas, this helped to lay a strong conceptual foundation. Once learners had grasped these basics, they proceeded to a computer-based learning environment, where the integration of technology was introduced. Lessons were conducted in the computer lab, with a projector displaying real-time demonstrations of MS Excel functions to facilitate step-by-step guidance.

Since the number of available computers was limited, learners were divided into two sections to ensure that each learner had individual access to a computer. This setup provided an optimal learning experience, which allowed each learner to independently engage with MS Excel and practice statistical computations. To orient learners on the use of Excel, the teacher conducted an initial demonstration, explaining essential spreadsheet functions and navigation techniques. This included an introduction to the interface of Excel, data entry procedures, and basic formula applications. The teacher also showed how to use built-in functions relevant to statistical analysis, such as AVERAGE, MODE, MEDIAN, QUARTILE, VAR.P, and STDEV.P. Following the demonstration, learners were given hands-on activities, where learners now replicated and practiced the steps shown by the teacher to reinforce their learning.

The teaching approach used was guided by Excel lessons as demonstrated by Chaamwe and Shumba's (2016) on e-learning approach to teaching secondary school statistics in MS Excel. Learners participated in activities where they entered raw data into MS Excel, generated frequency tables, and constructed various statistical graphs, including bar charts, pie charts, histograms, frequency polygons, and cumulative frequency curves. A hands-on approach was implemented, since learners actively practiced what the teacher demonstrated rather than passively observing. By engaging with Excel directly, they gained practical experience in data manipulation, statistical computation, and graphical representation.

To incorporate real-world data into the learning experience, learners worked in groups of three to research on the internet the ages of African presidents in 2022. The teacher verified the accuracy of the collected data before compiling it into a final dataset that included the names, ages, and regions of the presidents (see appendix 20). Using this dataset, learners created frequency distributions and computed key descriptive statistics for both grouped and ungrouped data. Through built-in functions of MS Excel, they calculated measures such as the mean, median, mode, variance, and standard deviation, this reinforced their understanding of these statistical concepts while developing proficiency in using digital tools for analysis.

Technology played a crucial role in facilitating various aspects of the learning process. The internet was used as a research tool for data collection, it allowed learners to gather real-world information. The projector enabled the teacher to deliver clear visual demonstrations of Excel functions and statistical procedures, this was to ensure learners followed along with each step of the process.

Excel itself served as a computational and visualization tool, it helped learners perform calculations efficiently while generating accurate and visually interpretable graphs.

The learning process was structured to balance individual practice with collaborative activities. While some tasks were completed independently, group discussions and peer-to-peer learning were actively encouraged. Discussions were often triggered by observations made during the analysis of graphs and results. For instance, when students created histograms and cumulative frequency curves, they engaged in conversations about data distribution patterns. The teacher also facilitated discussions by prompting learners to interpret their figures, findings, relate them to real-world contexts, and justify their reasoning. Assessments of the experimental group's progress were based on several criteria, including their ability to correctly apply statistical functions in Excel, accurately generate graphical representations, and articulate their understanding of data patterns. Class participation, individual assignments, and group presentations were used as evaluation tools to measure both conceptual understanding and technical proficiency. Homework assignments further reinforced learning by requiring learners to independently construct frequency tables, histograms, and cumulative frequency curves using new datasets

Among the activities by performed by learners in the experimental group was where they were tasked to generate a relative cumulative frequency curve in MS Excel. This is depicted in image 3.3.

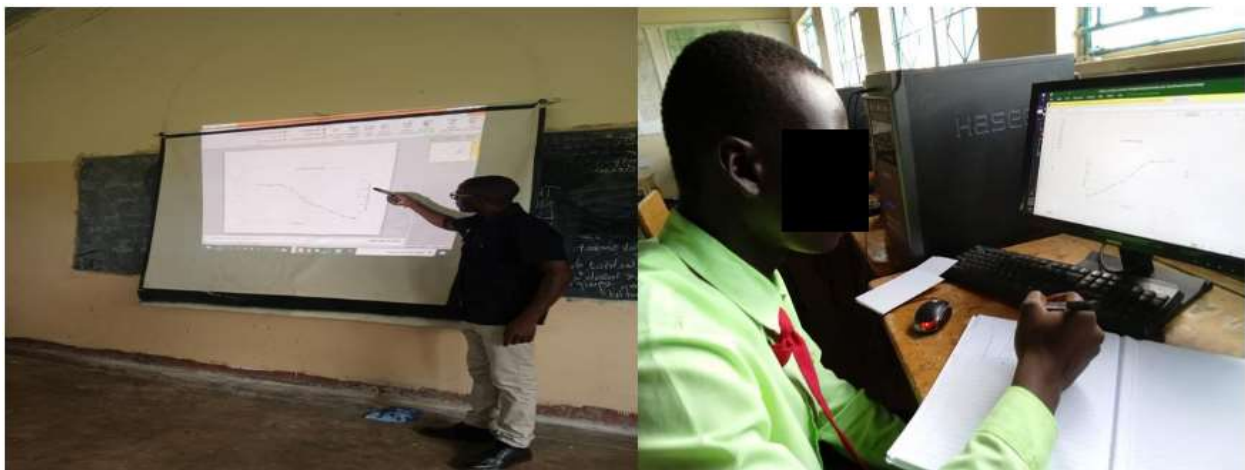


Image 3.3: Teaching and learning with MS Excel

The image 3.3 captures a teacher and a learner from the experimental group engaged in a lesson. The teacher is demonstrating the step-by-step process for generating a relative cumulative frequency curve, with learners actively following along and practicing each step on their computers. As the graph is generated, the teacher explains the results, guiding students in interpreting the output. Learners take notes and record key findings in their books to reinforce their understanding. Sample of a lesson plans have been attached on appendices 18 and 19. A sample of a worksheet has also been provided on appendix 16.

3.4.2 Control group

In the control group, the learners were taught the same concepts in statistics using a conventional teaching method, which reflects the traditional approach commonly applied in secondary schools. This approach involved the teacher explaining concepts, introducing formulas, and demonstrating fixed procedures through oral explanations and physical demonstrations on a blackboard, using only a chalk, a scientific calculator, and the pupils' textbooks. The traditional approach did not incorporate technological tools such as MS Excel or any digital resources. The activities and content taught were based on the Grade 11 Progress Mathematics textbook by Chiyaka et al. (2016). The content included constructing cumulative frequency tables, drawing cumulative frequency curves, calculating the quartiles, mean, variance, and standard deviation, and understanding measures of central tendency and dispersion. In the conventional teaching approach, the teacher's primary role was to explain and model the procedures, which guided the learners through the steps needed to solve problems and complete exercises. This involved a structured, step-by-step explanation of the various concepts, with the teacher writing on the blackboard for the learners to copy and follow. The teacher used traditional tools (blackboard, chalk, and a scientific calculator) to demonstrate the key concepts and procedures of statistics, without the aid of any technological tool such as MS Excel.

For instance, when teaching the construction of cumulative frequency tables and curves, the teacher introduced the concept by first explaining how to organize data into a cumulative frequency table. One specific example where a data set of the number of school absences of 52 pupils was used. The teacher first presented the data the blackboard in the form of a table as shown below:

Table 3.1: Number of school absences of 52 students

Days Absent	0	1	2	3	4	5	6	7	8	9
Frequency	2	3	6	7	6	9	11	6	0	2

The teacher then demonstrated how to convert this raw data into a cumulative frequency table and explained how to plot the cumulative frequency curve by hand on the blackboard. The learners followed along, copying the teacher’s work, and were encouraged to ask questions if they didn’t understand a particular step. The process of drawing the table and curve was done manually, and learners did not use any technological tools to complete the task. A sample of a lesson plan has been attached on appendix 17.

Once the cumulative frequency table and curve were completed, the teacher discussed the steps involved in creating relative cumulative frequency curves for both grouped and ungrouped data. In another lesson, the teacher explained how to calculate the measures of central tendency (mean) and dispersion (range, and quartiles, specifically, interquartile range and semi-interquartile range) by applying the relevant formulas. These concepts were thoroughly explained, with the teacher walking the students through the formulas and illustrating how to apply them to the data using the blackboard. The lessons also included detailed steps on how to calculate the mean, variance, and standard deviation for the given data sets, again using the formulas. In this instance, students copied the teacher’s work and engaged in independent practice through exercises found in the textbook.

The teacher in the control group was the central figure in the classroom. She guided the lesson by providing direct instruction, writing formulas and examples on the blackboard, and addressing the learners’ queries. Throughout the lessons, the teacher interacted with the learners through question-and-answer and encouraged learners to ask questions whenever they did not understand something. However, the teacher encouraged active participation through group discussions and by prompting questions. The learners were expected to absorb the information from the teacher’s explanations and apply it independently to complete the exercises and homework. The teacher monitored learners’ progress and provided further clarification when necessary. Discussion among learners was largely initiated when learners encountered difficulties or had questions about the material. For example, when a particular aspect of the cumulative frequency table or the calculation of measures of central tendency was unclear, learners would raise their hands, and the teacher

would address their queries. Occasionally, learners would collaborate in groups, particularly when working through more difficult problems or discussing the meanings of certain statistical terms.

The traditional teaching method in the control group also included brief group discussions, where learners could share insights or discuss solutions to problems. These discussions helped foster a sense of interaction among learners, though they were still largely constrained within the teacher-led framework of the lesson. The teacher guided these discussions by asking specific questions related to the lesson content, ensuring that the students remained focused on the mathematical concepts being taught. The use of a variety of data sets for specific concepts provided learners with a broad understanding of how statistics can be applied in different contexts. The teacher's demonstration of problem-solving techniques and step-by-step guidance was designed to ensure that students fully understood the material before they moved on to practice exercises in their textbooks. Image 3.4 illustrates the teaching and learning of statistics with the conventional method.

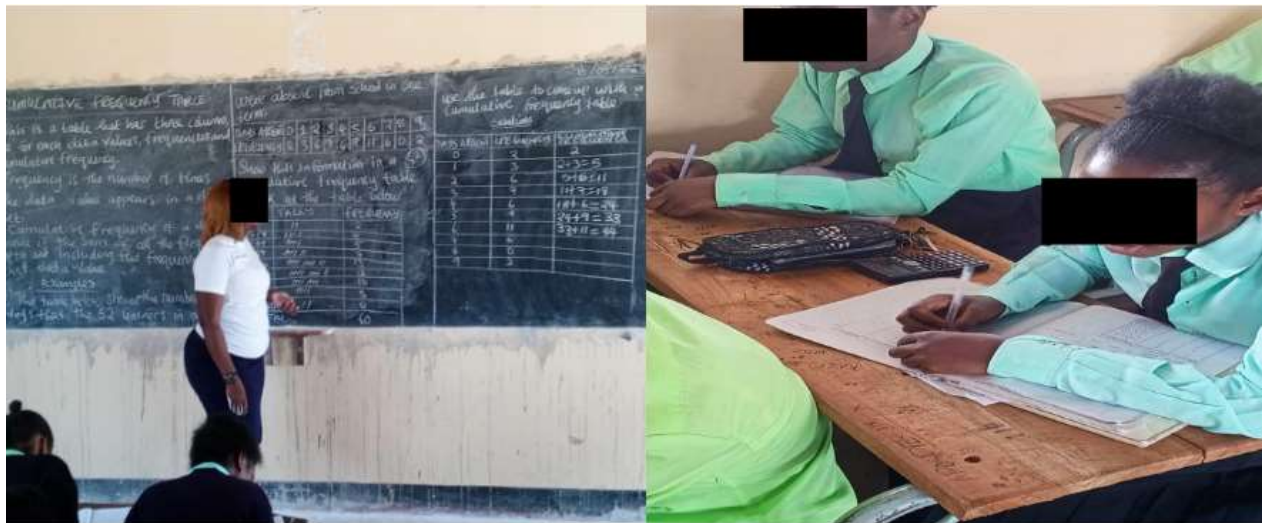


Image 3.4: Teaching and learning with conventional teaching method

As depicted in image 3.4, the control group was taught using a conventional teaching method, where the teacher acted as the primary source of knowledge, she explained concepts and guided the learners through examples and exercises. This traditional approach, with its reliance on blackboard demonstrations and chalk, represented a typical secondary school teaching style for mathematics. While learners were engaged in learning through copying, question and answer sessions, and brief group discussions, they did not utilize technological tools such as Excel. The

teacher's role was central in driving the lesson, explaining procedures, and facilitating learner engagement through direct instruction and occasional discussions.

3.5 Research methods

Almalki (2016) defines research methods as the instruments or tools that researchers use when conducting a research study. These methods can be categorized as either qualitative or quantitative. Qualitative methods involve collecting data in the form of words or text, while quantitative methods involve collecting numerical data through measurement (Cameron, 2009). This study utilized both qualitative and quantitative methods. The CITS Diagnostic test, CITS Questionnaire, LE Questionnaire, Statistics Test, and focus group interview guide were all used. The observation schedule was also utilized. Observations were used to monitor the effective implementation of teaching methods and to assess responses during focus group interview discussions. On the other hand, the acquisition of 21CS and learning experiences were demonstrated using a 5-point Likert Scale questionnaire for quantitative analysis and focus group interviews for qualitative analysis. Finally, the academic performance of learners in statistics was demonstrated quantitatively through a performance test.

3.6 Study site

The study took place at Mwense Secondary School in Mwense District, Luapula Province, from July 2023 to September 2023. Mwense Secondary School is a public school located in Mwense boma, with an estimated population of 122,605 (Zambia Statistics Agency, 2022). It is situated approximately 500m from the DEBS offices. The school was initially opened in 1966 but was closed due to a lack of teachers. It was officially reopened in 1967 and operated as a boarding school for boys until 2007 when it became a co-educational institution. The first girls to be enrolled were CAMFED-sponsored pupils, and later enrollment was opened to all girl learners. The school currently functions as both a day and boarding school, with a total of 20 classes. The junior section consists of 8 classes for grades 8 and 9, while the senior section has 12 classes for grades 10, 11, and 12, with each grade level having 4 classes. During the study period, the school had a total of 1,120 pupils.

At Mwense Secondary School, the process of class placement of learners to grade 10, 11 and 12 classes is done at grade 10 and follows a structured tradition based on learners' Grade 9 specializations and examination results. Learners are categorized into different streams depending

on their academic strengths and interests. Those who perform exceptionally well in Mathematics and Science are placed in the pure class. Another category is the Vocational class, which is designed for students who show interest in practical and technical fields. Learners in this stream specialize in subjects such as Design and Technology, Home Economics, and Agriculture. The final category is the Social Science class, which is open to all learners without any specific specialization. Unlike the other streams, this class provides a broad curriculum that includes subjects such as History, Civic Education, and Bemba. It accommodates learners with diverse academic abilities and interests.

3.7 Population and sample size

A population is a large collection of all subjects from which a sample is drawn and inferences are made (Smith, 2011; Sekaran, 2008). For this study, the population consisted of all grade 11 learners at Mwense Secondary School, totaling 211 learners across four classes. However, studying all subjects in the population would be time-consuming, expensive, and impractical. Therefore, a smaller group, known as a sample (Cohen et al., 2005), was selected to collect data in a way that represents the entire population. At the pre-test stage, the sample included 62 learners from two classes, with 30 and 32 pupils in the experimental and control groups, respectively. Additionally, there were 20 learners in the pilot study. By the post-test stage, three participants had dropped out, leaving a total of 59 learners (29 in the experimental group and 30 in the control group).

3.8 Sampling techniques

Polit and Beck (2010) defines sampling technique as the process of selecting a representative sample from a population to participate in a study. Sampling makes it possible for researchers to collect data from a representative sample which allows for accurate generalizations to the total population (Cohen et al., 2005). There are two kinds of sampling, namely: probability (random) and non-probability (non-random) sampling. To select the School and grade level, a non-probability technique called convenience sampling was used. Non-probability or non-random sampling is a sampling technique where the samples are gathered in a process that does not give all the individuals in the population equal chances of being selected. The school was chosen due to its easy accessibility as it was the school where the researcher was teaching during the time of the study. Additionally, the school was selected because it has enough computers available to learners and access to the internet. While the grade level was selected based on the level at which

the study topic (statistics) is taught. According to the Zambia mathematics syllabus for secondary schools, statistics is taught in grade 11. Thus, Mwense Secondary School and grade 11s were chosen using the convenience and purposive sampling technique.

In order to ensure the selection of participants depended purely on chance and no personal bias was involved, the probability sampling called Simple Random Sampling was used in the study to select groups for the actual study and pilot study. According to Saunders (2009), probability sampling is based on randomization in which every element of the population has an equal chance of being included in the sample. Cohen et al. (2005) also stated that the probability random sampling technique ensures that every element in the sampling frame has an equal chance of being included in the sample. The sampling frame of this research was all the four grade 11 classes of Mwense secondary school. Learners were not assigned to the control, experimental and pilot study group, instead, it was the classes which were randomly selected. Out of the four grade 11 classes at this school, the three required classes were selected randomly using a simple random draw with replacement method. The sample of two grade 11 classes was drawn from a total of four grade 11 classes. The classes were randomly assigned a one-digit number between 1 and 4, represented by folded papers. These papers were mixed, and then three papers were drawn sequentially to form both the study sample and the pilot study sample. The classes represented by the first, second and third produced random numbers which were assigned to the control, experimental and pilot study group respectively. A sub-group of 6 learners was also selected from the experimental group for Focus Group Discussion Interview, it comprised learners who had the highest (2), average (2) and lowest (2) score on the 21CS.

To maintain consistency in teaching approaches and minimize teacher-related variations, the teachers were selected based on the randomly assigned study groups, experimental and control group. Therefore, two mathematics teachers were involved in the study. Both teachers had prior experience teaching mathematics, including topics such as statistics, to grade 11 learners. The teacher for the experimental group was oriented by the researcher on how to integrate MS Excel into teaching statistics. The training covered practical applications of Excel in constructing frequency tables, drawing cumulative frequency curves, and computing measures of tendency and dispersion. The teacher for the control group did not receive any training or guidance. The teacher in the control group adhered to traditional teaching methods, which rely on chalk, a blackboard, and a scientific calculator. There was no use of MS Excel or any digital resources. This distinction

ensured a clear comparison between the control and experimental group. By randomly assigning entire classrooms and ensuring teachers were allocated based on pre-existing class assignments, the study controlled for potential teacher bias while maintaining the natural teaching environment of each class.

3.9 Data collection procedure

Both secondary and primary data was collected in this study. The information collected from public reports and documents, and articles constitute secondary data, this information has been used in Literature Review. Lessons with MS Excel was conducted based on the suggestions from the literature. Primary data was obtained to assess the level of demonstration of 21CS, acquisition of 21CS, learning experiences, and statistical knowledge where a CITS-diagnostic test, CITS-questionnaire, LE Questionnaire, performance test and focus group discussion interview was used. Two teachers were involved in teaching the experimental and control groups. One teacher was guided by the researcher on how to apply MS Excel in teaching statistics to the experimental group. While the other teacher taught the control group using the conventional teaching method. The teacher who taught the control group did not receive any training or guidance, this was to ensure that the activities meant for experimental group were not used in the control group. To further ensure that the groups were taught as expected and planned, both teachers were observed and monitored by the researcher during the learning process. In order to confirm and ensure validity/reliability of the instruments, a pilot study was conducted before the actual study.

Before learning started, a CITS-diagnostic test was administered to all the participants. Lessons for the two groups were conducted at different times so that the researcher was able to observe lessons and collect data. This also helped the researcher to ensure that what was taking place in one group did not affect learning in the other group. After the learning process, a statistics test and Likert scale questionnaires were administered to the two groups and focus group interview discussion was conducted on a sub-group. Learners were also observed during the learning process and interview by the researcher. Observation also focused on the attempts by the learners to demonstrate 21st century skills.

3.10 Development of Research Instruments

The diagnostic test, questionnaires, and interview guide were developed based on information obtained from the literature and existing questionnaires. A statistics test was created using the CDC

recommended textbook (Grade 11 Progress Mathematics Book) and ECZ past-papers. Questionnaires for assess 21CS and learning experiences were not developed by the researcher but were adapted from existing and already validated questionnaires by Kelley et al. (2019); Martins-Pacheco et al. (2020); Abdullahi and Moham, (2022); Ghavifekr et al. (2016); Hadi and Hashim (2021); Kaur and Warner (2017), hence, factor analysis was not performed. However, the instruments were refined after conducting a pilot study whereby statements with the lowest validity confidents were removed. The questions and statements were also revised to improve clarity. Some questions were added, while others were removed.

During the pilot study, a 40-item Likert scale was used to measure 21CS, and a 20-item Likert scale was used to measure learners' learning experiences. These scales showed poor internal reliability, with coefficients of 0.497 and 0.348, respectively. To address this, 25 items were deleted from the 40-item Likert scale, and 9 items were deleted from the 20-item Likert scale. Finally, two Likert scales were developed: one with 15 items and another with 11 items which had stronger reliability coefficients of 0.781 and 0.861, respectively. These questionnaires included items such as "I can use Excel to solve statistics problems" and "statistics is an interesting topic." Pupils were asked to indicate the degree to which they agreed or disagreed with each statement on a 5-point scale, ranging from "strongly agree" to "strongly disagree." Each response was assigned a value from 1 to 5.

3.11 Data analysis

A mixed methods approach to data analysis was employed where qualitative and quantitative data analysis was performed, however, there was a greater emphasis on quantitative analysis. A diagnostic test was used as a pre-test. It consisted of four questions, each focusing on communication skills, information literacy, technology literacy, and statistical literacy. Although the questions were qualitative in nature, they were analysed quantitatively. If the learner was able to perform, state or list the activity related to the skills, he/she scored a mark or more depending on the answers given. For instance, 2 marks were awarded to a learner who stated having used a computer software before and what they used it for. The results from diagnostic test was graded to determine the level of demonstration of learners' 21CS and to ensure that learners recruited in the study were at the same level. Statistics test and questionnaire results were scored and managed with MS Excel to determine the aggregate scores. The total scores were then analyzed using IBM

SPSS version 27.0 for windows. The scores were checked for normality to determine suitable and reliable tests for the study. Descriptive statistics were analyzed to determine the difference in demonstration of 21CS, learning experiences and academic performance between the two groups. Parametric and non-parametric tests were also performed where independent sample t-test, Mann-whitney U test were conducted to determine whether there was a significant difference between the control and experimental groups. The effect sizes were determined using Rank-Biserial Correlation values. The Friedman and Spearman's correction tests were also conducted. The responses from the interviews were recorded and transcribed with turboScribe, and analyzed thematically.

3.12 Validity and reliability for Mixed Methods Research

The validity and reliability for quantitative research was observed. The researcher also ensured that credibility and dependability (trustworthiness) for qualitative research was achieved.

3.12.1 Validity and reliability in Quantitative Research

Validity in quantitative research refers to the measurement of what is intended to be measured (Field, 2005). Ghauri and Gronhaug (2005) describe validity as how well the collected data covers the actual area of investigation. To ensure the validity of the study, it was important to ensure that the Excel lessons aligned with the suggestions and recommendations from the literature. In terms of instrument validity, two types were considered: face validity and content validity. Face and content validity were observed by adapting questionnaires existing and already validated questionnaires, and statistics test was developed based on the learning outcomes for Zambia secondary statistics as outlined in the Progress Mathematics Grade 11 Pupils' Book and passed ECZ examination questions.

Reliability in quantitative research refers to the consistency of the measure (Cohen et al., 2005). The reliability of the questionnaire was assessed before its use through internal consistency testing. Internal consistency measures the extent to which all items on the instrument measure a single construct (Heale & Twycross, 2015). To test the reliability of the questionnaire, internal consistency reliability was assessed using the Cronbach coefficient alpha with SPSS v27.0. The Cronbach coefficient alpha values for the two questionnaires were 0.781 and 0.861. Cronbach's alpha ranges from 0 to 1, with values closer to 1 indicating higher reliability. This indicates that the CITS questionnaire and LE-Questionnaire were reliable.

3.12.2 Credibility and dependability: Trustworthiness

The terminology used for validity in qualitative research is credibility (Creswell & Miller, 2000). Credibility is defined as the extent to which the results of qualitative research are accurate and appropriate (Denscombe, 2017). To achieve credibility, the researcher used multiple data collection sources such as interview, observation, and audio recording, this helped to build a coherent justification for the themes of the research. Thick description was also used to describe the findings of the study, whereby, quotes were used to provide detailed description of the responses so that results are more realistic and richer. Furthermore, the interview transcripts were returned to the participants to validate that what they said is what has been reported.

