

**TEACHERS' USE OF TECHNOLOGY AND ITS CORRELATION TO  
STUDENTS' ACHIEVEMENT ON NATIONAL MATHEMATICS  
EXAMINATIONS IN SECONDARY SCHOOLS IN MAKUENI COUNTY,  
KENYA**

**FRANCIS KATUMO NZOKA  
E83/CE/29056/2015**

**A THESIS SUBMITTED TO THE SCHOOL OF EDUCATION IN PARTIAL  
FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE  
DEGREE OF DOCTOR OF PHILOSOPHY IN CURRICULUM  
DEVELOPMENT, KENYATTA UNIVERSITY**

**MAY, 2023**

**DECLARATION**

I attest that the content of this document is my personal composition and that it has never been submitted to another university for the purpose of conferring a degree. The sources used to supplement this academic work have all been correctly cited. In accordance with anti-plagiarism laws for scholarly writings, graphics, tables, data, photographs, or text that were obtained from sources other than the researcher’s own work, including online content, have been clearly acknowledged and references have been provided.

**Sign.....Date.....**

**FRANCIS KATUMO NZOKA**

**E83/CE/29056/2015**

This thesis has been submitted for appraisal with our approval as university supervisors.

**Sign.....Date.....**

...

**DR. EPHANTUS KAUGI**

Lecturer, Department of Educational Management,  
Policy and Curriculum Studies,  
School of Education, Kenyatta University