Reliability in qualitative research is referred to as dependability (Lincoln & Guba, 1985). Dependability is the level of agreement of research findings, interpretation, and conclusion between the researcher and other researchers outside the study (Denscombe, 2017; Heale & Twycross, 2015). The researcher achieved dependability by ensuring that transcripts were free of errors, and interviews were transcribed as they were reported by the participants.

3.13 Control of Extraneous Variables

The validity of an experiment can either be internal or external. External validity pertains to the degree to which the relationship between variables can be generalized beyond the experimental setting, such as to the wider population (Cohen et al., 2005). To achieve external validity, the researcher ensured that the results of the study were valid and reliable. On the other hand, internal validity, as defined by Cohen et al. (2005), refers to the extent to which an independent variable truly affects the observed results or dependent variable, while ensuring that extraneous variables do not impact the results. Lack of control over extraneous variables can affect this validity. Extraneous variables are variables other than the independent variables that influence participants' response to intervention or treatment (Marudhar, 2019). Effort was made to control for extraneous variables, the following steps were taken:

1. A diagnostic test (pre-test) was conducted before the study to ensure equal group selection. This helped to address the issue of differential selection, which can occur when intact groups or classrooms are compared. By assessing the groups before the intervention, any initial differences can be identified.

2. Different instruments were used for pre-testing and post-testing to control for the effects of testing. Taking the same test twice (pre-test and post-test) can influence the results. Exposure to the pre-test may impact performance on the post-test.
3. The same instruments were administered to both the control and experimental groups to control for the threat to validity known as instrumentation. Changes in instrument calibration can affect study results, as tests with different difficulty levels can produce varying outcomes (Cohen et al., 2005). This threat typically arises from unreliability in the testing instruments.
4. The researcher did not personally teach the groups; instead, two class teachers were used. This was done to control for the self-fulfilling prophecy, which occurs when a belief becomes true because the researcher acts as if it is already true. Positive (Pygmalion/Rosenthal effect) or negative (Golem effect) expectations about a circumstance or group can influence the study (Cohen et al., 2005). Higher expectations may lead to improved skills or performance, while lower expectations can result in decreased skills or performance.
5. Teachers of mathematics for the respective groups were used to control for the John Henry Effect. This effect refers to the tendency of participants in the control group to perceive themselves as disadvantaged compared to the experimental group and work harder to overcome this perceived deficiency (Cohen et al., 2005).
6. The researcher observed both groups to ensure that the lessons were taught as they were supposed to and to also control for Hawthorne effects. The Hawthorne effect is the alteration of participants' behavior due to their awareness of being observed, and it can impact the experimental group (Cohen et al., 2005).

Despite the measures taken to control extraneous variables, certain factors were impossible to manage, which could potentially affect the results of the study. One significant factor was that, since the study was conducted in a boarding school where participants from both the experimental and control groups interacted regularly, there was a high likelihood of information sharing, which would not have occurred if the groups were in separate schools. This may have led to the transfer of knowledge and techniques related to the intervention, thereby reducing the distinct effects of the experimental treatment. Another uncontrollable variable was the varying levels of familiarity of learners with MS Excel prior to the intervention. Despite efforts to standardize exposure, some

learners may have had previous experience with MS Excel, this may have given them an advantage over their peers. Additionally, factors such as variations in teacher-learner interactions, learners' independent learning efforts, and differences in technological access outside formal lessons were beyond the researcher's control. These uncontrolled variables could have affected the findings of the study by influencing participants' acquisition of 21CS independently of the intervention. However, these factors were considered when interpreting the results of the study and assessing the true effect of applying MS Excel in teaching statistics.

3.14 Ethical Considerations

Ethical considerations refer to the values and principles that guide decisions about what is morally right or wrong in a study (Cohen et al., 2005). These considerations aim to protect the well-being and rights of participants, making them essential throughout the research process. In this study, care was taken to adhere to these ethical considerations before, during, and after data collection.

Firstly, the study ensured compliance with the ethical codes and guidelines for researchers at the University of Zambia. Ethical clearance was obtained from the Research Ethics Committee to ensure that the study met the required standards. Additionally, permission to conduct the study at the research site was sought from the school authorities. Before including participants in the study, the researcher provided them with detailed information about the purpose, importance, and potential benefits of the study. It was crucial to accurately communicate all necessary information, ensuring that participants fully understood what was expected of them. Voluntary participation was emphasized, allowing participants to withdraw from the study at any stage. The researcher also guaranteed that participants would not be harmed in any way. Furthermore, to maintain anonymity, participants were assigned code numbers instead of using their actual names. This ensured that their identities remained confidential throughout the data collection and presentation processes. The study also upheld the principles of honesty by avoiding any falsification, fabrication, or misrepresentation of research methods, data gathering, data analysis, acknowledgement of other researchers' work. This approach ensured trust and confidence in the methods and findings of the research, allowing other readers and researchers to rely on the findings of this study. Lastly, the researcher took precautions to minimize bias and disruption at the study site. Data collection and reporting were conducted without favouring any particular group, and normal learning activities were not disrupted.

3.15 Chapter Summary

This chapter presented the research methodology used in the study. A philosophical position of pragmatists was chosen. This research study made use of a mixed methods approach, utilizing both the quantitative and qualitative approaches. The study made use of Embedded Quasi-experimental Design. Two groups were involved, the experimental and control group which differed in their teaching methods. The study was conducted at Mwense Secondary School with 62 grade 11 learners. Both probability and non-probability sampling techniques were utilized. The chapter also presented that questionnaires, performance test, and interview guide was used to collect data and the collected was organized and analyzed with MS Excel, SPSS, and turboScribe. Furthermore, the chapter also presented the validity, reliability, credibility, dependability, control of extraneous variables and the ethical issues observed in the study.

CHAPTER FOUR

PRESENTATION OF FINDINGS

4.0 Overview

This chapter presents the findings on the comparisons of teaching secondary school statistics with MS Excel and the conventional teaching method. The researcher employed an embedded quasi-experimental design, which guided the researcher in answering the research questions and achieving the research objectives. The findings support the notion that targeted interventions aimed at promoting 21CS can have a positive effect on the acquisition of 21CS. By equipping learners with the ability to think critically, communicate effectively, collaborate productively, and adapt to technological advancements, we can better prepare them for the challenges and opportunities of the 21st century. The findings are presented as follows;

1. Findings on reliability test,
2. Normality test,
3. Pre-test results and
4. Post-test results.

4.1 Introduction

This study was aimed at investigating whether MS Excel is applicable in teaching secondary school statistics for learners' acquisition of 21CS. Chapter 4 present results obtained from the test, questionnaires and interview, the data was analysed based on data collected from the learners. Quantitative data was coded and summarised using Ms Excel, it was then analysed using IBM SPSS version 27.0. Whereas, qualitative data was analysed thematically. Data analysis was according to the research objectives. Figures and tables have been used to make presentation of findings easier.

4.2 Reliability Test: Pilot Study

The Likert-scale for learning experiences was developed based on established instruments by Abdullahi and Moham, (2022); Ghavifekr et al. (2016); Hadi and Hashim (2021); Kaur and Warner (2017); Mezhennaya and Pugachev (2019), and others. Reliability of 21CS Likert-scale was also enhanced by adapting Likert-scale from the validated questionnaires of Kelley et al. (2019) and Martins-Pacheco et al. (2020). While the original items from these questionnaires were deemed reliable, the adapted Likert-scale version was evaluated for reliability in the current study. In order

to further assess the reliability of the two adapted questionnaires, the 21CS and the LE Likert-scale questionnaires, Cronbach’s alpha coefficient was used. The results are presented in Table 4.1.

Table 4.1: Reliability test for research instruments

Likert-Scale	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
21st Century Skills	.497	40	.781	15
Learning Experiences	.348	20	.861	11

Table 4.1 presents the results of the internal reliability analysis for two Likert scales. Initially, the Likert scale used to measure 21CS consisted of 40 items, while the Likert scale for measuring learning experience (LE) had 20 items. The findings revealed poor internal reliability, with coefficients of 0.497 and 0.348 for the 21CS and LE scales, respectively.

In order to improve the internal reliability, a total of 25 items were removed from the 21CS scale, and 9 items were removed from the LE scale, based on the SPSS output recommendations. Following these adjustments, the reliability coefficients was 0.781 for the 21CS scale and 0.861 for the LE scale. The results suggest that the revised instrument demonstrated strong internal consistency and reliability. Therefore, the results of the Cronbach alpha coefficient analysis confirmed the reliability of the instruments.

4.3 Normality test

A diagnostic test, Likert-scale questionnaires and performance test were administered to determine whether the experimental and control groups had the same level of 21st century skills, learning experiences and performance in statistics. The results were scored and assessed for normality. Normality tests were conducted to determine a reliable test for the scores. One of the assumptions for parametric tests to be reliable is that the data must be approximately normally distributed (Ghasemi & Zahediasl, 2012). There are several methods for assessing whether datasets are normally distributed or not. These methods fall into two categories; graphical (histogram with a normal approximation curve, Q-Q probability plots, Cumulative frequency (P-P) plots, etc.) and statistical (Shapiro-Wilks test for $n < 50$, and Kolmogorov-Smirnov for $n > 50$, etc.). Statistical tests for normality can be more precise since actual probabilities are calculated but these should be used in conjunction with either a histogram or a Q-Q plot (Thode, 2002). Therefore, Kolmogorov-

Smirnov tests, histograms and Q-Q plots were used in this study, Kolmogorov-Smirnov test were used because the number of participants was greater than 50.

4.3.1 Graphical Check for Normality

The findings for graphical test for normality are presented in figures 4.1 to figure 4.8.

Pre-Test: Diagnostic Test

The graphical results for normality test for diagnostic test scores are presented in figure 4.1 and figure 4.2.

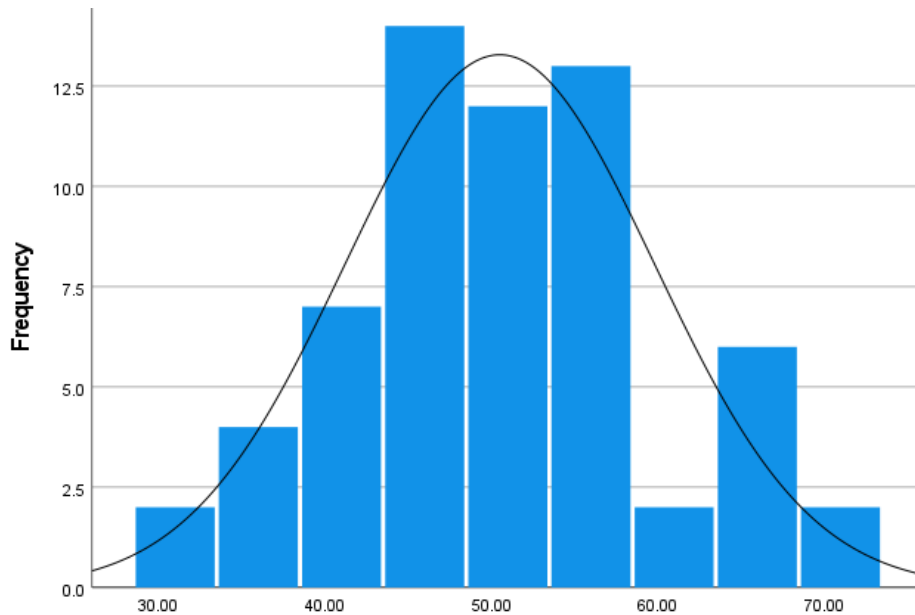


Figure 4.1: Histogram of diagnostic test results for the two groups

As seen in figure 4.1, the data is approximately normally distributed, with a peak in the middle and fairly symmetrical, the assumption of normality has been met. The results for the Q-Q plot of diagnostic test scores are presented in figure 4.2.

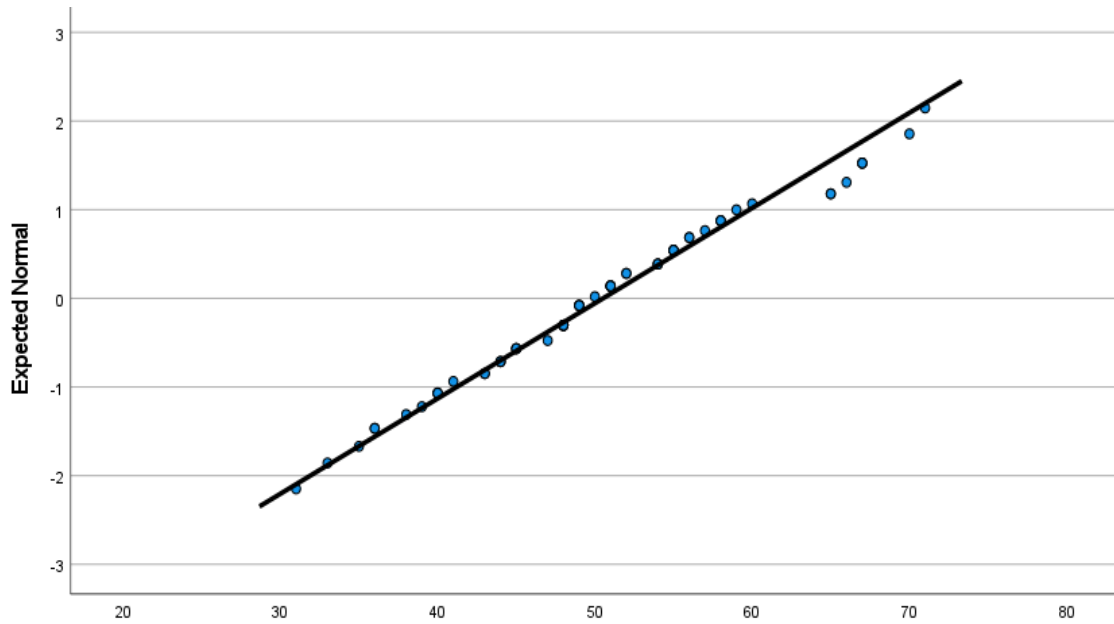


Figure 4.2: Q-Q plot of diagnostic test results for the two groups.

In figure 4.2, the data is normally distributed because the scatter lie are close to the line with not much obvious pattern coming away from the line.

Post-Test: 21st Century Skills Result Scores

The post-test scores for 21CS were also graphically checked for normality and the results are presented in figure 4.3 and figure 4.4

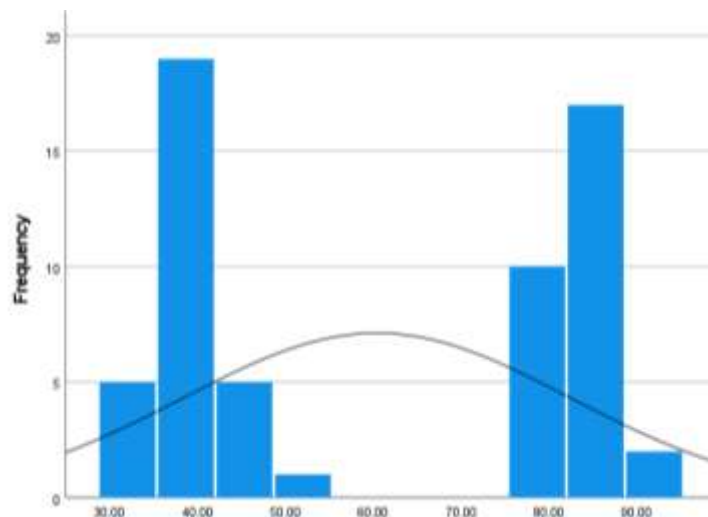


Figure 4.3: Histogram of 21CS results for the two groups

Figure 4.3 depicts that the dataset for 21CS is not approximately normally distributed. The bars are scattered with no peak in the middle and not symmetrical, therefore, the assumption of normality was not met. Q-Q plot was also utilized, figure 4.4 shows the results for 21CS scores.

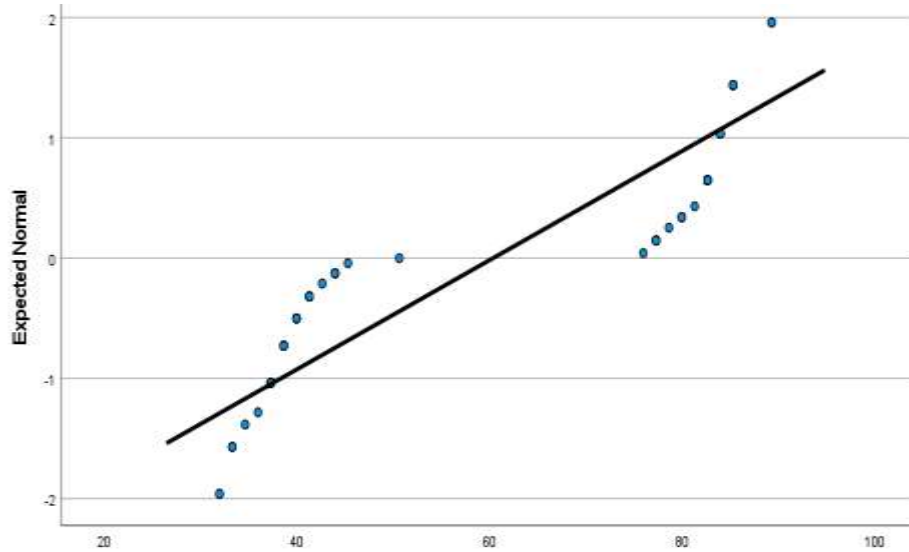


Figure 4.4: Q-Q plot of 21CS for the two groups.

In figure 4.4, the data is not normally distributed because the scatter lie are not close to the line with too much obvious pattern coming away from the line.

Post-Test: Learning Experiences

The post-test scores for learners' experiences were graphically checked for normality. Figure 4.5 and figure 4.6 presents the results.

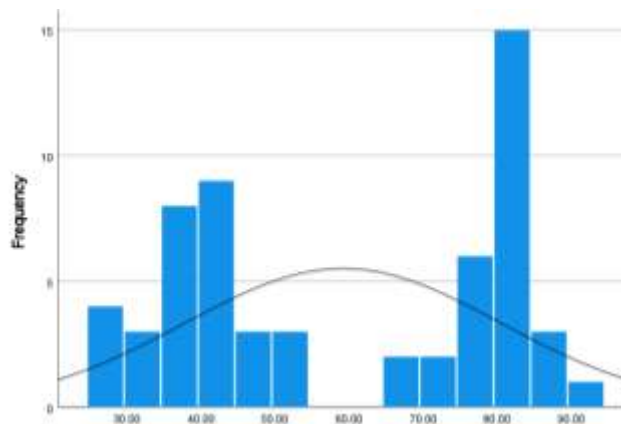


Figure 4.5: Histogram of scores for learning experiences

Figure 4.5 depicts that the data is not approximately normally distributed. The bars are not uniformly distributed, the graph has no peak in the middle and it is not symmetrical, and therefore, the assumption of normality was not met. Figure 4.6 presents the results for the Q-Q plot of scores for learning experiences.

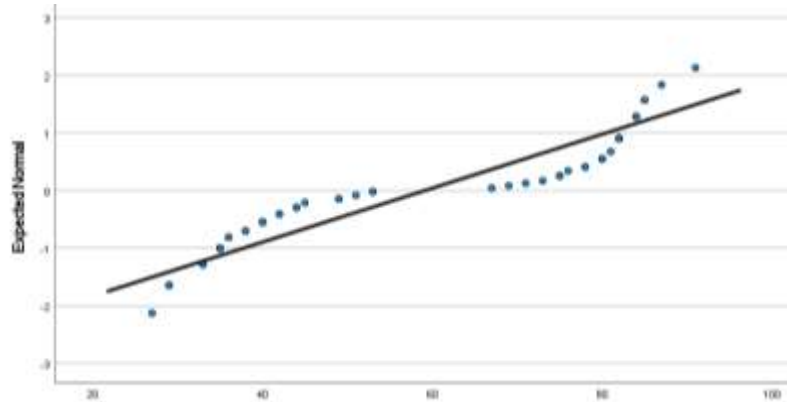


Figure 4.6: Q-Q plot of scores for learning experiences

As shown in figure 4.6, the data is not normally distributed. The scatter lie are not close to the line with too much obvious pattern coming away from the line.

Post-Test: Statistics Test Scores

Finally, the post-test scores for learners’ performance were also checked for normality using a histogram and Q-Q plot. Figure 4.7 and figure 4.8 presents the results.

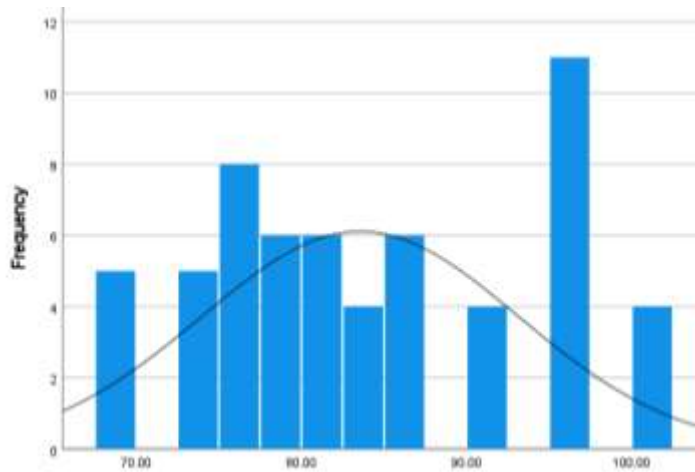


Figure 4.7: Histogram of scores for learners’ performance in statistics

As seen in figure 4.7, the dataset for performance is not approximately normally distributed. The bars are not uniformly distributed, the graph has no peak in the middle and it is not symmetrical.

The assumption of normality was not met. Figure 4.8 presents the results for the Q-Q plot of test scores for learners' performance in statistics.

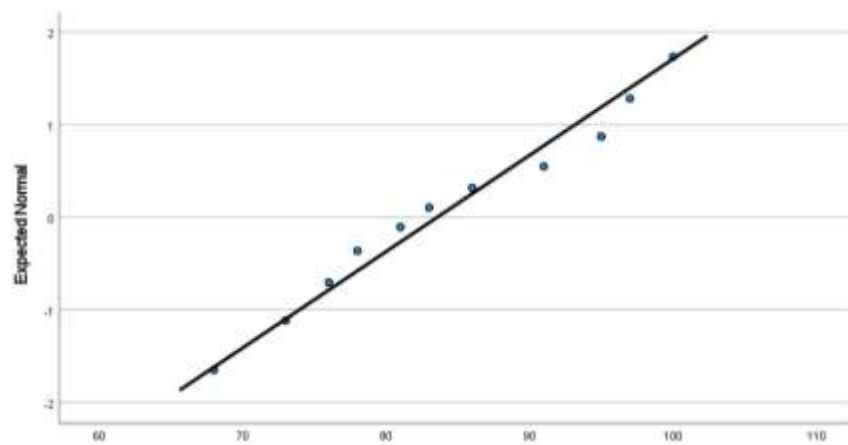


Figure 4.8: Q-Q plot of test scores for performance

As shown in figure 4.8, the data is not normally distributed. The scatter lie are not close to the line with not too much obvious pattern coming away from the line.

4.3.2 Statistical Check for Normality

To further assess the normality of the scores, statistical tests were performed. The findings for statistical test for normality are presented in Table 4.2

Table 4.2: Test of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Diagnostic test Scores	.076	62	.200*	.980	62	.412
21st century Scores	.253	59	.000	.776	59	.000
Experiences	.195	59	.000	.855	59	.000
Performance	.137	59	.008	.937	59	.004

The sig-value of the scores in table 4.2 were 0.200 for the diagnostic test (pre-test), 0.000 for 21CS, 0.000 for learning experiences, and 0.008 for the statistics test. It was found that only the sig-value for the diagnostic test scores was greater than the alpha value ($\alpha=0.05$), this indicates that the results were not significant. On the other hand, the sig-values for the other tests were less than the alpha value, the values suggest that the results were significant. Based on the graphical and statistical findings, it was concluded that the scores for the diagnostic test were approximately normally distributed, while the scores for post-test, namely 21CS, learning experiences, and the statistics test were not normally distributed. As the data set for the diagnostic test scores assumed

normality, an appropriate parametric test, specifically an independent sample t-test, was used. In contrast, a non-parametric tests, namely Mann-Whitney U and Spearman’s correlation tests were used on the 21CS, learning experiences, and statistics test scores.

4.4 Pre-test: Diagnostic Test

An independent-samples t-test was then used to compare the scores of the two groups before the learning process. This test aimed to determine if the 21CS of the learners in both groups were initially the same. The data set was further tested for equality of variance to fulfil the requirement for performing the t-test. The results of this test are presented in table 4.3.

Table 4.3: Levene’s Test for Equality of Variances

		F	df	Sig.
Pre_test	Equal variances assumed	.695	60	.408
	Equal variances not assumed			

The Sig-value (0.408) for the Levene test in table 4.3 indicates that there was no significant difference in variance between the experimental and control groups. As a result, it was assumed that the variance in pre-test scores was the same for the two groups. The sig-value for the independent sample t-test, assuming equal variances, is presented in table 4.4.

Table 4.4: Test for Equality of Means for diagnostic test scores, Pre-test

		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% ci of Difference	
							Lower	Upper
Pre_test	Equal variances assumed	-1.219	60	.228	2.873	2.357	-1.841	7.587
	Equal variances not assumed	-1.213	57.239	.230	2.873	2.369	-1.870	7.616

Since the sig-value of 0.228 in table 4.4 is greater than 0.05, we do not reject the hypothesis that the groups are not significantly different. Therefore, it was concluded that at a significance level of $\alpha = 0.05$, there is no significant difference between the experimental and control group. The descriptive statistics were also used to compare the pre-test scores for the two groups, as shown in table 4.5.

Table 4.5: Descriptive statistics of diagnostic test scores

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pre_test	Control	32	48.53	9.441	1.511
	Experimental	30	49.41	8.546	1.824

The table reveals that, on average, the learners in the control group scored 48.53%, while the learners in the experimental group scored slightly higher at 49.41%. Additionally, the distribution of scores around the mean is slightly higher in the control group (standard deviation of 9.441) compared to the experimental group (standard deviation of 8.546). These descriptive statistics indicate that the groups were quite similar.

The pre-test scores between the control and experimental groups indicate that the learners' 21st century skills were the same before the learning process. The mean score for the experimental group was 49.41 (SD=8.55), while the control group had a mean score of 48.53 (SD=9.44). The independent samples t-test showed that there was no significant difference between the two groups [$t(60) = -1.219$, $p = .228$, greater than .05].

4.5 Lesson Observations

4.5.1 Experimental group

The observations of the experimental group revealed an interactive and engaging learning environment. Unlike the conventional teaching method, where learners relied mainly on scientific calculators, the integration of MS Excel in the lesson brought a dynamic and hands-on approach to learning. The lesson was structured systematically, beginning with a brief recap of finding data on the internet, key statistical concepts, followed by the introduction of MS Excel as a tool for data analysis. The teacher guided the lesson step-by-step, initially demonstrating how to input data and use Excel functions to organize raw data, generate frequency tables, and plot relative cumulative frequency curves. This structured approach ensured that learners could follow the lesson comfortably and apply each new concept.

The classroom setup supported individual learning, with each student assigned a computer, although due to the limited number of computers, the class was divided into two sections. This arrangement ensured that every learner had an opportunity to engage with the lesson independently. The classroom atmosphere was energized, with learners actively engaged in exploring the various Excel features. The teacher played a pivotal role, not only as an instructor

but also as a facilitator, moving around the room to listen to learners' conversations, and pose guiding questions to encourage critical thinking.

The pace of the lesson was well managed, with plenty of opportunities for learners to follow along with the teacher's demonstrations. The interactive features of MS Excel, such as real-time data manipulation and instant feedback, kept learners highly engaged. As learners entered and adjusted their data, they were able to instantly see how their changes affected the generated graphs. This immediate feedback loop encouraged learners to experiment with different approaches, analyze their results, and ask questions about the accuracy and interpretation of their data. For instance, when one learner included an extra data point by mistake, the resulting graph differed significantly, prompting a discussion on the importance of data accuracy.

Collaborative learning was a central feature of these lessons. As learners worked through the tasks, they frequently interacted with each other, discussing their approaches, clarifying misunderstandings, and errors. Peer-to-peer interactions were especially evident when learners faced challenges in generating the cumulative frequency curve. Rather than immediately turning to the teacher for help, students consulted their peers, exchanging ideas and solutions. These discussions often led to deeper insights, such as interpreting the statistical patterns or debating the implications of certain measures. The teacher, in turn, encouraged this interaction by circulating through the room, offering support and posing guiding questions such as, "*What do you think the shape of the curve tells us?*" and "*How does this distribution compare to what we expected?*"

The lesson also highlighted the importance of teamwork and communication. Learners not only worked individually but also collaborated in small groups, especially when searching data on the internet and when analyzing the patterns in the data. For example, during a group task to generate a relative cumulative frequency curve for a dataset on African presidents' ages, learners actively debated trends in the data, discussing possible results and the implications for the analysis. This collaborative approach not only enhanced their statistical understanding but also developed their communication, information and teamwork skills.

The classroom climate remained warm and supportive throughout the lesson. The teacher's approach was facilitative, it guided learners to reflect on their work and encouraged them to solve problems independently. Instead of providing direct answers, the teacher posed questions that encouraged deeper engagement with the material. For example, when a learner struggled with

formatting the graph, the teacher ask, “*What do you think would make this graph clearer?*” such open-ended questions prompted learners to think critically and apply their learning.

Moreover, the lesson fostered a strong sense of ownership in the learners. Each learner was responsible for creating their own frequency distribution and generating their statistical graphs and figures. This individual responsibility was balanced with enough opportunities for peer collaboration, where learners shared insights, corrected each other’s mistakes, and clarified concepts. The exchange of ideas not only enhanced their individual understanding but also contributed to a collective learning experience.

The use of MS Excel was particularly effective in fostering 21CS such as technology literacy, critical thinking, communication, problem-solving and information literacy. The interactive nature of MS Excel encouraged learners to explore the data independently, experiment with different functions, insert formulae, calculate values, and make informed decisions based on their analysis. Additionally, the tool’s real-time feedback helped learners develop a more reflective approach to learning, as they could immediately see the results of their efforts and adjust their work accordingly.

Therefore, the experimental group demonstrated a dynamic and interactive learning environment where learners were actively engaged in the lesson, collaborating with their peers, and exploring statistical concepts using MS Excel. The structured yet flexible nature of the lesson, combined with the interactive features of Excel, fostered an environment that promoted inquiry, critical thinking, and teamwork. These observations highlight the effectiveness of applying technology into the learning process, as it not only enhanced learners’ understanding of statistical concepts but also helped improve essential 21CS. The classroom climate was collaborative, with learners supporting one another and engaging in discussions that deepened their understanding of the material. Compared to traditional methods, the use of MS Excel transformed the lesson from a passive instructional experience into an active, hands-on learning process.

4.5.2 Control Group

The control group, which adhered to a conventional teaching method, was characterized by a more teacher-centered approach, where the teacher was the primary source of knowledge and the focal point of instruction. This traditional approach resulted in a more structured and formal classroom environment, where the flow of the lesson was heavily guided by the teacher’s direct instruction.

Based on the researcher's observations and checklist, the following detailed notes were made regarding the lesson structure, activities, and classroom interaction.

The lessons in the control group were well organized, with a clear step-by-step progression through the content. The teacher began each lesson by introducing the topic and providing a brief overview of the key concepts. The content was delivered systematically, beginning with fundamental definitions and gradually building up to more complex statistical procedures. The teacher used the blackboard extensively, for writing out examples and demonstrating how to solve problems using chalk. The lessons followed a linear sequence which included concept introduction, formula explanation, teacher demonstration of problem-solving, and then learner practice.

While students were encouraged to copy the teacher's notes and follow the teacher's example, there was limited opportunity for deviations or explorations beyond the prescribed examples. The lesson flow remained constant, and it was clear that the focus was on completing tasks according to prescribed methods rather than engaging in exploratory or inquiry-based learning.

The nature of the lesson was primarily procedural. The teacher emphasized the step-by-step process involved in solving statistical problems, especially in topics such as constructing cumulative frequency tables and drawing cumulative frequency curves. Concepts such as measures of central tendency (mean, variance, and standard deviation) were introduced with a focus on memorization and rote learning of the relevant formulas. In contrast to the more flexible and exploratory nature of the experimental group's approach, the lessons for the control group was much more focused on following fixed procedures and the teacher's methods. While the teacher did attempt to engage the class with simple examples and illustrations, the lessons remained anchored in a traditional mode of transmission that is, teaching the learners how to apply formulas and perform calculations as dictated by the textbook.

The activities in the control group were heavily teacher-directed, with the majority of the lesson time spent on teacher demonstrations. The teacher would present the concept, explain how to apply a particular formula, and then demonstrate the procedure by working through an example on the blackboard. Once the teacher completed the demonstration, the learners were expected to follow along, copying the teacher's work and completing similar exercises from the textbook. Therefore, learners' participation was passive, and they were mostly observers rather than active participants. Questions from learners were infrequent, and when they did occur, they were usually related to

clarification of the steps in the procedures. This teacher-centered dynamic meant that learners had fewer opportunities to engage critically with the content, explore alternative methods of problem-solving, or interact with their peers about the concepts being taught.

The teacher's interaction with the class was predominantly through one-way communication, teacher to learners. Group discussions were used infrequently, and when they occurred, they were generally limited to clarifying doubts or reviewing specific points of confusion. For instance, if a student was uncertain about how to calculate a measure of central tendency, the teacher would re-explain the concept but did not provide an opportunity for learners to explore the concept on their own or engage in peer-led discussions.

The classroom climate was generally quiet and controlled, with a clear distinction between the teacher as the authority figure and the learners as passive recipients of knowledge. This structured environment, while conducive to maintaining order, did not foster the same level of collaboration or active engagement observed in the experimental group. The learners were focused on copying the teacher's work and completing the textbook exercises and homework, which did not allow for much personal exploration or discussion. The limited interaction and lack of inquiry-based learning opportunities meant that the overall classroom climate was less dynamic compared to more interactive teaching methods. Learners followed the teacher's lead, but there was minimal opportunity for them to engage in independent thinking or collaborative problem-solving.

Assessment activities in the control group predominantly focused on rote memorization of formulas and statistical procedures. Rather than encouraging learners to develop a deeper understanding of statistical concepts or apply them to real-world problems, the assessments emphasized the mechanical application of learned procedures. For example, students were often required to replicate the steps demonstrated by the teacher and solve exercises, which were designed to test their ability to apply formulas correctly but did not require critical thinking or real-world application. While this approach ensured that learners could recall formulas and perform calculations, it did not provide opportunities for them to develop a deeper conceptual understanding of statistics or the ability to apply statistical techniques to diverse contexts. The emphasis on memorization limited the learners' ability to think critically about the concepts and reduced the potential for engaging, inquiry-based learning.

The researcher noted several key observations during the control group lessons. The teacher's role was central throughout, with the teacher taking the lead in explaining and demonstrating statistical procedures. This resulted in a more passive learning environment where learners were more focused on copying the teacher's work than on engaging with the material in a meaningful way. There was minimal interaction between learners, and the group discussions that did take place were largely centered on clarifying specific procedural steps rather than exploring the concepts in depth. The researcher observed that the classroom climate, while orderly and structured, lacked the energy and dynamism that comes with more interactive, learner-centered approaches. The learners appeared less confident in their understanding of the material, and their participation in discussions was limited. There was little evidence of independent thinking or creativity in solving statistical problems, as the learners were primarily focused on replicating the teacher's methods. The researcher also noted that the limited use of technology hindered the learners' ability to engage with the content in a more interactive way. The absence of tools like Excel meant that learners did not have the opportunity to work with larger datasets or explore statistical concepts beyond the fixed examples provided by the teacher.

Therefore, the structure of the lessons, activities, and classroom climate reflected a traditional, teacher-centered approach that emphasized rote learning and procedural knowledge. While this approach provided learners with the computational skills to perform statistical calculations, it did not foster deeper understanding or independent exploration of the material. The limited use of technology and the lack of inquiry-based learning opportunities restricted the learners' ability to engage critically with the content and apply statistical concepts in real-world contexts.

4.6 Post-test: Learners' acquisition of 21CS

After the learning process, both quantitative and qualitative data was collected to determine learners' acquisition of 21CS. From 30 learners who were in the experimental and 32 learners in control group, 29 and 30 learners respectively participated in the study. The results are presented and interpreted below.

4.6.1 Quantitative Results

The p-value of the post-test scores for 21CS in table 4.2 was less than the alpha value, it was concluded that the scores were not approximately normally distributed. Since normality was not

assumed for the data set, a non-parametric test; Mann-whitney U-test, was performed on the scores to test the first research hypothesis. The results are presented in table 4.6.

Table 4.6: Difference between two groups in terms of 21CS

	Null Hypothesis	Test	Statistic	Sig.	Decision
1	The distribution of post-test is the same across categories of Group.	Independent-Samples Mann-Whitney U Test	112.230	.000	Reject the null hypothesis.

Since sig-value is less than 0.001 in table 4.6, which is less than 0.05, the null hypothesis that the groups are not significantly different was rejected and it was conclude that at $\alpha = 0.05$ level of significance, there is a significant difference between the experimental and control group. This means that the two groups of learners were not at the same level in terms of 21CS after the learning process.

To assess the degree of separation between the experimental and control groups, an effect size analysis was conducted for the Mann-Whitney U test using the Rank-Biserial Correlation. According to Cureton (1956), a Rank-Biserial Correlation value between 0.1 and 0.2 indicates a small effect size, a value between 0.3 and 0.4 suggests a medium effect, and a value equal to or greater than 0.5 signifies a large effect size.

To compute the Rank-Biserial Correlation (r_s), Wendt's (1972) formula was applied:

$$r_s = 1 - \frac{2U}{G_1G_2} \quad [1]$$

From Table 4.6, the Mann-Whitney U test statistic value is $U=112.230$. Given the sample sizes $G_1 = 29$ (experimental group) and $G_2 = 30$ (control group), the Rank-Biserial Correlation is calculated as follows:

$$r_s = 1 - \frac{2U}{G_1G_2}$$

$$r_s = 1 - \frac{2(112.230)}{(29)(30)}$$

$$r_s = 1 - \frac{224.460}{870}$$

$$r_s = 0.742$$

Since the Rank-Biserial Correlation value exceeds 0.5, the effect size is classified as large. This indicates that after the intervention, there was a substantial difference between the experimental and control groups in terms of 21CS, specifically communication skills, information technology, and statistical literacy. This effect size suggests that the difference between the groups is not due to random variation but is meaningful and practically relevant. The intervention may have provided students in the experimental group with better opportunities to apply statistical concepts using technology, thereby enhancing their communication, information, technology, and statistical skills.

The descriptive statistics were also used to further explore the difference in post-test questionnaire scores between the two groups. This was to determine which group performed better than the other. The mean scores are presented in table 4.7.

Table 4.7: Descriptive statistics of 21CS scores, Post-test (N=59)

	Group	N	Mean	Std. Deviation	Std. Error Mean
Post-test	Control	30	39.23	4.122	.753
	Experimental	29	82.28	3.378	.627

Table 4.7 presents the descriptive statistics results, it reveals that, on average, learners in the control group scored 39.23% (SD = 4.12), whereas those in the experimental group scored significantly higher at 82.27% (SD = 3.38). Therefore, the results of this test indicate that after the learning process, the average scores of the experimental group and the control group were different and learners in the experimental group had higher scores in terms of 21CS than learners in the control group.

However, it can be noted that the pre-test results for 21st century skills in the experimental and control groups were 49.41% and 48.53%, respectively, with standard deviations of 8.546 and 9.441 (see Table 4.5). For the post-test, the mean scores in Table 4.7 indicate 82.28% for the experimental group and 39.23% for the control group. Therefore, the value of the mean score for the control group had reduced from 48.53% to 39.23%. One possible contributing factor to this difference could be the nature of the assessments used. The pre-test was a diagnostic assessment which evaluated basic 21st century skills, whereas the post-test required learners to demonstrate these skills in practical situations. Consequently, the decrease in the mean score for the control group in the post-test compared to the pre-test does not indicate a loss of 21st century skills when

conventional teaching method is used. Instead, it suggests that the post-test posed higher demands for skill demonstration. This finding supports the idea that the demonstration of 21st century skills varies depending on the demands of the task. For example, starting and shutting down a computer is a basic technological skill, whereas working with Excel represents a more advanced technological competency.

4.6.2 Analysis of the Acquired Skills

The second hypothesis was tested to determine whether there was a significant difference in the level of acquisition of the four categories of skills (21CS) developed by learners in the experimental group. Specifically, the null hypothesis posited that there would be no significant difference in the median ranks of the categories of skills, meaning that the learners in the experimental group would have acquired these skills at similar levels. To test this hypothesis, the Friedman Test was applied, which is a non-parametric statistical test used to compare the median ranks of more than two related groups. Table 4.8 below presents the results of the Friedman Test.

Table 4.8: Friedman Test for median rank difference across the four skills (21CS)

N	29
Chi-Square	76.824
df	3
Asymp. Sig.	.000

As shown in table 4.8, the Asymptotic Significance (p-value) is reported as 0.000. This value is much smaller than 0.05 which indicates that the difference in median ranks across the four skills is statistically significant. Specifically, since the p-value is less than 0.001, it provides strong evidence against the null hypothesis, which suggests that the learners' acquisition of the four skills is not the same, therefore, we reject the null hypothesis and conclude that there was a significant difference in the acquisition of 21st century skills among the learners in the experimental group. To further examine which of the four skills was acquired the most or least by learners in the experimental group, median ranks and descriptive statistics were analysed. This approach helped identify the relative ranking of each skill and provided understanding of the variation in acquisition levels. The median rank values from the Friedman Test provide a direct comparison of the four categories of the skills. It indicated which skill was acquired at the highest or lowest level. Table 4.9 presents the median ranks of the four skills.

Table 4.9: Mean rank difference across the four skills (21CS)

	Mean Rank
Communication	1.52
Information	1.50
Technology	3.10
Statistical	3.88

From table 4.9, Statistical Literacy has the highest mean rank (3.88), followed by Technology Literacy (3.10), while Communication Skills (1.52) and Information Literacy (1.50) have the lowest mean ranks. This suggests that statistical and technology literacy were acquired at a higher level compared to communication and information literacy.

To complement the median rank analysis, descriptive statistics were computed for each of the four skills, including the mean and standard deviation. Table 4.10 presents these results.

Table 4.10: Descriptive statistics across the four skills

	N	Minimum	Maximum	Mean	Std. Deviation
Communication Skills	29	10	15	12.28	1.251
Information Literacy	29	11	14	12.17	1.037
Technology Literacy	29	14	20	16.86	1.866
Statistical Literacy	29	18	24	20.41	1.452
Valid N (listwise)	29				

Table 4.10 reveal that Statistical Literacy has the highest mean score (20.41), this reinforces the earlier finding that it was the most acquired skill, Technology Literacy follows with a mean of 16.86 which suggests a relatively high level of acquisition, and Communication Skills (12.28) and Information Literacy (12.17) have the lowest means, indicating they were acquired at lower levels. However, the standard deviation values suggest that Technology Literacy (1.866) had the highest variability, meaning that learners demonstrated a wider range of proficiency in this skill. In contrast, Information Literacy (1.037) had the lowest variability, this indicates that learners had more consistent performance levels in this skill. The findings of mean rank and descriptive statistics analysis have revealed that Statistical and technology literacy were the most acquired skills, while communication and information literacy were acquired at lower levels.

4.6.3 Qualitative Results

In order to further achieve the first objective, an open ended question was asked during FGD interview to 6 participants from the experimental group. During the discussion, learners were

requested to mention the statistical concepts they learnt, to express their views on how the concepts were taught, their learning experiences, the challenges they faced learning statistics with MS Excel, and what they had learnt apart from statistics concepts. The responses that revealed 21CS were identified from the transcript and analysed thematically to identify themes related to 21CS, the nature of the open-ended questions allowed participants to express their acquisition of 12CS. Photo 4.9 depicts the discussion with the research participants.



Image 4.9: Researcher discussing with the six participants during the interview

Through the analysis of responses gathered from participants in FGD, four major themes emerged, reflecting their acquisition of 21CS. These include information literacy, technology literacy, statistical literacy, and communication skills. The qualitative responses provided understanding of how learners engaged with statistical concepts and the additional skills they acquired through the integration of MS Excel in learning.

One of the key themes identified was information literacy. A participant noted, *“Apart from statistics, I learned how to summarize information,”* this highlights their ability to process and synthesize data efficiently. Another learner expressed, *“I now know how to find reliable information on the internet,”* which suggests an improvement in their ability to access and evaluate digital information. These responses indicate that learning with MS Excel encouraged learners to engage with statistical content beyond calculations, developing their skills in handling and interpreting information effectively. Technology literacy was another prominent theme. One learner stated, *“I learnt how to use a computer,”* this demonstrates that exposure to MS Excel

facilitated the development of basic digital skills. Another participant shared, *“I found Excel easy to use,”* implying that practical engagement with the software enhanced their technological proficiency. Additionally, a learner mentioned, *“I now know how to use a projector,”* signifying that the learning environment introduced them to essential digital tools beyond just statistical software. These responses collectively suggest that technology played a crucial role in enhancing learners’ adaptability to digital platforms, a fundamental component of 21CS. In terms of statistical literacy, learners recognized the significance of statistical reasoning. One participant reflected, *“While learning how to solve statistics questions, I also understood the meaning of statistical results,”* which shows that the integration of MS Excel aided in conceptual understanding rather than just procedural knowledge. Another stated, *“I know the importance of results in statistics,”* this emphasize the practical value of statistical analysis. Furthermore, a learner mentioned, *“I learned to summarize, present, and interpret data,”* which aligns with the core competencies of statistical literacy, namely, data management, interpretation, and communication. These responses highlight the effectiveness of using technology in deepening learners’ understanding of statistical concepts. Communication skills also emerged as a key theme. One participant noted, *“I asked the teacher when I was not clear,”* which demonstrates active engagement and the confidence to seek clarification when needed. Another learner stated, *“It was easy to interact with my classmates, and I was able to share what I knew,”* this indicate that the learning environment fostered collaboration and peer discussions. These responses suggest that applying MS Excel not only facilitated individual learning but also encouraged collaborative problem-solving and knowledge-sharing, which reinforce communication skills essential for academic and professional growth.

It was found that learners demonstrated better Information literacy, technology literacy, statistical literacy, and communication skills. Additionally, the responses also showed that learners had improved problem-solving and collaboration skills. This interview revealed that participants had improved 21CS. The observations also revealed that learners in the experimental group were actively engaged in the lessons, they were seen working on activities with computers in groups and as individuals. The findings of the observation checklist showed that learners exhibited communication, collaboration skills, problem-solving, and technology literacy skills.

4.7 Post-test: Learning experiences

Both quantitative and qualitative data was collected to determine the learning experiences of learners. The results are presented and interpreted below.

4.7.1 Quantitative Results

To determine the effect of applying MS Excel on learners' learning experiences, an analysis of post-questionnaire (LE scale) responses of learning experiences. Responses from the 5-point Likert scale were coded and analysed in two ways. Firstly, MS Excel was used to code the responses for the two groups. Responses were scored to determine the aggregates. Finally, the aggregate scores were then checked for normality, the results were presented in table 4.2 and the scores were not approximately normally distributed. Since normality was not assumed for the data set, a Mann-whitney U-test was performed on the scores and the results are presented in table 4.11.

Table 4.11: Difference between two groups in terms learning experiences

	Null Hypothesis	Test	Statistic	Sig.	Decision
1	The distribution of post-test is the same across categories of Group.	Independent-Samples Mann-Whitney U Test	169.215	.000	Reject the null hypothesis.

Since sig-value is less than 0.001 in table 4.11, which is less than 0.05, the null hypothesis that the groups are not significantly different was rejected and it was concluded that at $\alpha = 0.05$ level of significance there is a significant difference between the experimental and control group with regards to their learning experiences. This means that the two groups of learners were not at the same level in terms of learning experiences. To assess the degree of separation between the experimental and control groups in terms of learners' experiences, an effect size analysis was conducted for the Mann-Whitney U test using the Rank-Biserial Correlation (r_s) where a Wendt's (1972) formula was applied: From Table 4.11, the Mann-Whitney U test statistic value is $U=169.215$. Given the sample sizes $G_1 = 29$ (experimental group) and $G_2 = 30$ (control group), the Rank-Biserial Correlation is calculated as follows:

$$r_s = 1 - \frac{2U}{G_1 G_2}$$

$$r_s = 1 - \frac{2(169.215)}{(29)(30)}$$

$$r_s = 1 - \frac{338.43}{870}$$

$$r_s = 0.611$$

Since the Rank-Biserial Correlation value exceeds 0.5, the effect size is classified as large. This indicates that after the intervention, there was a substantial difference between the experimental and control groups in terms of learning experiences.

To further determine which of the two groups had positive learning experiences, the descriptive statistics were also used. The results are presented in table 4.12.

Table 4.12: Mean and standard deviation after the intervention

	Group	N	Mean	Std. Deviation	Std. Error Mean
Post-test	Control	30	38.76	6.830	1.315
	Experimental	29	79.72	5.390	1.001

Table 4.12 presents the descriptive statistics results for learning experiences, and the results shows that on average, the learners in control group scored 38.76% (with a standard deviation of 6.830), whereas the learners in the experimental group scored higher, at 79.72% (with a standard deviation of 5.390). Therefore, the results indicate that after the learning process, the average scores of the experimental group and the control group were different and learners in the experimental group had higher scores in terms of learning experiences than learners in the control group. Therefore, the experimental group exhibited more positive learning experiences compared to the control group where MS Excel software was not used.

4.7.2 Qualitative results

To further determine learners' learning experiences after learning statistics with MS Excel software. FGD interview with 6 participants selected from the experimental group was conducted. Responses related to learning experiences, and views towards statistics were identified from the transcript. The nature of the questions and discussions allowed participants to express their views towards statistics and learning experiences with MS Excel. The responses provided by the participants were subjected to thematic analysis. The analysis of learners' responses from the FGD revealed key themes related to their learning experiences and views toward statistics after using MS Excel. Participants shared understanding of how the software influenced their understanding, engagement, and perception of the subject.

A common theme that emerged was that learning statistics with MS Excel made the subject easier to understand. One participant stated, *“Learning statistics with MS Excel made the topic much easier for me,”* while another added, *“The activities and pictures helped me understand concepts more quickly.”* These responses suggest that the visual and interactive features of MS Excel contributed to simplifying the concepts in statistics, making learning more accessible and less intimidating for learners. Another significant theme was the usefulness of statistics in real life. One learner expressed, *“Lessons helped me to see how statistics is used in real-life,”* and another shared, *“The activities and examples have made the topic more relevant.”* These statements highlight how applying MS Excel allowed students to make connections between classroom learning and real-world applications which reinforced the practical value of statistics. Many participants also described statistics as interesting and engaging after learning with MS Excel. One student remarked, *“Honestly, I never thought statistics could be interesting, but activities changed how I now see it.”* Another participant noted, *“The lessons were interactive and quick results kept us engaged and made learning more enjoyable.”* These responses indicate that the use of MS Excel transformed learners’ attitudes toward statistics, shifting their perception from seeing it as a difficult subject to one that is engaging. The practical nature of statistics was another major theme identified. One participant stated, *“Excel made statistics more practical for me,”* while another commented, *“I was able to see the connections between what was being taught, which made the topic more applicable.”* These responses suggest that MS Excel helped learners to bridge the gap between theoretical knowledge and practical application which reinforced their ability to apply statistical concepts in meaningful ways. The analysis shows that learners found statistics easy, interesting, useful and practical. Results revealed that learners had positive learning experiences. The findings indicate that MS Excel significantly enhanced learners’ experiences with statistics by making the subject easier, more useful, engaging, and practical.

4.8 Post-test: Academic performance of learners in statistics.

To determine the performance learners after the intervention, a statistics test was administered. The scores were first tested for normality. The p-value of the post-test scores for performance in table 4.2 was less than the alpha value, it was concluded that the scores were not approximately normally distributed. Since normality was not assumed for the data set, a Mann-whitney U-test was performed on the scores to test the second research hypothesis. The results are presented in table 4.13.

Table 4.13: Difference between two groups in terms performance

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of post-test is the same across categories of Group.	Independent-Samples Mann-Whitney U Test	.214	Retain the null hypothesis.

Since sig-value is 0.214 in table 4.13, 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 difference in performance scores between the two groups. The mean scores are presented in table 4.14.

Table 4.14: Mean and standard deviation after the intervention

	Group	N	Minimum	Maximum	Mean	Std. Deviation	Std. Error Mean
Post test	Control	30	68		82.00	8.952	1.634
	Experimental	29	68		83.17	9.188	1.892

Table 4.14 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, it was noted that the two groups had higher scores, learners' performance was good for the experimental and control groups despite using Excel and conventional teaching approaches, respectively. Nevertheless, the test scores revealed that the two groups had the same minimum score, however, the experimental group had the highest score of 100 percent, while the control group scored 95 percent. Additionally, it was observed through the analysis of the marked scripts that none of the learners in the control group answered question 3 correctly, which asked, "What does a small (close to zero) standard deviation mean?" This was the main reason none of the learners in the control group got all the questions correct. The sample marked scripts for the experimental and control groups are shown in image 4.10 and 4.11.

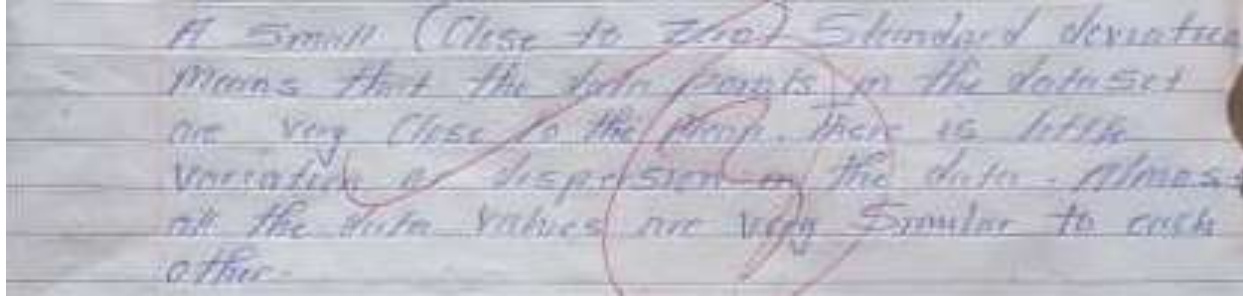


Image 4.10: Answer of a learner from the experimental group to Question 3

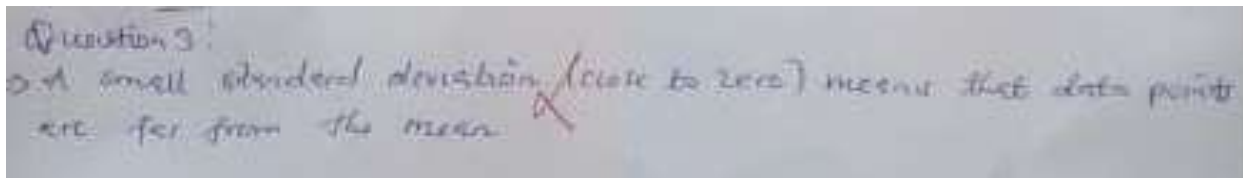


Image 4.11: Answer of a learner from the control group to Question 3

As seen in image 4.10 and 4.11, the learner from control group struggled with a question related to interpreting the meaning of a small standard deviation. This indicates a limitation of the conventional teaching method in fostering conceptual understanding of statistics among learners.

However, based on the findings of this study, it can be concluded that both groups performed at a similar level. It was also imperative to note that the test mainly consisted of questions that required learners to recall formulas and calculation procedures. These questions were taken from the ECZ exam past-papers and the recommended progress mathematics textbook for grade 11. Learners in the experimental group managed to answer most (if not all) questions that required recall of formulas and calculation procedures, and the question that demanded understanding of statistics concepts.

4.9 Relationship between 21st Century Skills and learning experiences

In order to determine the relationship between acquisition of 21CS, and learning experiences, a non-parametric correlation test; Spearman rank test, was performed to determine the strength and direction of the relationship between learners' acquisition of 21CS and their experiences. This was to test the second hypothesis. The results of the correlation test are shown in table 4.15.

Table 4.15: Relationship between 21st Century Skills and learning experiences.

			Skills	Experiences
Spearman's rho	21st Century Skills	Correlation Coefficient	1	.761
		Sig. (2-tailed)	.	.000
		N	29	29
	Learning Experiences	Correlation Coefficient	.761	1
		Sig. (2-tailed)	.761	.
		N	29	29

The results in table 4.15 of a correlation test performed at $\alpha=0.01$ showed that there was a significant relationship between the acquisition of 21CS and their experiences (sig. =0.000 < 0.01). The result of Spearman's rho correlation coefficient was 0.761, meaning that there was a strong positive relationship between the acquisition of 21CS and their experiences. Therefore, it was found that there was a relationship between learners' acquisition of 21CS and their learning experiences.

4.10 Relationship between 21st Century Skills and academic performance

In order to determine the relationship between acquisition of 21CS and learner performance, Spearman rank test, was performed to determine the strength and direction of the relationship between learners' acquisition of 21CS and their performance in statistics. This was to further test the third hypothesis. The results of the correlation test are shown in table 4.16.

Table 4.16: Correlations between 21st Century Skills and Performance.

			Skills	Performance
Spearman's rho	21st Century Skills	Correlation Coefficient	1	.060
		Sig. (2-tailed)	.	.657
		N	29	29
	Performance	Correlation Coefficient	.060	1
		Sig. (2-tailed)	.657	.
		N	29	29

The results in table 4.16 of a correlation test performed at $\alpha=0.01$ 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 show that there was no relationship between acquisition of 21CS and performance of learners in statistics.

4.11 Chapter Summary

Chapter presented results on learners' acquisition of 21st century skills (21CS), learning experiences, and academic performance after they were taught statistics. This chapter also presented findings on the relationships between acquisition of 21CS and learning experiences, and the relationship between the acquisition of 21CS and performance. The next chapter presents the discussions of these findings.

CHAPTER FIVE

DISCUSSIONS OF FINDINGS

5.0 Overview

Chapter five discusses the findings presented in the previous chapter. It is an important chapter because it presents the findings of the study based on the research objectives, the theory or model, and the existing literature presented in chapter two. The findings were discussed according to the research objectives.

5.1 Introduction

This discussion integrates the quantitative and qualitative findings, contextualizes them within existing literature, and highlights the implications of integrating MS Excel into the teaching of statistics for the development of 21st century skills (21CS). The objective of the discussion is to interpret and characterize the importance of the findings in relation to existing knowledge about the research topic under investigation (Prathapan, 2015). Therefore, it aims to explain any new knowledge that have emerged as a result of studying the problem. According to Creswell (2012), the purpose of the discussion section is to interpret and describe the significance of the researcher's findings in light of what was already known about the research problem and to explain any new understanding gained from studying the problem.

In this chapter, the findings are based on responses from questionnaires, interview, a test and observations made. The main aim was to establish whether MS Excel is applicable in teaching secondary school statistics for learners' acquisition of 21CS. The relationship between acquisition of 21CS and learners' performance and their learning experiences was also explored. It was hypothesized that lack of acquisition of 21CS result from the way teachers teach Mathematics using conventional teaching methods, lack of acquisition of 21CS has contributed to poor performance in mathematics topics such as statistics and negative learning experiences resulting in negative perceptions towards the topic, and that the use of MS Excel in teaching statistics can foster the development of 21CS which can in turn enhance performance and perceptions of learners regarding statistics.

The results showed that learners taught with MS Excel demonstrated better skills. It was also found that applying MS Excel in teaching statistics had a positive effect on learning experiences.

Therefore, MS Excel was found to be applicable in teaching secondary school statistics for learners' acquisition of 21CS. Additionally, It was found that there was a relationship between acquiring 21CS and positive learning experiences. The results showed a positive effect of the learners' 21CS on performance. However, findings showed that learners' performance was good with and without applying MS Excel, and revealed no relationship between acquiring 21CS and academic performance.

To address research objectives, the following research questions were used:

1. What is the effect of applying MS Excel in teaching statistics on learners' acquisition of 21CS (Communication skills, and Information, technology and statistical literacy)?
2. What is the effect of learners' 21CS on their learning experiences?
3. What is the effect of the learners' 21CS on performance of learners in statistics?

5.2 Discussions

5.2.1 Pre-test Results

The responses from the diagnostic test were coded and analyzed. Findings in table 4.4 indicated that the two groups were at the same level before the intervention. In Table 4.5, the results show that both the control group and the experimental group had mean scores of approximately 49%, which indicated a similar level of achievement. This similarity was further supported by the independent sample test results, which showed no significant difference in the pre-test scores between the two groups. This suggests that they were at equivalent levels before the study began.

Specifically, the mean scores for the experimental group ($M=49.41$, $SD=8.55$) and the control group ($M=48.53$, $SD=9.44$), with a t-value of -1.219 and a p-value of 0.228 (greater than 0.05), indicate that learners from both groups demonstrated low proficiency in 21st century skills (21CS). Therefore, it can be concluded that the two groups were at the same level in terms of 21CS and exhibited a lack of these essential skills. This confirms the findings by Plecher (2020); World Bank (2017); SACMEQ (2011); UNESCO (2005), which also highlighted low proficiency of 21CS among secondary school learners in Zambia. The study by Masaiti et al. (2021) attributed this to limited access to technology facilities and low utilization of available technology resources by both learners and teachers, particularly in public secondary schools in Zambia.

5.2.2 Effect of applying MS Excel in teaching statistics on learners' acquisition of 21CS

Findings revealed that MS Excel was applicable in teaching statistics for 21CS. The results showed that learners taught with MS Excel demonstrated better skills. From the findings presented in table 4.6 and table 4.7, it was found that the null hypothesis (H_{0_1}) was rejected on the grounds that there was a statistically significant difference in the scores for the learners who were taught with MS Excel (Mean=82.27%, SD=3.38) and learners taught by conventional teaching method (Mean=39.23%, SD=4.12); $p < .001$ for Mann-Whitney U-test. The results show that the two groups of learners were not at the same level in terms of 21CS after the learning process. Therefore, quantitative findings indicated that after the learning process, the average scores of the experimental group and the control group were different and learners in the experimental group had higher scores in terms of 21CS than learners in the control group. The effect size ($r_s=0.742$) indicates that the application of MS Excel in statistics lessons had a significant effect on the acquisition of 21CS among the experimental group. The result highlights that applying MS Excel in statistics lessons contributed significantly to the development of 21CS in the experimental group compared to the control group. This result is in line with Gravemeijer et al. (2017) and Suh and Seshaiyer (2013) who stated that 21CS can be taught by applying computer technologies in the teaching and learning of Mathematics.

Furthermore, the result of the Friedman test in table 4.8 (p -value=0.000) suggests that there is a meaningful difference in how learners in the experimental group had acquired the skills. It shows that at least one of the skills has a median rank that differs significantly from the others. This finding implies that learners' acquisition of these skills were not uniform, and some skills were likely acquired at a higher or lower level than others. The findings in table 4.9 and table 4.10 further indicate that statistical literacy and technology literacy were the most acquired skills, while communication and information literacy were developed at lower levels. This maybe as the result of the instructional approach used, which placed emphasis on statistics concepts and technology-driven learning where MS Excel was used. The high acquisition of technology literacy aligns with Garcia (2022), who emphasizes the importance of digital tools in fostering problem-solving, computational thinking, and digital creation. Erwin and Mohammed (2022), and Ezziane (2007) further argue that software such as MS Excel provides hands-on learning experiences that enhance technological proficiency. Nocar et al. (2019) and Smith et al. (2023) highlight the significance of

technology literacy in preparing learners for success in an increasingly digital world. Similarly, Yelland, Diezmann, and Butler (2008) stress that technology literacy is essential for mastering 21CS and thriving in educational environments. The strong performance in statistical literacy support findings by Utomo (2021), who states that computer software plays a crucial role in developing skills such as data analysis, interpretation, and communication of findings. Doyle (2008) and Gordon & Nicholas (2010) also emphasize the importance of statistical literacy in enabling data-driven decision-making. Studies by Pamungkas & Khaerunnisa (2020) and Risqi & Setianingsih (2021) further highlights the importance of integrating statistical tools in teaching and learning practices. Sharma et al. (2012) assert that statistical literacy is a vital skill in today's data-driven world, a view supported by Yuniawatika (2018), who identifies statistical literacy as a key competency for 21st century learners.

Additionally, the findings from the thematic analysis further revealed the acquisition of 21CS. Through this qualitative investigation, four major themes emerged: Information Literacy, Technology Literacy, Statistical Literacy, and Communication Skill. Firstly, participants highlighted their enhanced ability to summarize information to extract relevant data, this indicates an improvement in Information Literacy. They mentioned being able to recognize reliable sources on the internet and evaluate information, a skill important not only in statistics but across other subjects as well. Secondly, there was a notable increase in Technology Literacy, with participants expressing proficiency in using computers, operating software such as MS Excel, and utilizing tools like projectors. They specifically mentioned tasks such as data entry, table and graph creation, and result interpretation digitally. Thirdly, Statistical Literacy was evident as participants discussed their understanding of statistical concepts alongside practical applications. They described how solving statistics problems helped them grasp the meaning behind statistical results, which emphasized the importance of data summarization, presentation, and interpretation. Lastly, Communication skill was identified as participants noted improvements in their interactions with computers, peers, and the teacher. They highlighted the clarity achieved in presenting results, facilitated by MS Excel, which they found applicable not only in classroom but also in expressing ideas more effectively in general. The thematic analysis revealed that learners in the experimental group acquired more 21CS through their engagement with MS Excel. Furthermore, the results from observations revealed that learners had improved communication, collaboration, problem-

solving, and technology literacy skills. This affirms the findings by Suson (2019) who revealed that 21CS are interconnected, and that by teaching one skill other skills are reinforced.

These findings complement the quantitative results which indicated acquisition of 21CS. Therefore, incorporating MS Excel into teaching secondary school statistics, assisted the teacher in providing learners with opportunities to develop 21CS. The application of MS Excel in teaching secondary school statistics had a significant effect on the acquisition of 21CS. This study confirms that integrating MS Excel into statistics instruction enhances both learners' conceptual understanding and their ability to apply essential skills such as communication, information literacy, technology literacy, and statistical literacy. These findings align with constructivist learning theory, particularly the experiential and cooperative learning approaches, which emphasize active learner engagement in constructing knowledge through interaction with their environment (Sadker & Sadker, 2005). By utilizing MS Excel in teaching statistics, learners were engaged in hands-on activities that allowed them to construct knowledge from their experiences with technology (Kolb, 1984; Kolb & Boyatzis, 1999). This process of "doing" not only deepened their understanding of statistical concepts but also enhanced essential 21CS, including communication, information literacy, technology literacy, and statistical literacy. Similarly, the integration of MS Excel created an environment where learners collaborated, exchanged knowledge, and worked on real-life statistical problems. Supported by Vygotsky's social constructivism (1978), this cooperative interaction enriched their learning process, which emphasized teamwork and collaborative problem-solving (Slavin, 1996; Johnson & Johnson, 1994).

These findings align with the TPASK framework which suggests that effective statistics instruction with technology requires an understanding of statistical content, the appropriate technological tools (such as MS Excel), and pedagogical strategies that promote active learning (Lee & Hollebrands, 2011). The use of MS Excel supported experiential and cooperative learning enabled learners to explore statistical concepts while engaging in collaborative tasks. As Lee et al. (2018), Cuadra (2021), and Gasigwa et al. (2022) suggested, well-prepared teachers can effectively utilize MS Excel to foster the development of 21CS. Additionally, this study confirms findings by Changwe and Mwanza (2019), Cuadra (2021), and Mulle (2023), who emphasized that technology, particularly MS Excel, fosters the development of Skills and statistical knowledge. By allowing learners to focus on understanding statistical concepts while acquiring practical skills,

MS Excel enhances the learning experiences. The ability to quickly compute figures, construct tables and graphs, and work with real-world data supports Gomez's (2014) claim that technology helps learners concentrate on learning and applying skills (Rahadyan et al., 2022; Borkulo et al., 2023). Furthermore, MS Excel transformed the learning experience into a learner-centered process. As Bvute (2017) highlighted, technology such as MS Excel not only supports learning of content but also prepares learners for real-life applications by equipping them with necessary skills for future careers. This aligns with Stemock and Kerns (2019), who stressed that engaging students in real-life problems enhances critical thinking and problem-solving abilities. Therefore, by working with real statistical problems in MS Excel, learners bridged the gap between theoretical knowledge and practical application, reinforcing the relevance of statistics in real-world contexts. The constructivist learning approach also played a crucial role in engaging learners meaningfully, enabling them to acquire both statistical knowledge and 21CS. This is supported by studies from Rosdiana et al. (2020), Barell (2020), Lapek (2018), Fulan (2014), Voogt & Roblin (2012), and Conneely (2013), who recommend constructivist teaching strategies for fostering 21CS. Suson (2019) further affirmed that integrating statistical software like Excel into constructivist approaches such as collaborative, problem-based, and experiential learning enables learners to work with real-life data and solve realistic problems.

5.2.3 Effect of applying MS Excel on learning Experiences

The study also investigated the effect of applying MS Excel on learners' learning experiences. It was found that applying MS Excel in teaching statistics had a positive effect on learning experiences. The quantitative results, as presented in Table 4.11 and the effect size ($r_s = 0.611$), revealed a substantial difference between the experimental and control groups in terms of their learning experiences. With a p-value of less than 0.001, the null hypothesis was rejected, this indicates that the groups were significantly different. The findings suggests that learners in the experimental group, who utilized MS Excel, had differing learning experiences compared to those in the control group. Further examination of descriptive statistics, displayed in Table 4.12, confirmed this discrepancy. On average, learners in the experimental group scored significantly higher (Mean=79.72%, SD = 5.390) compared to those in the control group (Mean=38.76%, SD = 6.830). This indicates that learners who utilized MS Excel had more positive learning experiences compared to those who did not. The findings show that the use of MS Excel positively

influenced learners' learning experiences and perceptions of statistics. The experimental group, which incorporated MS Excel into their learning process, exhibited significantly more positive experiences compared to the control group. Learners in the experimental group had more positive learning experiences due to the engaging and interactive nature of MS Excel-based lessons. The hands-on approach and opportunities for exploration made statistics lessons more meaningful and enjoyable for learners. This aligns with constructivism theory, which emphasizes the active role of learners in constructing knowledge through experience and interaction with their environment (Sadker & Sadker, 2005). The findings further confirm that experiential and cooperative learning approaches, both of which are grounded in constructivism theory, play a significant role in improving learners' engagement and understanding of statistics.

Experiential learning suggests that learners acquire knowledge through doing, and by using MS Excel, students were able to actively explore statistical concepts in a practical and meaningful way (Kolb, 1984; Singh, 2020). This interactive approach allowed learners to retain knowledge and apply statistical concepts in real-world contexts, this reinforced the importance of learning statistics through experience (Kolb & Boyatzis, 1999). The integration of MS Excel provided learners with an opportunity to experiment with data, visualize data, and apply statistical methods, thereby supporting experiential learning. Similarly, Cooperative learning emphasizes that learners construct knowledge through collaboration and peer interactions (Vygotsky, 1978; Johnson & Johnson, 1994). The findings indicate that learners who worked together in Excel-based tasks were able to discuss, analyze, and solve statistical problems more effectively which fostered a deeper understanding of the subject. Cooperative learning allowed them to exchange ideas, clarify concepts, and develop critical thinking skills which are key components of 21CS such as communication, information literacy, technology literacy, and statistical literacy (Jones & Jones, 2008; Williams, 2007).

The findings also align with the TPASK framework, which emphasizes the interconnectedness of technology, pedagogy, and statistical knowledge in the effective teaching of statistics (Lee & Hollebrands, 2011). According to TPASK, teachers must integrate technological tools like MS Excel into instruction while ensuring that pedagogical strategies, such as experiential and cooperative learning, are used to maximize learning outcomes. The results of this study suggest that the integration of MS Excel in teaching statistics not only improved students' understanding of statistical concepts but also fostered their engagement and perception of the subject. By creating

an interactive learning environment, Excel helped bridge the gap between abstract statistical theories and their practical applications, making learning more meaningful (Prodromou, 2015).

These findings confirm previous studies by Barell (2020) and Petocz (2002), which showed that technology can improve attitudes and perceptions toward statistics. Similarly, Simutenda & Musonda (2018) found that learners in experimental groups showed better attitudes toward learning statistics when computer software was integrated into the teaching and learning process. However, data from the Likert-scale also indicated that learners taught using the conventional method had lower scores, supporting Mulendema (2007), who argued that students develop negative attitudes toward mathematics when it is taught traditionally. In Zambia, pupils perceive mathematics as a boring, difficult, and abstract subject due to the way it is taught using conventional methods (Kafata & Mbetwa, 2016). The findings of this study demonstrate that after learning statistics with Excel, learners showed increased interest and more positive perceptions of the subject.

Furthermore, open-ended questions posed to the experimental group during a focus group discussion revealed four major themes: ease of learning, usefulness of statistics, interest, and practicality. Participants expressed that learning statistics with MS Excel made the subject much easier to grasp and more engaging. They also emphasized the relevance and application of statistics in real-life contexts, stating that Excel-based lessons helped them understand its practical implications.

A hands-on approach was implemented in the lessons, as learners actively practiced using MS Excel what the teacher demonstrated rather than passively observing. By engaging with Excel directly, they gained practical experience in data manipulation, statistical computation, and graphical representation. The internet was also used as a research tool, which allowed learners to collect real-world data, further reinforcing the practical application of statistics. The learning process balanced individual practice with collaborative activities, where learners completed some tasks independently while also engaging in group discussions and peer-to-peer learning. These discussions were often as a result of observations made during graph analysis and result interpretation.

The responses from participants revealed that their perception of statistics changed from boring to interesting due to the interactive nature of the lessons. This supports a study by Borkulo et al.

(2023), which highlighted the importance of teaching statistics with Excel in enhancing learners' awareness of its relevance. Similarly, Chebotib and Kering (2021) found that learners exposed to technology in learning exhibited more positive attitudes compared to those taught using traditional methods.

Conversely, studies by Giesbrecht (1996); Petocz (2002); Larwin and Larwin (2011), and Jatnika (2016) suggests that traditional methods, such as memorization of formulas and calculation procedures, increase cognitive load and make statistics seem irrelevant, abstract, and difficult. Studies by Basturk (2005); Gomez (2010); Morris (2013); Simutenda and Musonda (2017); and Jatnika (2015) highlight the benefits of using computer software in teaching statistics, as it enhances active engagement and promotes meaningful learning experiences. These findings reinforce the constructivist perspective that learning is most effective when students are actively engaged and when instructional approaches emphasize real-life applications (Sadker & Sadker, 2005).

5.2.4 Relationship between 21st Century Skills and learning experiences

To explore the connection between learners' 21st Century Skills (21CS) and their learning experiences, a Spearman rank correlation test was conducted. This analysis aimed to assess the strength and direction of the relationship between learners' proficiency in 21CS and their learning experiences, supporting our third hypothesis (H_{0_3}). It was found that there is a relationship between acquiring 21CS and positive learning experiences. As depicted in Table 4.15, the results of the correlation test conducted at a significance level of $\alpha=0.01$ revealed a statistically significant relationship between the acquisition of 21CS and learners' learning experiences (sig. = 0.000 < 0.01). The Spearman's rho correlation coefficient computed as 0.761 indicated a strong positive correlation between the acquisition of 21CS and learning experiences. The results indicate that there is a statistically significant positive relationship between 21CS and learning experiences. Hence, it was evident that there existed a relationship between learners' mastery of 21CS and their learning experiences and perceptions regarding statistics.

These findings confirm the results of previous studies by Borkulo et al. (2023), Chebotib and Kering (2021), Giesbrecht (1996), Larwin and Larwin (2011), Jatnika (2016), Basturk (2005), and Morris (2013), which have highlighted the relationship between technology proficiency, cognitive abilities, perceptions, and attitudes towards learning. Specifically, the findings align with Borkulo

et al. (2023) and Chebotib and Kering (2021), who found a strong and positive relationship between learners' skills and their attitudes towards mathematics. The authors highlighted the significance of technology integration in fostering positive attitudes towards learning and enhancing learners' awareness of subject relevance. Furthermore, the findings also corroborate the observations made by Giesbrecht (1996), Larwin and Larwin (2011), and Jatnika (2016) that in the process of learners acquiring 21CS, they are likely to have good learning experiences and positive views toward the subject. They emphasized that the development of 21CS has an effect on perceptions toward statistics. According to Abdullahi and Moham (2022), the acquisition of 21CS can contribute to positive learning experiences and learners' views towards mathematics.

These findings are further supported by constructivism theory, which guided this study. In the context of this study, the use of experiential and cooperative learning approaches enabled learners to engage meaningfully with statistical concepts and technology, reinforcing their mastery of 21CS. This study incorporated experiential learning, which suggests that learners acquire knowledge best through experience and active participation (Kolb, 1984). The findings align with the argument by Singh (2020), Kolb & Boyatzis (1999) that when learners engage in technology-enhanced experiential learning, they retain knowledge better and can apply it in real-world contexts. In this study, the integration of Excel in teaching statistics provided learners with hands-on experiences, enabling them to explore, analyze, and interpret data effectively. The strong association between 21CS and learning experiences observed in the findings suggests that experiential learning with technology fosters both proficiency and confidence in statistical concepts. The study also employed cooperative learning, where learners engaged in peer interactions to construct knowledge (Vygotsky, 1978; Johnson & Johnson, 1994). The results support the argument that cooperative learning promotes critical thinking, problem-solving, and collaborative skills (Slavin, 1996). The significant relationship between 21CS and learning experiences found in this study suggests that learners who worked collaboratively in Excel-based statistical tasks developed better communication, information literacy, technology literacy and teamwork skills, reinforcing previous research by Jones and Jones (2008), and Williams (2007).

The findings also align with TPASK framework, which emphasizes that teachers must integrate statistical knowledge, technological proficiency, and pedagogical strategies to enhance learning. The observed positive relationship between 21CS and learning experiences suggests that effective teaching using Excel in statistics as prescribed by TPASK, creates an interactive and meaningful

learning environment. The results corroborate prior studies (Harits et al., 2019; Murphrey & Theresa, 2011) that emphasize the effectiveness of MS Excel in teaching statistics through experiential and cooperative learning.

5.2.5 Effect of applying MS Excel on performance of learners in statistics

The analysis aimed to evaluate the effect of MS Excel on learners' performance in statistics. Following the intervention, a statistics test was administered, and the scores were examined for normality. The test revealed that the scores did not follow a normal distribution. Consequently, a Mann-Whitney U-test was conducted to compare the performance scores of the experimental and control groups. Findings showed that learners' performance was good with and without applying MS Excel. The results, depicted in Table 4.13, demonstrated that the p-value (0.214) was greater than the alpha value (0.05). Hence, we failed to reject the null hypothesis, indicating no significant difference in the performance between the two groups. This was further corroborated by descriptive statistics presented in Table 4.14, where the average scores for both groups were similar, with the experimental group (Mean=83.17%, SD=9.188) scoring slightly higher than the control group (Mean=82.00%, SD=8.952). The learners performed well. One contributing factor could be the sharing of information and intervention techniques among learners, as both groups were from the same school. Hence performance being the same for experimental and control group. These findings align with Gasigwa et al. (2022), who also observed a positive impact of Excel Spreadsheet on learner performance in statistics. Similarly, Chance et al. (2007) emphasized the significant role of technology in teaching statistics. This supporting active and collaborative learning, which is consistent with constructivism theory. Constructivism suggests that learners actively construct their own knowledge through experience and social interactions (Sadker & Sadker, 2005). The experiential and cooperative learning approaches within constructivism reinforce this idea by promoting hands-on engagement and peer collaboration in knowledge acquisition (Kolb, 1984; Johnson & Johnson, 1994).

This study was guided by constructivism theory, specifically following the experiential and cooperative learning approaches. In this study, the integration of MS Excel allowed learners in the experimental group to engage in experiential learning by manipulating data, generating statistical visualizations, and interpreting results in real time. This hands-on experience facilitated deeper conceptual understanding, as demonstrated by the experimental group's better performance on

questions requiring the interpretation of statistical concepts. These results are in line with studies emphasizing that experiential learning fosters retention and practical application of knowledge (Singh, 2020; Kolb & Boyatzis, 1999). Additionally, Cooperative Learning posits that knowledge is constructed through social interaction and collaboration among learners (Vygotsky, 1978; Slavin, 1996). The use of Excel in group activities encouraged peer discussion, problem-solving, and collective interpretation of statistical results. The collaborative nature of Excel-based learning aligns with prior studies that found cooperative learning enhances critical thinking and conceptual understanding of statistics (Jones & Jones, 2008; Williams, 2007). This is further supported by studies indicating that students benefit from using technology in cooperative environments, where they share knowledge and learn from each other's perspectives (Johnson & Johnson, 1994).

The findings of this study are also consistent with the TPASK framework. TPASK, emphasizes that effective technology-integrated statistics instruction requires a balance of statistical knowledge, technological proficiency, and pedagogical strategies. In this study, the application of Excel facilitated the intersection of these knowledge domains. Teachers needed to understand statistical content, possess Excel proficiency, and apply constructivist teaching methods to create an interactive and meaningful learning environment. This aligns with previous studies such as Harits et al. (2019); Murphrey and Theresa (2011), which found that integrating Excel with constructivist teaching approaches enhances statistical learning and the development of Skills.

Despite these advantages, the results of this study contrast with findings from Simutenda & Musonda (2018), who reported significantly better achievement among learners in an experimental group using technology-based methods. Similarly, Gomez (2014) found higher passing and retention rates among students taught with technology-enhanced instruction. While the experimental group in this study demonstrated a stronger grasp of conceptual understanding, overall performance differences between the groups were not statistically significant. This aligns with Larwin and Larwin (2011), who found a moderate impact of computer-based learning on student achievement, and Das (2019), who highlighted both benefits and limitations of technology in mathematics instruction. Furthermore, while studies such as Seyram et al. (2021) emphasized the potential of Excel to enhance learning outcomes, others, such as Jatnika (2015), reported mixed results, noting an increase in cognitive aspects but a decrease in achievement following technology use.

However, a key observation in this study emerged when examining performance on conceptual questions. The control group struggled with a question related to interpreting the meaning of a small standard deviation, with their highest score reaching 95 percent compared to 100 percent for the experimental group. This suggests that conventional teaching methods may be effective in helping learners memorize formulas and master procedural calculations but are less effective in fostering deep conceptual understanding (NCTM, 2000; Wiggins & McTighe, 2005). In contrast, constructivist teaching approaches, supported by Excel, provided learners with opportunities to explore and manipulate data, this reinforced their understanding of statistical concepts. The finding supports research by OECD (2019), which highlighted the increasing need for educational assessments that measure not only computational skills but also conceptual understanding and the ability to apply knowledge in various contexts.

Applying MS Excel positively influenced conceptual understanding among learners in the experimental group, as evidenced by their performance on the question requiring statistical interpretation. These findings further validate Pellegrino and Hilton's (2013) argument that modern education should move beyond rote learning and focus on critical thinking, problem-solving, and real-world application of knowledge. The results also align with studies that emphasize that technology-integrated instruction fosters 21CS, this equip learners with skills necessary for data-driven and decision-making in the 21st century (P21, 2009; Facione, 1990; ISTE, 2008).

5.2.6 Relationship between learners' 21CS and their performance

The aim of this analysis was to investigate the association between learners' 21st Century Skills (21CS) and their performance in statistics. A Spearman rank correlation test was conducted to assess the strength and direction of this relationship, thereby testing our third hypothesis (H_{0_3}). It was found that there is a no relationship between acquiring 21CS and performance. As presented in Table 4.16, the correlation test, carried out at a significance level of $\alpha=0.01$, yielded results indicating no significant relationship between the learners' 21CS and their performance in the statistics test (sig. = 0.657 > 0.01). Furthermore, the Spearman's rho correlation coefficient was computed at 0.060, revealing a positive and very weak relationship between 21CS acquisition and academic performance. These findings suggest that there was no connection between the two variables. These results are consistent with those of Bircan and Akman (2023), who similarly

found no relationship between learners' 21CS and their academic performance. However, the findings differ from studies by Smit (2016) and Lancaster (2012), which indicated that a lack of 21CS could contribute to poor performance in statistics. Conversely, Rabi et al. (2021); Onur and Kozikoglu (2020) discovered a positive correlation between learner performance and 21CS skills when utilizing computer software. The findings of this study did not reveal any significant relationship between the learners' 21CS and their performance in statistics.

5.3 Implications of the Results

The discussions of the findings of this study has provide important information for curriculum development, pedagogy, teaching tools, content delivery, and assessment in mathematics education. The integration of MS Excel into statistics instruction has been shown to enhance learning experiences, conceptual understanding while promoting 21CS such as communication skills, information literacy, technology literacy and technology literacy as well as critical thinking, and problem-solving. However, the study also highlights the complexity of the relationship between 21CS and academic performance in statistics, this calls for a more structured and balanced approach to technology-enhanced learning and assessment. The study emphasizes the need to revise secondary school statistics curricula to incorporate technology-driven learning experiences. Given that MS Excel fosters active engagement with statistical concepts, curriculum developers should ensure that digital tools are embedded into instructional content in a way that supports conceptual understanding rather than just computational proficiency. Additionally, the curriculum should emphasize experiential learning approaches that align with constructivist principles which can enable learners to apply statistical knowledge to real-world problems.

The findings support the adoption of constructivist teaching methods, including experiential, cooperative, and inquiry-based learning. Teachers should adopt learning strategies in teaching statistics that encourage learners to actively explore data, visualize statistical concepts, and collaborate on problem-solving tasks using MS Excel. Since technology integration alone does not guarantee improved performance, educators should focus on designing lesson plans that effectively connect 21CS to subject-specific content to ensure that learners develop both statistical reasoning and digital proficiency. Furthermore, the study has highlighted the potential of MS Excel as a valuable instructional tool for enhancing statistical learning. However, the effectiveness of Excel-based instruction depends on teachers' ability to integrate technological tools meaningfully.

The TPASK framework suggests that teachers need expertise in statistics, pedagogy, and Excel functionalities to maximize learning outcomes. Therefore, teacher training programs should focus on equipping educators with the necessary digital skills to effectively incorporate technology into statistics instruction. Since MS Excel facilitates hands-on engagement with statistical data, its integration in teaching should be structured to align with learners' cognitive development. Lessons should emphasize data manipulation, visualization, and interpretation rather than just numerical computations. By incorporating interactive and real-world datasets, teachers can enhance learners' ability to analyse and interpret statistical information, this makes learning more engaging and relevant. Additionally, the study calls for a shift in assessment practices to better evaluate learners' understanding of statistical concepts and their ability to apply knowledge in practical contexts. Traditional assessments that focus solely on computational skills and calculation procedures may not capture the depth of conceptual understanding fostered by technology-enhanced learning. Therefore, assessments should include data-driven projects, problem-solving tasks, and real-life case studies that require learners to demonstrate both statistical reasoning and 21CS. Questions that require application, creativity and critical thinking must be encouraged.

From a policy perspective, the findings reveal the importance of incorporating 21CS development into education reforms. While 21CS are essential for preparing learners for the modern workforce, their integration into the curriculum should be carefully structured to ensure they contribute to measurable learning outcomes. Policymakers should advocate for increased access to technological tools, professional development for teachers, and curriculum adjustments that support technology-enhanced statistics education.

5.4 Chapter Summary

The main purpose of this chapter was to discuss the study findings focusing on the application of MS Excel in teaching secondary school statistics to enhance learners' acquisition of 21CS. The discussion was grounded on the literature reviewed, highlighting that applying MS Excel in teaching secondary school statistics had a positive effect on learners' acquisition of 21CS. It also influenced learners' learning experiences and views of statistics. Additionally, a statistically significant positive correlation was identified between 21CS and learning experiences. The study also revealed that there was no significant relationship between learners' 21CS and their

performance in statistics. The final chapter will present the conclusions and recommendations of the study.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Overview

In this chapter, the researcher provides an overview of the study, citing the literature, research objectives, and data analysis. The main conclusions, recommendations, expected contributions of the study and suggestions for further research are also presented.

6.1 Introduction

The study investigated the use of MS Excel in teaching statistics for enhancing the acquisition of 21st century skills (21CS), specifically communication skills, information literacy, technology literacy, and statistical literacy (CITS). The main aim was to assess whether MS Excel is applicable in teaching secondary schools statistics for learners' acquisition of 21CS. Additionally, the research examined how learners' 21CS influenced their academic performance and their learning experiences. The study sought to answer the following research questions:

1. What is the effect of applying Excel on learners' acquisition of 21CS?
2. What is the effect of learners' 21CS on their learning experiences?
3. What is the effect of learners' 21CS on their performance in statistics?

The chapters draw conclusions from the discussion of findings in chapter five and makes recommendations based on the findings.

6.1.1 Effect of applying MS Excel in teaching statistics on learners' acquisition of 21CS

This study has demonstrated that applying MS Excel into the teaching of statistics significantly enhances learners' acquisition of 21st century skills (21CS). The quantitative analysis revealed a substantial difference between learners taught with MS Excel and those instructed through conventional teaching method, with the former group achieving higher scores in 21CS. These results indicate that technology-enhanced learning fosters the acquisition of essential skills needed in today's technology and information-driven world. Additionally, the qualitative analysis of open-ended responses highlighted the acquisition of 21CS, including information literacy, technology literacy, statistical literacy, and communication skills. Learners who engaged with MS Excel not only improved their understanding of statistical concepts but also developed practical skills in data analysis, digital tools, and collaborative problem-solving. These findings reinforce the role of

technology in cultivating a well-rounded skill set that extends beyond traditional statistical knowledge. By incorporating MS Excel into statistics lessons, learners were provided with opportunities to actively engage with real-world data, work collaboratively, and apply their knowledge in meaningful ways. This learner-centered approach promoted experiential learning, encouraged critical thinking, and strengthened their ability to analyze and interpret data effectively. The integration of MS Excel also fostered a dynamic and interactive learning environment, which made statistics more engaging and relevant to learners. Therefore, this study confirms that the application of MS Excel in teaching statistics not only enhances conceptual understanding but also supports the holistic development of 21CS. Given the growing demand for these skills in both education and the workforce, applying technology into statistics education presents a vital strategy for preparing learners to succeed in the 21st century. The findings emphasize the importance of adopting innovative teaching approaches that bridge theoretical knowledge with practical application, this ensures that learners are well-equipped for future academic and professional challenges.

Summary

The findings of this study indicate a significant difference in terms of 21CS between learners who were taught using MS Excel and those taught through conventional methods. Results revealed that applying MS Excel in teaching secondary school statistics has a positive effect on learners' acquisition of 21CS. The study demonstrated that learners had improved 21CS when MS Excel was utilized. The findings highlight the significant role of MS Excel in fostering the acquisition of 21CS.

6.1.2 Effect of learners 21CS on learning Experiences

This study investigated the application of MS Excel into the teaching of statistics for 21CS. It further looked into how learners' 21CS influenced their learning experiences.

Effect of MS Excel on learning experiences

The findings of this study has demonstrated that the use of MS Excel in teaching statistics significantly enhances learners' experiences, engagement, and understanding of the subject. The quantitative analysis revealed a substantial difference between the experimental and control groups, with learners who used MS Excel reporting more positive learning experiences compared

to those taught through conventional methods. This highlights the effectiveness of technology-enhanced learning in making statistical concepts more accessible and engaging. The qualitative findings further support these results, as learners in the experimental group expressed that MS Excel made statistics easier to comprehend, more relevant to real-life applications, and more enjoyable. Many participants noted a change in their perception of statistics from being boring and challenging to interesting and practical. This suggests that integrating MS Excel into statistics education not only improves conceptual understanding but also fosters a more positive attitude toward the subject. Moreover, the study highlights the role of MS Excel in creating an interactive and learner-centered environment. The hands-on approach encouraged active participation, critical thinking, and collaboration, all of which are essential for meaningful learning. By incorporating real-world data analysis and visualization, MS Excel helped bridge the gap between theoretical knowledge and practical application, which made learning experiences more dynamic and impactful. Therefore, the findings confirm that the application of MS Excel into statistics instruction enhances both learning outcomes and learner perceptions. This approach supports the acquisition of 21st century skills while promoting a deeper and more engaging understanding of statistical concepts. The study has revealed the value of technology-driven teaching methods in fostering meaningful, practical, and enjoyable learning experiences.

Relationship between learners' 21st Century Skills and learning experiences

The results of this study established a strong positive relationship between the acquisition of 21st century skills (21CS) and learners' learning experiences. The Spearman rank correlation test confirmed that higher proficiency in 21CS is associated with more positive learning experiences, this highlights the crucial role these skills play in shaping learners' engagement and attitudes toward learning. The findings indicate that learners with strong 21CS not only demonstrate a deeper understanding of statistical concepts but also develop more favourable perceptions of the subject. The integration of technology-driven skills enhances cognitive abilities, promotes critical thinking, and fosters an interactive and engaging learning environment. This relationship emphasize the importance of equipping learners with 21CS to improve both their academic performance and overall learning experiences. Therefore, these findings reveal the need for secondary schools to prioritize the development of 21CS within the curriculum. By integrating these skills into the teaching of statistics and other subjects, schools can create more dynamic, learner-centred environments that support active participation and meaningful knowledge

acquisition. Strengthening 21CS in secondary education is essential for enhancing learners' attitudes, improving subject comprehension, and preparing them for the demands of an evolving, technology-driven world.

Summary

The study revealed that learners' learning experiences are improved when MS Excel is used. The findings show that teaching method is a significant factor in contributing to the current negative attitudes and perceptions towards Mathematics. It has been shown that the methods of teaching regulate how learners perceive statistics. It has also been established in this study that MS Excel has positive effect on learners' learning experiences and views towards Mathematics topics such as statistics. Learners taught using MS Excel found statistics to be an interesting, easy, practical topic and useful in their lives. This is due to the way the concepts were presented to them and how they were actively involved in their learning. Furthermore, the nature and direction of the relationship between learners' 21CS and their learning experiences was found to be significantly and positively related.

The results showed that the acquisition of 21CS has a bearing on learning experiences and how they perceive the topic. Therefore, the findings of this study have shown that MS Excel is effective in improving learners' 21CS, which in turn improves their learning experiences and views towards statistics. It can be concluded that learners' 21CS has an effect on learners learning experiences.

6.1.3 Effect of learners' 21CS on performance of learners in statistics

Effect of learning with MS Excel on performance of learners in statistics

The findings of this study indicate no significant difference in performance between learners taught using MS Excel and those taught through conventional methods, as reflected in the statistical analysis where the p-value exceeded the alpha value. Descriptive statistics further supported this outcome, showing high but comparable average scores for both groups, with a slight advantage observed in the experimental group. Despite the lack of a significant difference in overall performance, the study revealed that learners in the experimental group excelled in questions requiring conceptual understanding, while both groups performed similarly on questions that assessed recall of formulas and statistical procedures. This suggests that while MS Excel may not necessarily enhance rote learning outcomes, it may support deeper comprehension of statistical

concepts. Additionally, potential contamination between the groups may have influenced the results, as both were from the same boarding school, allowing opportunities for the exchange of information and techniques. This factor could have contributed to the similarity in performance outcomes. Therefore, 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.

Relationship between learners' 21CS and their performance

The results of this study reveal no significant relationship between learners' 21st century skills (21CS) and their performance in statistics. The Spearman rank correlation test indicates that there is no meaningful connection between 21CS and academic performance in statistics. The Spearman's rho correlation coefficient further suggest a very weak, positive relationship, this reinforces the lack of a significant relationship. Despite the importance of 21CS in modern education, these findings suggest that, within the context of this study, the acquisition of these skills did not directly affect learners' ability to perform in a statistics test. This outcome challenges the assumption that 21CS automatically translate into improved academic performance. The findings emphasize the complexity of factors that contribute to academic success and suggest that other variables may be more influential in determining performance in statistics.

Summary

Findings of this study have 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 from Mann-Whitney U-test and descriptive statistics revealed that applying 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 whether MS Excel is used or not. The findings show that MS Excel is not significant in contributing to the high performance in statistics. Furthermore, the nature and direction of 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. It can be concluded that learners' 21CS have no effect on performance.

6.2 Conclusion

The findings of the study have shown that learners who were taught with MS Excel had higher 21CS demonstration and learning experience compared to those taught using conventional teaching methods. The results indicated a difference in 21CS between learners taught with MS Excel and those taught conventionally. However, there was no significant difference in performance between the two groups, although test scores were high for both groups. Additionally, the findings revealed a positive relationship between learners' 21CS and their learning experiences. Therefore, teachers are encouraged to apply MS Excel in statistics teaching to enhance learners' understanding of mathematical concepts and prepare them for the digital age. By using computer software such as MS Excel in teaching statistics, comprehension can be improved, leading to the acquisition of 21CS. Through MS Excel, teachers can create interactive activities that promote hands-on learning experiences, which enhances learners' grasp of statistical concepts and proficiency in using the software. Furthermore, MS Excel provides opportunities for learners to collaborate and communicate effectively. The effectiveness of MS Excel in teaching secondary school statistics is clear, as it not only improves learners' understanding of statistical concepts but also equips them with essential 21CS. This study has emphasized the significant role of MS Excel in teaching secondary school statistics and fostering the acquisition of 21CS in learners. Therefore, the findings support the integration of MS Excel as an educational tool.

6.3 Recommendations

Based on the findings of this study and previous research, it is evident that incorporating MS Excel into the teaching of Mathematics, particularly topics such as statistics, holds significant potential to enhance the quality of education in secondary schools in Zambia. Therefore, the researcher makes the following recommendations:

1. To ensure that future teachers at secondary schools, such as Mwense Secondary School, are equipped with the necessary skills to effectively apply computer software such as MS Excel in statistics or mathematics instruction, educational institutions, particularly, Teacher Training Colleges and Universities should enhance training programs that focus on the application of technology in teaching methodologies. This can empower student teachers with the tools and knowledge needed to incorporate technology into their instructional practices effectively.

2. Additionally, efforts should be made to support secondary school teachers with the time and resources needed for successful implementation of MS Excel in teaching statistics.
3. Continuous Professional Development (CPD) programs in secondary schools (specifically, mathematics departments) should be conducted to ensure that teachers of mathematics stay updated on best practices and innovative uses of computer technologies such as MS Excel in teaching statistics.
4. Furthermore, the Ministry of Education should take proactive measures to provide secondary schools with adequate computer resources and internet access. Establishing well-equipped computer laboratories and ensuring internet connectivity will facilitate the integration of technology tools such as Excel into statistics classrooms, this will enable learners to engage more effectively with mathematics.
5. To maximize the benefits of technology integration, the Ministry of Education should invest in professional development programs for mathematics teachers, with a focus on fostering 21CS acquisition among learners. This could involve updating curriculum and assessment guidelines to explicitly promote the use of computer technology, specifically MS Excel, in teaching Mathematics topics such as statistics.
6. Incentives should be considered to encourage schools and mathematics teachers to actively integrate technology into their teaching practices. Recognition programs, awards, and additional resources can motivate schools to innovate and excel in utilizing technology for Mathematics education.
7. Collaboration with the CDC is essential to integrate technology into the overall curriculum. This collaboration should involve the development of learning materials that incorporate technology tools such as MS Excel. This will ensure access to online resources and educational materials, enhancing learning experiences for learners. Improving internet connectivity in schools is crucial for successful implementation of technology-based teaching methods.
8. Continuous research and evaluation on the effect of technology integration in teaching Mathematics topics such as Excel should be encouraged.
9. Examination Council of Zambia (ECZ) should prioritize on assessing learners understanding and application of statistical concepts, and 21CS.

By implementing these recommendations, the Ministry of Education, CDC, ECZ, School authorities and teachers can contribute to the advancement of 21CS among secondary school learners and enhance the overall quality of Mathematics education.

6.4 Future Studies

Since the findings of this study may not be universally applicable to all grade 11 pupils across secondary schools, it is imperative to conduct similar studies in different school settings. Future studies could incorporate experimental and control groups from different schools to allow for comparison of findings with the current study. Comparing the outcomes of MS Excel integration in statistics lessons across various secondary schools can enhance the understanding of its impact and effectiveness. Moreover, future research could enhance generalizability by employing larger sample sizes from diverse secondary schools throughout Zambia.

Future research could investigate the influence of gender on the acquisition of 21CS when MS Excel is utilized in statistics lessons. This investigation could reveal the potential gender disparities in technology integration and skill acquisition. Additionally, investigating teachers' competencies in utilizing MS Excel for teaching and their perceptions of its effectiveness can provide an understanding of professional development needs and instructional practices. Furthermore, future studies could focus on exploring learners' opinions regarding MS Excel, assessing teachers' knowledge and proficiency in using MS Excel effectively, and examining the perceptions of teachers towards its integration into teaching practices. Understanding these perspectives can inform strategies for more effective implementation and support systems. In addition, future studies could extend beyond MS Excel to explore other technological tools and platforms. By diversifying the range of technology resources available to educators, researchers can gain understanding of which tools are most suitable for different learning objectives and learner demographics. This broader investigation can contribute to the ongoing evolution of technology integration in education and its impact on pupil learning outcomes such as the acquisition of 21CS.

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APPENDICES

1. Permission to Research Site



THE UNIVERSITY OF ZAMBIA

Telephone:	+260-211-290258/293937	P. O. Box 32379
Fax:	+260-211-290258/293937	Lusaka, Zambia
E-mail	drgs@unza.zm	

13th February, 2023

The Head Teacher
Mwense Secondary School,
P.O Box 760100,
Mwense, Luapula.

Dear Sir/Madam

RE: **REQUEST TO CONDUCT RESEARCH AT MWENSE SECONDARY SCHOOL**

I am writing to request permission to conduct a research study at your school. I am currently enrolled for a PhD in Mathematics Education at the University of Zambia, and I am in the process of writing my thesis. I am conducting a study entitled “*Applicability of MS Excel in Teaching Secondary School Statistics for Learners’ Acquisition of Twenty-first Century Skills*”. Your school has been selected for this study as it is expected to have a projector, computers and internet available for learners.

I hope that you will allow me to recruit grade 11 learners to participate in the study. Interested learners, who volunteer to participate, will be asked to sign a consent form and returned to the researcher at the beginning of the study.

If approval is granted, participants will answer a diagnostic test before being assigned to two groups. The two groups will be taught statistics using two different teaching methods for approximately five weeks, after which they will write a test, complete a questionnaire and attend a group interview discussion. Participation of learners will be anonymous and information gathered will be kept confidential. No costs or risks will be incurred by either the school or learners.

I therefore request permission to conduct my research study at your school. Please know that your approval to conduct this study will be greatly appreciated

Yours sincerely,

Mr. Gift M. Kazika

0974463270

giftkazika70@gmail.com

2. Participant Information Sheet



THE UNIVERSITY OF ZAMBIA
Directorate of Research and Graduate Studies

Telephone: +260-211-290258/293937
Fax: +260-211-290258/293937
E-mail: drgs@unza.zm

P. O. Box 32379
Lusaka, Zambia

Participant Information Sheet

You are invited to participate in a research study which will investigate the applicability of MS Excel in teaching secondary school statistics for learners' acquisition of 21st century skills. The purpose of this study is to investigate whether the application of Excel in teaching statistics can lead to learners' acquisition of 21st Century Skills, namely; communication, information literacy, technology literacy, and statistical literacy (CITS). This study is important because it may help improve teaching and learning of secondary school statistics for the needs of today's society of Information and technology.

The study will involve secondary school learners and in order to participate in the study, you must be in grade 11. Participation in the study will consist of randomly assigning learners to two groups before which you will be asked to answer a diagnostic test. After lessons in statistics which will last for approximately five weeks, you will write a statistics test, answer questionnaire and attend a group interview discussion.

Your decision whether or not to participate in this study is voluntary and will not affect you in anyway. If you choose to participate in this study, you are free to withdraw from the study at any time without any penalty. You will not receive payment for participating in this study. However, participating in this study will be beneficial to you as it will give you an opportunity to learn statistics and/or 21st Century skills. Please know that there are no known or anticipated risks associated with participation in this study. Your participation will be anonymous, and the information you share will kept confidential by using a code number so that your name is not associated with the data.

This study was reviewed and received ethical clearance through Research Ethics Committee of the University of Zambia. If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact:

1. **Principal Investigator:** Mr. Gift M. Kazika, Mobile phone No.: +260 974 463 270 or e-mail; giftkazika70@gmail.com.
2. **Supervisor:** Dr. P. Malambo, Department of Mathematics and Science Education, School of Education, University of Zambia. Mobile phone No.: +260 971 470 711 or e-mail: priestly.malambo@unza.zm.
3. **Chairperson:** Dr. Jason Mwanza, Research Ethics Committee, Humanities and Social Sciences, University of Zambia .P O Box 32379, Lusaka.
4. **Director:** Dr. Henry M. Sichingabula, Directorate of Research and Graduate Studies, University of Zambia. P .O Box 32379, Lusaka.

3. Consent Form (UNZAREC FORM 1b)



**THE UNIVERSITY OF ZAMBIA
DIRECTORATE OF RESEARCH AND GRADUATE STUDIES
HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE**

Telephone: +260-211-290258/293937
Fax: +260-211-290258/293937
E-mail: drgs@unza.zm

P. O. Box 32379
Lusaka, Zambia

CONSENT FORM

TITLE OF RESEARCH: *Applicability of MS Excel in Teaching Secondary School Statistics for Learners' Acquisition of Twenty-first Century Skills.*

REFERENCE TO PARTICIPANT INFORMATION SHEET:

1. Make sure that you read the Information Sheet carefully, or that it has been explained to you to your satisfaction.
2. The group interview discussions will be audio recorded, therefore, your permission is required.
3. Your participation in this research is entirely voluntary, i.e. you do not have to participate if you do not wish to.
4. Refusal to take part will involve no penalty or loss of services to which you are otherwise entitled.
5. If you decide to take part, you are still free to withdraw at any time without penalty or loss of services and without giving a reason for your withdrawal.
6. You may choose not to answer particular questions that are asked in the study. If there is anything that you would prefer not to discuss, please feel free to say so.
7. The information collected in this study will be kept confidential.
8. If you choose to participate in this research study, your signed consent is required below before you can be included in the study.

VOLUNTARY CONSENT

I have read (or have had explained to me) the information about this research as contained in the Participant Information Sheet. I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction.

I now consent voluntarily to be a participant in this study and understand that I have the right to leave the study at any time, and to choose not to answer particular questions that are asked in the study.

My signature below says that I am willing to participate in this study:

Participant's name:

Participant's signature: Consent Date:

Researcher Conducting Informed Consent.....

Signature of Researcher: Date:

Signature of parent/guardian: Date:.....

4. Study Approval

4.1 Research Ethics Committee: UNZA



THE UNIVERSITY OF ZAMBIA DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road Campus | P.O. Box 32379 | Lusaka 10101 | Tel: +260-290 258/291 777
Fax: (+260) 211 290 258/253 952 | Email: director.drugs@unza.zm | Website: www.unza.zm

APPROVAL OF STUDY

IORG No. 0005376

HSSREC IRB No. 00006464

12th July, 2022

REF NO. HSSREC-2022-MAY-019

Gift Muke Kazika
The University of Zambia
School of Education
Department of Science and Mathematics Education
P.O. Box 32379

LUSAKA

Dear Mr. Kazika,

**RE: "APPLICABILITY OF SPSS IN TEACHING SECONDARY SCHOOL STATISTICS
FOR LEARNERS' ACQUISITION OF 21ST CENTURY SKILLS"**

Reference is made to your submission of the protocol captioned above. The HSSREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

REVIEW TYPE	ORDINARY REVIEW	APPROVAL NO. HSSREC-2022-MAY-019
Approval and Expiry Date	Approval Date: 12 th July 2022	Expiry Date: 11 th July, 2023
Protocol Version and Date	Version - Nil.	11 th July, 2023
Information Sheet, Consent Forms and Dates	<input type="checkbox"/> English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	
Number of Participants Approved for Study		

4.2 School Authority

THE UNIVERSITY OF ZAMBIA

Telephone: +260-211-290258/293937
Fax: +260-211-290258/293937
E-mail: dres@unza.zm

P. O. Box 32379
Lusaka, Zambia

13th February, 2023

The Head Teacher
Mwense Secondary School,
P.O Box 760100,
Mwense.



Request
Accepted
You are welcome
HT.

Dear Sir

RE: REQUEST TO CONDUCT RESEARCH AT MWENSE SECONDARY SCHOOL

I am writing to request permission to conduct a research study at your school. I am currently enrolled for a PhD in Mathematics Education at the University of Zambia, and I am in the process of writing my thesis. I am conducting a study entitled "*Applicability of Excel in Teaching Statistics for Learners' Acquisition of Twenty-first Century Skills*". Your school is among the schools that have been selected for this study. It is expected that the school has a projector, computers and internet connection available for learners.

I hope that you will allow me to recruit grade 11 learners to participate in the study. Interested learners, who volunteer to participate, will be asked to sign a consent form and returned to the researcher at the beginning of the study.

If approval is granted, participants will answer a diagnostic test before being assigned to two groups. The two groups will be taught statistics using two different teaching methods for approximately five weeks, after which they will write a test, complete a questionnaire and attend a group interview discussion. Participation of learners will be anonymous and information gathered will be kept confidential. No costs or risks will be incurred by either the school or learners.

I therefore request permission to conduct my research study at your school. Please know that your approval to conduct this study will be greatly appreciated.

Yours sincerely,

Mr. Gift M. Kazika

0974463270

gifikazika70@gmail.com

5. Pilot Study: Revising CITS-Questionnaire

5.1 Results

Communication Skills										Information Literacy										Technology Literacy										Statistical Literacy										
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
1	2	3	1	1	3	1	3	4	2	2	1	2	5	1	1	1	1	2	3	2	4	1	1	2	3	5	1	3	1	3	3	2	1	3	1	2	5			
2	2	3	2	2	2	1	2	5	2	3	1	2	4	3	2	1	2	3	4	2	5	1	2	1	2	3	2	4	1	2	1	4	4	1	1	4	2	3	4	
2	2	3	3	3	1	1	1	4	2	3	1	3	3	3	3	1	3	4	5	2	4	2	3	2	2	1	3	2	2	1	5	5	2	1	5	2	4	3		
2	2	2	1	4	2	2	2	3	2	3	3	2	2	2	4	1	4	5	4	2	3	2	4	3	1	1	2	2	2	1	1	4	4	1	1	4	1	5	2	
2	2	3	3	5	3	2	3	2	2	2	1	2	1	2	5	2	5	4	3	2	2	1	5	4	1	1	3	1	2	1	2	3	3	1	1	3	1	4	1	
2	2	2	2	4	4	1	4	1	1	3	3	2	2	1	4	2	4	3	2	1	1	2	4	5	1	2	4	2	1	2	2	2	2	1	3	2	2	3	2	
1	2	3	4	3	5	2	5	2	1	2	1	2	3	3	3	2	3	2	1	1	2	1	3	4	1	1	5	3	1	2	2	1	1	2	3	1	1	2	3	
2	2	3	5	2	4	2	4	3	1	2	3	2	4	2	2	2	2	1	2	1	3	2	2	3	1	1	4	4	2	1	1	2	2	3	2	2	2	1	4	
2	2	2	1	1	3	1	3	4	2	3	1	2	5	2	1	1	1	2	3	2	4	1	1	2	2	2	3	5	2	1	1	3	3	2	1	3	2	2	5	
2	1	3	2	2	2	1	2	5	3	3	1	1	4	2	2	1	2	3	4	1	5	1	2	1	2	2	4	2	1	1	4	4	3	2	4	2	3	4		
1	2	2	3	3	1	1	1	4	2	3	1	2	3	2	3	1	3	4	5	2	4	2	3	2	2	1	1	3	2	1	1	5	5	1	1	5	2	4	3	
2	1	3	1	4	2	1	2	3	1	3	3	1	2	2	4	2	4	5	4	2	3	2	4	3	1	1	2	2	2	2	2	4	4	1	2	4	1	5	2	
1	1	2	5	5	3	2	3	2	1	3	3	1	1	2	5	2	5	4	3	1	2	1	5	4	1	2	3	1	1	1	2	3	3	2	2	3	1	4	1	
2	1	3	1	4	4	1	4	1	2	2	1	1	2	1	4	2	4	3	2	2	1	2	4	5	1	2	4	2	1	2	3	2	2	2	2	2	1	3	2	
1	1	2	2	3	5	2	5	2	2	3	1	2	3	3	3	2	3	2	1	1	2	3	3	4	2	1	5	3	1	3	3	1	1	2	2	1	2	2	3	
2	1	3	3	2	4	1	4	3	2	2	1	2	4	1	2	1	2	1	2	1	3	2	2	3	3	1	4	4	1	2	2	2	2	2	1	2	2	2	1	4
1	1	3	2	1	3	1	3	4	1	3	1	2	5	2	1	1	1	2	3	1	4	2	1	2	2	3	5	1	2	2	3	3	1	1	3	2	2	5		
2	1	3	5	2	2	1	2	5	2	3	3	2	4	2	2	3	2	3	4	2	5	2	2	1	2	1	2	4	2	1	1	4	4	1	3	4	2	3	4	
2	1	3	1	3	1	1	1	4	2	2	1	1	3	2	3	2	4	4	5	2	4	1	3	2	2	1	1	3	2	1	1	5	5	3	2	5	2	4	3	
2	1	3	2	4	2	2	2	3	2	3	1	1	2	1	4	2	5	5	4	2	3	1	4	3	2	2	2	2	1	2	4	4	3	1	4	2	5	2		
2	2	2	3	5	3	2	3	2	2	2	1	1	1	1	5	2	1	3	3	2	2	2	5	4	1	2	3	1	1	1	1	3	3	2	1	3	1	4	1	
2	2	2	4	1	4	2	4	1	1	2	1	2	2	1	4	2	2	2	2	2	1	2	4	5	1	2	4	2	2	2	2	2	2	2	1	2	2	1	3	2
2	2	2	5	2	5	3	5	3	2	2	3	2	3	1	3	1	3	1	1	2	2	2	3	4	2	2	5	3	1	1	2	1	1	1	2	1	2	2	3	

6. Pre-test

6.1 CITS Diagnostic Test

Information and Instructions

- a) This assessment tool comprise of four (4) questions based on Communication, Information Literacy, Technology Literacy, and Statistical Literacy Skills (CITS). The questions will take approximately 15 minutes for you to answer.
- b) Ensure that you write your name and class on the answer sheet. Know that this information is only for academic purpose and will be kept confidential.
- c) Try to answer all the questions. When answering you are expected to use short answers, examples, and to be as brief as possible.

Questions

Code Name: **Gender:**.....**Grade:**

- 1. What can you do when you are not sure about what the teacher is saying or doing during mathematics lesson?
.....
- 2. Apart from the information you receive from classroom, do you have other sources of information you use to learn mathematics? If so, mention three.
.....
- 3. Have you used a computer software before? What did you use it for?
.....
- 4. Briefly explain (with example(s)) how you can apply statistics in real-life.
.....
.....

6.2 Results

Control Group

ID	Score (%)
001	58
002	52
003	59
004	67
005	51
006	51
007	67
008	60
009	49
010	58
011	49
012	49
013	55
014	36
015	38
016	48
017	44
018	56
019	45
020	48
021	48
022	40
023	54
024	70
025	67
026	43
027	51
028	56
029	54
030	48
031	40
032	50

Experimental Group

ID	Score (%)
001	55
002	49
003	57
004	65
005	48
006	48
007	66
008	58
009	71
010	55
011	45
012	55
013	45
014	52
015	43
016	35
017	47
018	40
019	51
020	44
021	44
022	48
023	54
024	33
025	65
026	39
027	31
028	36
029	51
030	41

7. Post-test

7.1 Statistics Achievement Test (SAT)

Instructions:

- Answer all the questions
- Show all your work to avoid loss of marks.

Durations; 2 hours

34 Marks.

1. The table below shows the number of days that 52 learners in a class were absent from school in one school term.

Days absent	0	1	2	3	4	5	6	7	8	9
Frequency	2	3	6	7	6	9	11	6	0	2

- a) Show this information in a cumulative frequency table. [4]
- b) Draw a relative cumulative frequency curve. [4]
2. In a presidential campaign by the new dawn government against Covid-19, a doctor inquired into the number of times 150 people aged 16 and over in Lusaka District had been vaccinated. He obtained the following results: five times, 4 people; three times, 38; twice, 42; never, 12 people; once, 24; four times, 30. What is the mean number of times those people had been vaccinated and what is the standard deviation? [6]
3. What does a small (close to zero) standard deviation mean? [3]
4. The following marks out of 100 were obtained by 60 learners in a Mathematics test.

75	50	52	70	73	81	82	62	63	66
90	58	76	88	90	67	70	57	65	68
59	61	69	71	55	72	72	74	75	84
70	77	74	62	71	68	72	78	78	69
79	64	76	80	75	77	82	79	76	74
78	85	80	81	88	82	80	82	89	86

- a) Construct a frequency table for this data. Group the data in these class intervals; 50 – 54, 55 – 59, and so on. [5]
- b) Use your frequency table in question (a) to construct a cumulative frequency table for this data. [4]
5. A school Head teacher launched a campaign to encourage decent behavior amongst her learners. For positive actions that promoted gender equality, human rights, awareness of the environment and of people with special needs, she awarded certificates for good behavior to

the deserving learners once in a week. During 40 school weeks, she awarded the following numbers of certificates.

Certificates awarded weekly	1-5	6-10	11-15	16-20	21-25	26-30
Number of weeks	12	10	8	5	4	1

Estimate the mean and standard deviation. [8]

Good Luck!!

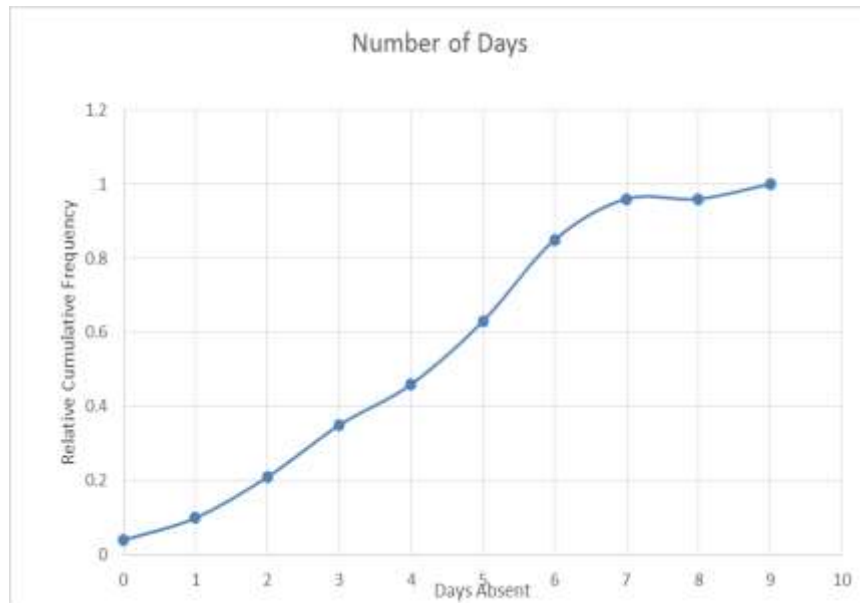
7.2 Marking Key – SAT

1. Solutions

a)

Days Absent	Frequency	Cumulative frequency
0	2	2
1	3	5
2	6	11
3	7	18
4	6	24
5	9	33
6	11	44
7	6	50
8	0	50
9	2	52

b)



2.

Number of Times (x)	Frequency (f)	$x \times f$	$f(x - \bar{x})^2$
0	12	0	69.6972
1	24	24	47.7144
2	42	84	7.0602
3	38	114	13.2278
4	30	120	75.8430
5	4	20	26.8324
Σ	150	362	240.375

a) Mean = 2.41

b) Standard Deviation = 1.27

3. A small (close to zero) standard deviation mean that the values in the data set are close to the mean.
4. Solutions

a)

Marks	Tally	frequency
50 - 54	II	2
55 - 59	IIII	4
60 - 64	HHH	5
65 - 69	HHH II	7
70 - 74	HHH HHH III	13
75 - 79	HHH HHH II	12
80 - 84	HHH HHH	10
85 - 89	HHH	5
90 - 94	II	2

b)

Marks	frequency	Cumulative frequency
50 - 54	2	2
55 - 59	4	6
60 - 64	5	11
65 - 69	7	18
70 - 74	13	31
75 - 79	12	43
80 - 84	10	53
85 - 89	5	58
90 - 94	2	60

5. Solution

Certificates per week	Number of weeks	Midpoint (x)	$x \times f$	$f(x - \bar{x})^2$
1-5	12	3	36	758.4300
6-10	10	8	80	87.0250
11-15	8	13	104	33.6200
16-20	5	18	90	248.5125
21-25	4	25	100	789.6100
26-30	1	28	28	290.7025
Σ	40		438	2,207.9

Mean = 10.95 and Standard Deviation = 7.4295

8. Results

Control group

ID	Score (%)
001	78
002	68
003	73
004	73
005	81
006	76
007	76
008	95
009	68
010	83
011	78
012	81
013	81
014	78
015	95
016	86
017	95
018	95
019	76
020	76
021	91
022	95
023	73
024	91
025	86
026	83
027	86
028	68
029	95
030	78

Experimental Group

ID	Score (%)
001	86
002	95
003	100
004	97
005	86
006	68
007	68
008	73
009	78
010	81
011	81
012	83
013	100
014	91
015	76
016	91
017	76
018	83
019	95
020	81
021	76
022	76
023	100
024	86
025	100
026	73
027	97
028	95
029	78

9. CITS-Questionnaire before revisions

Instructions:

1. For each of the items on the table below, tick [✓] your appropriate choice; strongly Agree, Agree, Not Sure, Disagree or Strongly Disagree.
2. For the Group, enter your group, for instance, **G1** for group 1 or **G2** for group 2.
3. For Gender, enter **M** for male or **F** for female.

Gender

Group

Skills	S/N	Assertion	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
Communication Skills	1.	I am able to effectively communicate statistical concepts and findings.					
	2.	I can present statistical information clearly and coherently using charts and graphs.					
	3.	I can clearly communicate the meaning and implications of statistical concepts and results to others.					
	4.	I can explain the concepts I learnt in statistics clearly.					
	5.	When not clear about what the teacher or classmate says or does during statistics lessons, rather than ask questions, I wait to learn more.					
	6.	I believe statistics terms and words one choses in communicating conveys most of the message about the concepts.					
	7.	I feel comfortable sharing my data analysis results and interpretations with others.					
	8.	I am patient with my classmates who do not express or explain the concepts.					
	9.	When the teacher or classmate brings out concepts/ideas I don't understand , I ask for clarification					
	10.	I believe my communication skills can improve through using a computer in learning statistics					
Information Literacy	1.	I can effectively search for and locate relevant data sources for statistical analysis.					
	2.	I can critically evaluate the credibility and reliability of data sources used.					
	3.	I can select and gather appropriate data for statistical analysis.					
	4.	I can easily find information on the internet.					
	5.	I can effectively integrate and synthesize information from multiple data sources.					
	6.	I make sure the information I use is correct.					
	7.	I can accurately interpret and draw conclusions from statistical results.					
	8.	I get information from reliable sources.					
	9.	I have more than one source of information.					
	10.	I search for more information and read beyond class notes.					

Technology Literacy	1.	I am comfortable using Microsoft Excel to input, manipulate, and analyze data for statistical purposes.					
	2.	I can use the internet to find information.					
	3.	I can effectively use formulas and functions in Microsoft Excel to perform statistical calculations.					
	4.	I can install a computer software.					
	5.	I know how to create graphs and tables with a computer.					
	6.	I feel confident in my ability to create and format tables, charts, and graphs in Excel.					
	7.	I believe Excel helps me organize and present data in a structured and visually appealing manner.					
	8.	I can use computer software to solve statistics problems					
	9.	I can use a projector to present my work in PowerPoint.					
	10.	I believe my technological skills can improve through using Microsoft Excel to learn statistics.					
Statistical Literacy	1.	I can apply statistical concepts to analyze and interpret data accurately.					
	2.	I can effectively interpret and explain the results of statistical analyses.					
	3.	I can present data on a bar chart and histogram.					
	4.	I know the meaning of the terms mean and standard deviation of a data set.					
	5.	I can effectively use Excel's statistical functions to calculate descriptive statistics and measures of central tendency.					
	6.	I can interpret and draw meaningful conclusions from statistical results.					
	7.	I can create/draw cumulative frequency tables.					
	8.	I understand the purpose and significance of different statistical measures and calculations available in Microsoft Excel.					
	9.	I can create/draw frequency cumulative curves (Ogive).					
	10.	I can explain the meaning of quartiles and percentiles.					

10. CITS-Questionnaire after revisions

Instructions:

4. For each of the items on the table below, tick [✓] your appropriate choice; strongly Agree, Agree, Not Sure, Disagree or Strongly Disagree.
5. For the Group, enter your group, for instance, **G1** for group 1 or **G2** for group 2.
6. For Gender, enter **M** for male or **F** for female.

Gender

Group

Skills	S/N	Indicators	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
Communication Skills	1.	I can explain the concepts I learnt in statistics clearly.					
	2.	I believe statistics terms and words one choses in communicating conveys most of the message about the concepts.					
	3.	When the teacher or classmate brings out concepts/ideas I don't understand , I ask for clarification					
Information Literacy	1.	I can easily find information on the internet.					
	2.	I make sure the information I use is correct.					
	3.	I have more than one source of information.					
Technology Literacy	1.	I can use Excel to solve statistics problems.					
	2.	I can install a computer software.					
	3.	I know how to create graphs and tables with a computer.					
	4.	I can use a projector to present my work in PowerPoint.					
Statistical Literacy	1.	I can present data on a bar chart and histogram.					
	2.	I know the meaning of the terms mean and standard deviation of a data set.					
	3.	I can create/draw cumulative frequency tables.					
	4.	I can create/draw frequency cumulative curves (Ogive).					
	5.	I can explain the meaning of quartiles and percentiles.					

11. 21CS Results

Experimental group

1. Coded Responses

	Communication			Information			Technology				Statistical				
	C1	C2	C3	I1	I2	I3	T1	T2	T3	T4	S1	S2	S3	S4	S5
1.	5	4	3	4	4	4	4	5	5	5	4	4	5	3	4
2.	4	5	4	4	4	5	5	5	5	2	3	3	5	4	4
3.	2	4	5	4	5	3	3	4	4	3	4	4	4	4	4
4.	3	4	4	5	4	5	5	5	5	4	4	3	5	4	3
5.	4	5	4	4	5	4	4	5	5	3	4	4	5	3	3
6.	3	5	4	4	4	5	4	4	4	2	4	5	4	4	4
7.	4	3	4	5	3	4	5	4	4	4	5	5	4	5	5
8.	4	4	4	4	4	3	3	5	4	4	4	5	5	4	5
9.	4	4	3	4	4	3	4	4	5	4	5	4	4	5	4
10.	4	5	4	3	4	5	4	4	3	5	5	4	4	3	5
11.	5	5	3	4	3	4	5	4	3	2	5	2	5	3	5
12.	2	3	5	4	4	3	4	4	4	5	3	5	5	3	4
13.	5	5	5	4	4	3	5	5	4	5	3	3	3	4	5
14.	5	2	4	5	4	5	3	5	4	5	3	5	5	4	5
15.	5	4	4	5	3	3	4	5	3	3	4	3	4	5	3
16.	5	5	3	5	3	3	5	4	4	5	5	4	4	4	5
17.	5	3	4	3	5	4	4	3	4	4	5	5	4	4	3
18.	5	4	4	4	5	4	5	4	5	5	4	4	3	3	4
19.	4	3	3	3	3	5	5	4	5	4	4	5	4	3	4
20.	4	5	5	4	4	5	5	5	5	4	4	5	5	3	4
21.	3	5	5	3	5	5	4	4	3	4	4	4	5	4	4
22.	5	4	4	5	5	4	4	4	2	4	5	5	4	4	3
23.	3	3	4	4	4	5	5	5	5	5	4	4	5	3	3
24.	4	5	5	4	4	5	5	5	5	4	4	5	5	3	4
25.	5	4	4	5	3	3	4	5	3	3	4	3	4	5	3
26.	5	5	3	5	3	3	5	4	4	5	5	4	4	4	5
27.	5	3	4	3	5	4	4	3	4	4	5	5	4	4	3
28.	5	4	3	4	4	4	4	5	5	5	4	4	5	3	4
29.	4	5	4	4	4	5	5	5	5	2	3	3	5	4	4

2. Total scores for each skill

	Communication	Information	Technology	Statistical
Participant 01	12	12	19	20
Participant 02	13	13	17	19
Participant 03	11	12	14	20
Participant 04	11	14	19	19
Participant 05	13	13	17	19
Participant 06	12	13	14	21
Participant 07	11	12	17	24
Participant 08	12	11	16	23
Participant 09	11	11	17	22
Participant 10	13	12	16	21
Participant 11	13	11	14	20
Participant 12	10	11	17	20
Participant 13	15	11	19	18
Participant 14	11	14	17	22
Participant 15	13	11	15	19
Participant 16	13	11	18	22
Participant 17	12	12	15	21
Participant 18	13	13	19	18
Participant 19	10	11	18	20
Participant 20	14	13	19	21
Participant 21	13	13	15	21
Participant 22	13	14	14	21
Participant 23	10	13	20	19
Participant 24	14	13	19	21
Participant 25	13	11	15	19
Participant 26	13	11	18	22
Participant 27	12	12	15	21
Participant 28	12	12	19	20
Participant 29	13	13	17	19

3. Total scores across the skills

	Score	%
Participant 1	63	83.979
Participant 2	62	82.646
Participant 3	57	75.981
Participant 4	63	83.979
Participant 5	62	82.646
Participant 6	60	79.98
Participant 7	64	85.312
Participant 8	62	82.646
Participant 9	61	81.313
Participant 10	62	82.646
Participant 11	58	77.314
Participant 12	58	77.314
Participant 13	63	83.979
Participant 14	64	85.312
Participant 15	58	77.314
Participant 16	64	85.312
Participant 17	60	79.98
Participant 18	63	83.979
Participant 19	59	78.647
Participant 20	67	89.311
Participant 21	62	82.646
Participant 22	62	82.646
Participant 23	62	82.646
Participant 24	67	89.311
Participant 25	58	77.314
Participant 26	64	85.312
Participant 27	60	79.98
Participant 28	63	83.979
Participant 29	62	82.646

Control Group

1. Coded Responses

	Communication			Information			Technology				Statistical				
	I1	I2	I3	I1	I2	I3	I1	I2	I3	I4	I1	I2	I3	I4	I5
1.	3	2	1	2	2	2	1	2	3	2	1	2	2	1	3
2.	2	2	1	2	4	2	3	2	1	2	2	2	2	4	2
3.	2	2	1	2	2	2	3	2	1	3	2	1	1	2	3
4.	1	2	1	2	3	2	3	3	2	2	1	2	1	1	2
5.	2	1	4	3	1	1	3	2	1	2	3	1	3	2	4
6.	2	2	3	2	2	2	3	3	1	2	1	2	1	3	1
7.	1	1	2	2	1	2	3	2	2	1	1	4	3	1	3
8.	2	1	1	1	3	2	3	3	1	2	2	2	1	2	1
9.	1	2	2	1	2	2	3	3	3	1	2	2	2	2	2
10.	4	1	2	2	2	2	2	3	3	1	2	2	2	2	1
11.	1	3	1	2	1	2	2	3	3	3	1	2	2	1	4
12.	2	2	3	1	2	2	1	2	4	1	2	1	2	2	3
13.	2	1	2	2	2	3	1	2	1	2	3	3	3	3	2
14.	3	2	1	2	1	2	1	2	1	3	2	2	1	2	1
15.	2	1	1	2	2	2	2	2	3	2	2	2	2	4	2
16.	2	2	2	1	3	2	2	1	1	2	1	2	2	1	1
17.	1	1	2	1	2	1	2	1	2	2	2	2	1	2	2
18.	2	2	2	2	3	1	2	2	2	4	1	2	2	2	2
19.	3	1	2	3	2	2	1	2	3	1	4	2	1	4	2
20.	2	2	3	1	2	2	5	1	1	2	1	1	2	2	1
21.	2	1	3	2	2	2	1	2	3	2	3	2	2	2	1
22.	2	2	3	2	1	2	1	2	2	2	1	1	2	3	2
23.	1	3	3	2	1	2	3	3	2	5	2	2	2	4	3
24.	2	2	1	1	2	2	1	2	4	1	2	1	1	3	3
25.	2	1	2	2	2	3	1	2	1	1	3	2	3	1	2
26.	3	2	1	2	1	2	1	2	3	3	2	3	1	2	1
27.	2	1	2	2	2	2	2	2	3	2	2	2	2	1	2
28.	2	2	2	1	3	2	2	1	1	2	1	2	2	1	1
29.	1	3	2	1	2	1	2	1	2	1	1	2	1	2	2
30.	4	2	2	2	3	1	2	2	2	4	1	2	2	3	2

2. Total scores for each skill

	Communication	Information	Technology	Statistical
Participant 01	6	6	8	9
Participant 02	5	8	8	12
Participant 03	5	6	9	9
Participant 04	4	7	10	7
Participant 05	7	5	8	13
Participant 06	7	6	9	8
Participant 07	4	5	8	12
Participant 08	4	6	9	8
Participant 09	5	5	10	10
Participant 10	7	6	9	9
Participant 11	5	5	11	10
Participant 12	7	5	8	10
Participant 13	5	7	6	14
Participant 14	6	5	7	8
Participant 15	4	6	9	12
Participant 16	6	6	6	7
Participant 17	4	4	7	9
Participant 18	6	6	10	9
Participant 19	6	7	7	13
Participant 20	7	5	9	7
Participant 21	6	6	8	10
Participant 22	7	5	7	9
Participant 23	7	5	13	13
Participant 24	5	5	8	10
Participant 25	5	7	5	11
Participant 26	6	5	9	9
Participant 27	5	6	9	9
Participant 28	6	6	6	7
Participant 29	6	4	6	8
Participant 30	8	6	10	10

3. Total scores across the skills

	Aggregate	%
Participant 1	29	38.657
Participant 2	33	43.989
Participant 3	29	38.657
Participant 4	28	37.324
Participant 5	33	43.989
Participant 6	30	39.99
Participant 7	29	38.657
Participant 8	27	35.991
Participant 9	30	39.99
Participant 10	31	41.323
Participant 11	31	41.323
Participant 12	30	39.99
Participant 13	32	42.656
Participant 14	26	34.658
Participant 15	31	41.323
Participant 16	25	33.325
Participant 17	24	31.992
Participant 18	31	41.323
Participant 19	33	43.989
Participant 20	28	37.324
Participant 21	30	39.99
Participant 22	28	37.324
Participant 23	38	50.654
Participant 24	28	37.324
Participant 25	28	37.324
Participant 26	29	38.657
Participant 27	29	38.657
Participant 28	25	33.325
Participant 29	24	31.992
Participant 30	34	45.322

12. Learning Experiences

12.1 Quantitative Results: Questionnaire

Likert-Scale Questionnaire

Dear Participants,

This questionnaire is designed to get information on views and perceptions towards Statistics, particularly your learning experience with Statistics. You have been considered as one of those whose responses is of benefit to this study, so please be honest to provide useful information as much as possible. The information provided is strictly to be used for academic purpose. Your confidentiality is ensured. The findings of the study will help improve Mathematics learning.

Instructions: For each of the items in the table below, tick [✓] the appropriate option; Strongly Disagree=1, Disagree=2, Not Sure=3, Agree=4 or Strongly Agree=5. For the Class, enter your class, for instance, 11 A.

Group

--	--

S/N	Activity	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
1.	I enjoyed learning Statistics.					
2.	Statistics is not a difficult topic.					
3.	Statistics is important in everyday life.					
4.	I easily understood the topic					
5.	Everyone is capable of understanding statistics.					
6.	I can name several ways we can use statistics in real life.					
7.	I can figure out a way to solve real word problems on statistics.					
8.	Statistics is an interesting topic.					
9.	I could rather understand the concept than getting a correct answer.					
10.	Statistics does not scare me at all.					
11.	Statistics is not a confusing topic					

Experimental Group

Participants	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	Aggregate	%
Participant 01	3	4	4	4	5	4	5	5	5	3	4	46	84
Participant 02	4	3	4	4	5	4	5	4	4	4	4	45	81
Participant 03	4	3	3	3	5	4	5	4	4	4	3	42	76
Participant 04	4	3	3	3	4	3	4	4	3	3	3	37	67
Participant 05	4	4	4	3	4	3	3	3	4	3	4	39	71
Participant 06	4	4	3	3	4	4	3	3	3	4	3	38	69
Participant 07	3	4	5	5	4	4	4	3	4	5	4	45	82
Participant 08	3	4	3	3	4	5	5	5	5	4	4	45	82
Participant 09	3	5	3	5	4	5	4	5	5	1	4	44	80
Participant 10	3	5	4	2	4	4	4	4	5	4	5	44	80
Participant 11	4	2	4	4	4	5	4	4	4	4	5	44	80
Participant 12	5	3	4	4	5	4	4	4	5	2	5	45	82
Participant 13	4	3	3	5	5	5	5	4	5	4	4	47	85
Participant 14	5	4	3	5	5	5	5	4	4	4	3	47	85
Participant 15	5	4	5	4	1	4	4	2	4	4	4	41	75
Participant 16	4	4	5	5	5	2	4	3	5	4	5	46	84
Participant 17	4	5	5	4	5	4	4	5	5	5	2	48	87
Participant 18	3	5	5	4	5	4	4	1	4	5	3	43	78
Participant 19	3	5	4	4	4	4	3	5	4	5	4	45	82
Participant 20	1	5	3	1	4	4	5	5	5	4	4	41	75
Participant 21	4	4	4	4	4	4	3	2	3	4	5	41	75
Participant 22	4	4	4	5	4	2	3	5	4	5	5	45	82
Participant 23	3	3	5	4	5	4	4	4	4	4	4	44	80
Participant 24	4	4	4	4	4	4	5	4	4	5	4	46	84
Participant 25	5	4	5	5	5	4	4	3	3	4	1	43	78
Participant 26	5	4	5	4	5	5	5	4	4	4	5	50	91
Participant 27	4	4	4	4	5	3	4	4	4	4	5	45	82
Participant 28	4	5	4	4	4	4	2	5	4	3	1	40	73
Participant 29	4	4	4	4	3	4	5	5	5	4	3	45	82

Control Group

Participants	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	Aggregate	%
Participant 01	1	2	2	3	4	2	1	3	3	2	1	24	44
Participant 02	3	2	2	2	2	2	2	3	3	2	1	24	44
Participant 03	1	1	2	2	2	1	2	2	2	2	1	18	33
Participant 04	2	1	2	3	1	1	2	2	1	1	2	18	33
Participant 05	3	1	2	2	1	2	1	2	4	2	2	22	40
Participant 06	2	2	1	3	1	2	1	1	1	3	2	19	35
Participant 07	3	2	1	2	4	2	1	1	2	2	1	21	38
Participant 08	1	2	1	2	1	3	3	2	1	1	2	19	35
Participant 09	1	3	2	2	3	3	3	3	4	3	2	29	53
Participant 10	4	2	2	1	2	2	3	3	3	4	1	27	49
Participant 11	1	1	3	2	2	3	2	2	2	2	2	22	40
Participant 12	1	4	3	2	1	2	2	2	2	1	1	21	38
Participant 13	5	5	3	1	2	1	2	1	1	1	2	24	44
Participant 14	1	2	3	2	2	1	3	2	1	1	2	20	36
Participant 15	1	2	2	1	1	1	2	2	1	2	4	19	35
Participant 16	3	1	2	1	3	3	3	2	5	2	3	28	51
Participant 17	4	1	2	2	4	2	2	2	4	2	2	27	49
Participant 18	2	2	1	1	2	2	1	1	1	1	2	16	29
Participant 19	1	2	2	1	2	1	1	2	2	1	1	16	29
Participant 20	1	1	1	2	1	1	1	2	2	2	1	15	27
Participant 21	3	1	2	2	5	1	2	1	1	3	4	25	45
Participant 22	4	1	1	2	2	2	3	1	3	2	2	23	42
Participant 23	1	2	2	2	1	1	2	2	1	1	1	16	29
Participant 24	1	2	3	2	1	2	1	2	1	1	2	18	33
Participant 25	2	1	3	3	3	2	2	2	2	2	1	23	42
Participant 26	2	1	2	1	3	2	2	2	2	2	1	20	36
Participant 27	1	2	2	1	1	1	1	3	3	2	2	19	35
Participant 28	2	2	1	2	2	1	2	2	4	2	2	22	40
Participant 29	2	2	1	2	2	3	1	2	1	3	3	22	40
Participant 30	2	5	1	2	1	1	2	3	5	4	3	29	53

13. Qualitative Findings - Interview Guide (Focus group discussion)

Interview Guide

Learning Experiences

1. What did the lessons cover?
2. How can statistics concepts be applied in real-life situations?
3. How was your experience learning statistics with MS Excel?
4. What do you think about Statistics?
5. Are there any drawbacks or challenges you encountered?
6. What did you learn apart from the core statistics concepts?

14. Interview Transcript

Researcher: Good afternoon, everyone. Thank you for joining today's discussion. I would like to know what you learnt, "**What did the lessons cover?**" Let's begin by sharing your thoughts on the topics you have learned in your recent statistics lessons. Who would like to start?

P01: I will begin. In our lessons, we covered how to construct frequency tables. It involved organizing data into classes or intervals and counting the number of observations in each interval.

Researcher: That's a good starting point. Anyone else who wants to add to that or share their thoughts on frequency tables?

P02: Well, we also learned how to draw cumulative and relative cumulative frequency curves. Cumulative frequencies show the running total of data, and relative cumulative frequencies express them as proportions or percentages.

Researcher: Excellent! So, we are discussing some important concepts here. Let us keep the conversation going. What else do you recall from your lessons?

P03: We also learnt about calculating the mean, variance and standard deviation.

Researcher: Precisely. Who can explain how to calculate the mean, variance, and standard deviation for grouped data?

P06: The mean for grouped data is calculated by summing up the products of the midpoints of the intervals and their corresponding frequencies, then dividing by the total frequency.

P02: Variance and standard deviation are calculated based on the mean and frequency distribution, helping us understand the variability in the data.

Researcher: very good! It seems like we have covered a lot in our lessons. Now, before we conclude, does anyone have any additional information or questions regarding these topics?

P01: I would like to know more about when and why we could use these different statistical measures. How do we decide which one to use in a given situation?

Researcher: That's an excellent question, and it touches on the practical application of these concepts. Thank you all for your input today. Your questions and discussions will help us gain an understanding of these statistical concepts and their real-world applications. That was a great question. **How can statistics concepts be applied in real-life situations?**

P02: Well, I think statistics can help us understand things better. Like, if we are trying to find out how many people in our class like mathematics, we could use statistics to figure that out.

Researcher: That is a great example! So, you are saying we can use statistics to collect data and analyse it to understand preferences, like how many people like mathematics. Can anyone else think of another way we might use statistics in real life?

P05: I think we can use statistics to make predictions. For instance, if we are planning a football match and we want to know if it is going to rain, we could look at the weather data from previous days to see the chances of rain on the day of our game.

Researcher: Excellent point! So, statistics can help us make predictions based on patterns and trends in data. Anyone else have an idea?

P04: I think statistics can also help us make decisions. Like, if we are trying to decide which route to take to school, we could look at the number of people using the routes to figure out which route might be faster.

Researcher: That is a very practical example! So, statistics can inform decision-making by providing us with information to weigh our options. Does anyone have anything else to add?

P01: Yes sir! I think statistics can help us understand the world around us better. For example, if we are learning about wild animals, we could use statistics to analyse data on their populations and see how we can help protect them.

Researcher: These are all good examples of how statistics are applied in various fields. It is clear that statistical knowledge is essential for making evidence-based decisions and improving outcomes in numerous real-life situations.

P01: I agree. It is great to see how useful statistics can be across different fields.

Researcher: Thank you all for sharing your information and experiences. This discussion highlights the practical applications of the statistical concepts we have covered in our lessons. Your answers have been important, and I am sure they will help us appreciate the real-world relevance of statistics even more.

Researcher: Now, let's shift our focus a bit. We have covered what you learned in your statistics lessons, but **how was your experience learning statistics with MS Excel? and what do you think about Statistics?**

P03: Learning statistics with MS Excel made the topic much easier for me.

P05: I agree. The activities were interactive and pictures helped me to understand concepts more quickly.

P01: I loved it. I never thought statistics could be interesting, but Excel changed my mind

P04: The internet was a valuable resource as well. It made self-study more accessible.

P02: The lessons were interactive and the immediate feedback kept me engaged and made learning statistics a bit more enjoyable.

P06: I appreciated the flexibility it offered. We could revisit lessons if we missed anything.

P01: I feel Excel made statistics more practical for me by providing real-life examples and practical activities.

Researcher: Yes please, you may say what you wanted to say.

P02: I can now see the connections between statistics concepts and everyday situations, it made the topic more meaningful and applicable.

Researcher: Okay!

P06: I found Excel useful because it allowed me to see how statistics is applied in real-life

P03: The activities and examples made the topic more relevant and applicable.

Researcher: It sounds like the use of technology and software tools really enhanced your learning experience. **Are there any drawbacks or challenges you encountered during these lessons?**

P01: Sometimes the computers didn't work correctly and in some cases power outage could disrupt the lesson.

P05: I agree, electricity was a challenge, and also we didn't have enough computers in class.

P04: True, and not everyone had access to a computer at home, which could be a disadvantage for some pupils.

P03: I also noticed that it required a certain level of knowledge to work with MS Excel, which some pupils never had initially. But the teacher was very helpful.

Researcher: These are valid points. Technology can be a double-edged sword. While it offers many advantages, it can also present challenges.

P02: Despite the challenges, I think I learnt a lot.

P06: Absolutely. I feel more confident using a computer and Excel now.

P05: I think the lessons prepared us for college and work.

Researcher: It's clear that the use of MS Excel played a significant role in your learning experience.

Researcher: We have talked extensively about the statistics concepts you learned and how they were taught. Now, let's know look at what else you gained from these lessons. **What did you learn apart from the core statistics concepts?**

P04: Well, I learnt how to use a computer.

P02: Yes, I now know how to work with Excel and use a Projector.

P05: Apart from statistics, I learnt how to summarize huge amounts of information to find important data.

P01: I think the activities taught me to see reliable sources on the internet and assess information, which has been important not only in statistics but in other subjects as well.

P03: I also feel my interaction with the computer, fellow learners and the teacher improved

P06: Excel helped us to present our results. This has been beneficial not only in discussing or presenting results but in expressing ideas in general.

Researcher: It is fantastic to hear that you gained not only statistical knowledge but also a range of skills. These are skills that are relevant in today's world and in furthering your education.

P02: Absolutely. While learning how to solve statistics problems, I also understood the meaning of statistical results.

P05: Plus, I learned how to summarize, present and interpret data, and I also understood the importance of results in statistics.

Researcher: That's a great point. Thank you all for sharing what you have learned beyond just statistics concepts.

Researcher: Thank you all for sharing what you have learned beyond just statistics concepts.

15. Lesson Observation Schedule

Aspect	Description	Evidence to Look For
Teacher Role		
Facilitation	Teacher acts as a facilitator, guiding discussions and activities, not simply delivering information.	<ul style="list-style-type: none"> ✓ Learners actively participate in discussions and activities. ✓ Teacher uses open-ended questions to encourage critical thinking. ✓ Teacher provides scaffolding and support as needed.
Inquiry-Based Learning	Learners are encouraged to ask questions, explore ideas, and make connections.	<ul style="list-style-type: none"> ✓ Activities are designed to spark curiosity and investigation. ✓ Learners are given opportunities to research and solve problems independently. ✓ Learners collaborate and share their findings with one another.
Assessment	Assessment focuses on understanding learner thinking and progress, not just memorization.	<ul style="list-style-type: none"> ✓ Teacher uses a variety of assessment methods, such as observations, discussions, and learner self-reflection. ✓ Feedback is formative, helping learners improve their learning. ✓ Learners are encouraged to set learning goals and track their progress.
Learner Engagement		
Active Learning	Learners are actively involved in the learning process, not passively receiving information.	<ul style="list-style-type: none"> ✓ Learners are engaged in discussions, asking questions, and participating in activities. ✓ Learners are working collaboratively with others. ✓ Learners are using prior knowledge to build new understanding.
Critical Thinking & Problem Solving	Learners are challenged to think critically, analyze information, and solve problems.	<ul style="list-style-type: none"> ✓ Learners are able to explain their reasoning and justify their answers. ✓ Learners are able to identify and solve problems independently or collaboratively. ✓ Learners are reflecting on their learning and making connections between concepts.
Collaboration & Communication	Learners are working together to learn from each other and share ideas.	<ul style="list-style-type: none"> ✓ Learners are interacting respectfully with one another. ✓ Learners are able to communicate their ideas clearly and concisely. ✓ Learners are building on each other's ideas and working towards a common goal.
Learning Environment		
Resources	A variety of resources are available to support learner learning, beyond just textbooks.	<ul style="list-style-type: none"> ✓ The classroom is filled with books, manipulative, technology, and other learning materials. ✓ Materials are relevant to the topic being studied and allow for different learning styles.
Learner Choice & Ownership	Learners have some degree of choice in their learning activities and projects	<ul style="list-style-type: none"> ✓ Learners are able to choose from different learning options or approaches. ✓ Learners have a sense of ownership over their learning and take responsibility for their progress. ✓ Learners are empowered to explore their own interests within the learning objectives.
Positive & Supportive Atmosphere	The classroom environment is positive, encouraging risk-taking and exploration.	<ul style="list-style-type: none"> ✓ Learners feel safe to ask questions and make mistakes. ✓ Learners are celebrated for their effort and perseverance. ✓ The classroom fosters a sense of community and respect.

16. Worksheet

TOPIC: STATISTICS

SUBTOPIC: Cumulative Frequency Tables

INSTRUCTIONS:

- Attempt all questions.
 - Use MS Excel where applicable.
-

SECTION A: CONSTRUCTING A CUMULATIVE FREQUENCY TABLE (10 Marks)

The following data shows the ages of 54 African presidents for 2022:

77, 68, 64, 61, 34, 54, 89, 62, 65, 38, 63, 79, 59, 76, 68, 80, 76, 54, 72, 63, 57, 78, 42, 50, 80, 56, 59, 56, 46, 48, 67, 39, 66, 63, 59, 63, 81, 62, 80, 65, 61, 63, 58, 67, 70, 71, 62, 62, 56, 64, 78, 60, 80.

Use MS Excel to answer the following questions

1. Organize the data into the class intervals. (3 marks)
2. Create the cumulative frequency table. (3 marks)
3. How many presidents are older than 60? (2 marks)
4. How many presidents are younger than 50? (2 marks)

SECTION B: PLOTTING A CUMULATIVE FREQUENCY CURVE (10 Marks)

Using the cumulative frequency table from Section A:

1. Enter the data into MS Excel and create a cumulative frequency graph (ogive). (4 marks)
2. Label the axes appropriately and add a title to the graph. (2 marks)
3. Describe the trend of the cumulative frequency curve. (2 marks)
4. Identify the median age from the graph. (2 marks)

The end

17. Sample Lesson Plan: Control group

MINISTRY OF EDUCATION
MWENSE SECONDARY SCHOOL

NAME OF TEACHER	CLASS	SUBJECT	DEPARTMENT	DATE
Ms M. Chileshe		Mathematics	MATHEMATICS	28/09/23
TIME: 14:30 - 15:40 hours		DURATION: 80 Minutes		
No. OF PUPILS: M: 31 F: 34 TOTAL: 65		ATTENDANCE: M: 14 F: 16 TOTAL: 30		
LEND: M: 17 F: 18 TOTAL: 35				
TOPIC: STATISTICS				
SUB-TOPIC: CUMULATIVE FREQUENCY TABLE				
T/L AIDS: Board Book				
REFERENCES: Progress in Mathematics II Pg 163-164, ZSS Mathematics II Pg. 208 Mathematics II				
RATIONALE: Learners will learn how to construct cumulative frequency tables. This lesson will develop the learners knowledge about the cumulative frequency tables. Class discussion and pair work method shall be used. This is lesson 1 out of 4 lessons on Statistics.				
PRE-REQUISITE KNOWLEDGE: Learners already know how to construct tables and finding the sum of two numbers.				
SPECIFIC OUTCOME (S)/COMPETENCES				
(i) Learners to construct Cumulative Frequency tables using grouped and ungrouped data set.				

TIME/PHASE	TEACHER ACTIVITY	PUPIL'S ACTIVITY	METHOD
10 minutes	Group the learners in 5 pairs and guide them with the question. <u>QUESTION</u> The following are the numbers of people living in each house in a small village. 5, 5, 4, 10, 8, 7, 7, 6, 8, 7, 7, 9, 2, 1, 10, 6, 4, 3, 3. Find the a) mode b) median c) mean	learners to find the pair mode, mean and median in pairs of 5.	pair work

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MINISTRY OF EDUCATION
28 SEP 2023
H.O.D. MATHEMATICS
MWENSE SECONDARY SCHOOL
RT. BOX 74010, MWENSE

Write learners

To copy in their exercise books.

Days	Frequency	Cumulative F
0	2	2
1	3	5 (2+3=5)
2	6	11 (5+6=11)
3	7	18 (11+7=18)
4	6	24 (18+6=24)
5	7	31 (24+7=31)
6	11	42 (31+11=42)
7	6	50 (42+8=50)
8	0	50 (50+0=50)
9	0	50 (50+0=50)

In this example, we used the original data values in the frequency table.

∴ this example is ungrouped data.

Task

The ages of people living at Paradise village are recorded in the frequency table below.

Ages	10	16	11	20	30
Frequency	2	5	1	3	7

Show this information as a cumulative frequency table.

Expected ans:

Age	Frequency	Cumulative F
10	2	2
11	1	2+1=3
16	5	3+5=8
20	3	8+3=11
30	7	11+7=18

Monitor and mark the learners work.

Offer help to learners with difficult ques.

Copy and answer the question

Independent work

DPV110

Examples ungrouped data

1) The table below shows the number of days that the 50 learners in a class were absent from school in one school term.

Days absent	0	1	2	3	4	5	6	7	8	9
Frequency	2	3	6	7	6	7	11	6	0	2

60 Minutes

2) Show this information in a cumulative frequency table.

SOLUTION

Note: Frequency means the number of learners who were absent for a given number of days.

Days A	Frequency	Cumulative Frequency
0	2	2
1	3	$2+3=5$
2	6	$5+6=11$
3	7	$11+7=18$
4	6	$18+6=24$
5	7	$24+7=31$
6	11	$31+11=42$
7	6	$42+6=48$
8	0	$48+0=48$
9	2	$48+2=50$

learners to participate through the formulating or cumulative frequency table

class discussion

Question and Answer

Demonstration

To copy in their exercise books.

Note: in this example, we used the original data values in the frequency table.

∴ this example is under ungrouped data.

SELF EVALUATION:

The lesson was successfully taught.

18. Sample Lesson Plan 1: Experimental group

MINISTRY OF EDUCATION
MWENSE SECONDARY SCHOOL

NAME OF TEACHER	CLASS	SUBJECT	DEPARTMENT	DATE
AKK PHARO	11C	MATHEMATICS	MATHEMATICS	19-03-23

TIME: 14:30hrs DURATION: 80min

No. OF PUPILS: M: 24 F: 28 TOTAL: 62 ATTENDANCE: M: 12 F: 17 TOTAL: 29

LEND: M: 22 F: 11 TOTAL: 33

TOPIC: Measures of Dispersion (Statistics)

SUB-TOPIC: Quartiles

T/LAIDS: MS Excel, computers, projector, black board, chalk

REFERENCES: Progress in Mathematics Grade 11, MS Excel Manual & MS Excel tutorial

RATIONALE: Learners will learn about the quartile in statistics. They are expected to develop digital skills, problem solving and critical thinking abilities. Group discussion, class discussions, and question and answer. This is the fourth lesson in a series of five lessons.

PRE-REQUISITE KNOWLEDGE: (a) learners understand how to arrange data
(b) learners have basic knowledge of MS Excel.

SPECIFIC OUTCOME(S)/COMPETENCES ^{2. MIB AT}

- (i) calculate the first, second and third quartiles
- (ii) calculate the interquartile range.

TIME/PHASE	TEACHER ACTIVITY	PUPIL'S ACTIVITY	METHOD
Lesson Introduction 10 minutes	Group the learners in 5 groups and give each group a question to discuss on what they know about the median. - Teacher gives an example 4, 8, 12, 16, 20, 25, 28, 32, 36 Median = 20	- To identify different types of numbers - Arrange	Group work

<p>Lesson Development 20 minutes</p>	<p>Define quartiles as follows, - lower quartile as median of the lower half of the data $Q_1 = \frac{1}{4}(n+1)$ - Median as middle value $Q_2 = \frac{3}{4}(n+1)$ - upper quartile as median of the upper half of data $Q_3 = \frac{7}{4}(n+1)$ - Defines interquartile range as $IQR = Q_3 - Q_1$ - Teacher explains the formula for quartile positions</p>	<p>- follow the explanation and take notes - Identify Q_1, Q_2 and Q_3 - Determine IQR - Ask questions for clarity</p>	<p>Question and answer.</p>
<p>Lesson Development 20 minutes</p>	<p>- Demonstrate how to use MS Excel functions to calculate quartiles and IQR. - Shows step by step applications in Excel. - To find the quartiles in Excel write: $=QUANTILE(array, quant)$ where array is cell range of numeric values for which you want the quartile value and quant indicates which value to return. If quant is equal to 1, 2 or 3 then Q_1, Q_2 and Q_3 will be calculated.</p>	<p>- To use the formulae to calculate the quartiles and IQR in Excel</p>	<p>Demonstrate and collaborative learning</p>

<p><u>EXAMPLE</u> 15 minutes</p>	<p>- Teacher to guide learners in entering the data for the age of 2022 African presidents in MS Excel spreadsheet and also explain how to sort data in ascending order.</p> <p>33, 40, 64, 61, 74, 54, 59, 63, 65, 70, 63, 73, 59, 76, 60, 90, 70, 54, 70, 67, 57, 70, 40, 50, 80, 50, 69, 50, 90, 40, 67, 50, 60, 67, 67, 61, 60, 80, 65, 61, 67, 50, 67, 70, 71, 62, 52, 50, 64, 70, 60, 80</p> <p>- using ;</p> <p>(i) = QUANTILE (B2 : B54, 1) → Q₁</p> <p>(ii) = QUANTILE (B2 : B54, 2) → Q₂</p> <p>(iii) = QUANTILE (B2 : B54, 3) → Q₃</p> <p>Q₄ = Q₃ - Q₁ → IQR</p>	<p>- use MS Excel to calculate Q₁, Q₂ & Q₃</p> <p>- use the formulae to calculate Quartile and IQR in Excel</p> <p>- Copy Enter data into Excel and verify correct arrangement</p> <p>- compare results with classmates</p> <p>- work in pairs</p>	<p>Hands-on practice / demonstration / collaborative learning</p>
<p><u>EXERCISE</u> 15 minutes</p>	<p>Assign a new data set and ask learners to compare and enter into excel ;</p> <p><u>TABLE</u></p> <p>For the data set</p> <p>45, 50, 50, 55, 60, 60, 65, 67, 70, 73, 75, 70, 80, 80, 85, 90, 90, 92, 95, 90</p> <p>calculate : (i) Q₁ (ii) Q₂ (iii) Q₃ (iv) IQR</p>	<p>- Enter data into Excel and calculate</p> <p>- take Q₁, Q₂, Q₃ and IQR</p> <p><i>Handwritten notes:</i> IQR = 75 - 60 = 15</p>	<p>Hands-on practice / discussion</p>

SELF EVALUATION:

The lesson was effective in achieving its intended objectives, with minimal challenges and strong evidence of learner engagement and understanding.

19. Sample Lesson Plan 2: Experimental group

MINISTRY OF EDUCATION
MWENSE SECONDARY SCHOOL

NAME OF TEACHER	CLASS	SUBJECT	DEPARTMENT	DATE
MR. FRANKO J	11C	MATHEMATICS	MATHEMATICS	01-07-21

TIME: 14:20 hrs DURATION: 30 min

NO. OF PUPILS: M: 34 F: 21 TOTAL: 55 ATTENDANCE: M: 12 F: 17 TOTAL: 29

LEND: M: 22 F: 11 TOTAL: 33

TOPIC: Statistics

SUB-TOPIC: Cumulative Frequency Tables

T/LAIDS: Computers, MS Excel, Projector, Internet, board

REFERENCES: Mathematics Pupils book, Grade 11 progress Mathematics textbook (Page 16-44), MS Excel tutorials, MS Excel Manual

RATIONALE: This lesson introduces learners to cumulative frequency tables, which are useful for analyzing data trends and distributions. Using Excel, learners will gain hands-on experience in organizing data, constructing frequency tables, and visualizing data with relative cumulative frequency curves. This approach enhances their 21st-century skills.

PRE-REQUISITE KNOWLEDGE: Basic knowledge of MS Excel functions and statistical tools to work with frequency tables.

SPECIFIC OUTCOME (S)/COMPETENCES: By the end of the lesson, learners should be able to:

- (i) Construct a frequency table.
- (ii) Generate a cumulative frequency curve table.

TIME/PHASE	TEACHER ACTIVITY	PUPIL'S ACTIVITY	METHS
10 min Introduction	<ul style="list-style-type: none"> Explains that cumulative frequency tables help in analyzing data distributions and trends. Gives an example using a small dataset (5, 7, 10, 12, 15, 10, 7, 5, 10, 9) and explains the concept of cumulative frequency. 	<ul style="list-style-type: none"> Answer questions based on prior knowledge. Take notes on cumulative frequency concepts. 	Question and answer

<p>Lesson Development / 50 min</p>	<p>- Guide learners in entering the following data for the age of African presidents for 2009 into an Excel Spreadsheet: 37, 68, 04, 01, 74, 58, 47, 62, 65, 78, 63, 79, 59, 74, 65, 80, 76, 54, 72, 67, 52, 78, 43, 50, 88, 56, 59, 81, 46, 48, 67, 79, 60, 61, 81, 62, 88, 65, 61, 69, 58, 47, 70, 71, 62, 62, 56, 64, 70, 60, 80</p> <p>- Explain how to sort data in ascending order</p> <p>- Demonstrate how to create class-intervals in Excel, count data points in each interval and how to compute cumulative frequencies.</p> <p>- Display the cumulative frequency table</p>	<p>- Enter the age data into an Excel Spreadsheet.</p> <p>- Verify that the data is correctly ordered</p> <p>- Use Excel to create a table</p> <p>- Calculate the cumulative frequencies</p>	<p>Hands-on practice with teacher supervision</p> <p>Collaborative frequency learning - learners work in pairs</p>
<p>Lesson conclusion / 20 min</p>	<p>- Teacher summarizes the key takeaways:</p> <p><u>CLASSWORK</u></p> <p>1. Using the following dataset, create a cumulative frequency table in MS Excel.</p> <p>Data: 15, 18, 20, 22, 25, 27, 30, 32, 35, 38, 42, 45, 50, 52, 55, 57, 60, 62</p> <p>2. Discuss how cumulative frequency tables can be applied in analyzing the performance of learners in mathematics.</p>	<p>- Copy question</p> <p>- Enter the data into Excel Spreadsheet</p> <p>- Create a table using Excel.</p> <p>- Answer Multi-question</p> <p>01/07/23</p>	<p>Hands-on practice with teacher supervision</p>

SELF EVALUATION

The lesson on cumulative frequency tables was well-structured and Excel helped to clarify concepts. However, some learners struggled with creating class intervals in Excel. Next lesson, to add more practice and group work.

20. Mostly used data for lessons in the experimental group

No.	Country	Region	Name	Gender	Age
01	Algeria	Northern Africa	Abdelmadjid Tebboune	Male	77
02	Angola	Southern Africa	Joao Lourenco	Male	68
03	Benin	Western Africa	Patrice Talon	Male	64
04	Botswana	Southern Africa	Mokgweetsi Masis	Male	61
05	Burkina Faso	Western Africa	Ibrahim Traore	Male	34
06	Burundi	Central Africa	Evaristin	male	54
07	Cameroon	Central Africa	Paul Biya	Male	89
08	Cape Verde	Western Africa	Jose Maria Neves	Male	62
09	Central African Republic	Central Africa	Faustin-Archange Touadera	Male	65
10	Chad	Central Africa	Mahamat Deby	Male	38
11	Comoros	Eastern Africa	Azali Assoumani	Male	63
12	Congo-Brazzaville	Central Africa	Denis Sassou Nguesso	Male	79
13	Congo-Kinshasa (DRC)	Central Africa	Felix Tshisekedi	Male	59
14	Djibouti	Eastern Africa	Ismail Omar Guelleh	Male	76
15	Egypt	Northern Africa	Abdel Fattah El-Sisi	Male	68
16	Equatorial Guinea	Central Africa	Teodoro Mbasogo	Male	80
17	Eritrea	Eastern Africa	Isaias Afwerki	Male	76
18	Eswatini	Southern Africa	Mswati III	Male	54
19	Ethiopia	Eastern Africa	Sahle-Work Zewde	Female	72
20	Gabon	Central Africa	Ali Bongo Ondimba	Male	63
21	Gambia	Western Africa	Adama Barrow	Male	57
22	Ghana	Western Africa	Nana Akufo-Addo	Male	78
23	Guinea	Western Africa	Mamady Doumbouya	Male	42
24	Guinea-Bissau	Western Africa	Umaro Sissoco Embalo	Male	50
25	Ivory Coast	Western Africa	Alassane Ouattara	Male	80
26	Kenya	Eastern Africa	William Ruto	Male	56
27	Lesotho	Southern Africa	Letsie III	Male	59
29	Liberia	Western Africa	George Weah	Male	56
30	Libya	Northern Africa	Mohamed al-Menfi	Male	46
31	Madagascar	Eastern Africa	Andry Rajoelina	Male	48
32	Malawi	Southern Africa	Lazarus Chakwera	Male	67
33	Mali	Western Africa	Assimi Goita	Male	39
34	Mauritania	Northern Africa	Mohamed Ould Ghazouani	Male	66
35	Mauritius	Eastern Africa	Pritvirajsing Roopun	Male	63
36	Morocco	Northern Africa	Mohammed VI	Male	59
37	Mozambique	Southern Africa	Filipe Nyusi	Male	63
38	Nambia	Southern Africa	Hage Geingob	Male	81
39	Niger	Western Africa	Mohamed Bazoum	Male	62
40	Nigeria	Western Africa	Muhammadu Buhari	Male	80
41	Rwanda	Eastern Africa	Paul Kagame	Male	65
42	Senegal	Western Africa	Macky Sall	Male	61
43	Seychelles	Eastern Africa	Wavel Ramkalawan	Male	63
44	Sierra Leone	Western Africa	Julius Maada Bio	Male	58
45	Somalia	Eastern Africa	Hassan Sheikh Mohamud	Male	67
46	South Africa	Southern Africa	Cyril Ramaphosa	Male	70
47	South Sudan	Eastern Africa	Salva Kiir Mayardit	Male	71
48	Sudan	Eastern Africa	Abdel Fattah al-burhan	Male	62
49	Tanzania	Eastern Africa	Samia Suluhu	Female	62
50	Togo	Western Africa	Faure Gnassingbe	Male	56
51	Tunisia	Northern Africa	Kais Saied	Male	64
52	Uganda	Eastern Africa	Yoweri Museveni	Male	78
53	Zambia	Southern Africa	Hakainde Hichilema	Male	60
54	Zimbabwe	Southern Africa	Emmerson Mnangagwa	Male	80

21. Timeline: Research plan

	2021	2022	2023												2024		
	Feb- Dec	Jan - Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Topic selection																	
Proposal Writing																	
Data Collection																	
Data Analysis																	
Preparation of findings																	
Writing thesis																	
Draft of manuscript																	

22. Budget

No.	Item	Quantity	Price	Total price(K)
1.	Printing of Proposal	03	K50.00	K150
2.	Payment for Ethical Clearance	01	K1,500	K1,500
3.	Transport to and from Study Site	01	K500.00	K500
4.	Printing research instruments	02	K2.00	K4.00
5.	Allowances for the assistant researchers	02	K1,000	K2,000
6.	Photocopying performance test	105	K0.50	K52.50
7.	Photocopying Questionnaires	10	K0.50	K5.00
8.	Printing of the thesis (draft)	300 pages	K2	K600
9.	Printing of the thesis (final)	300 pages	K2	K600
10.	Binding of thesis	4	K400	K1,600
	TOTAL:			K7,011.50
	Contingency			K1,000
			GRAND TOTAL:	K8,011.50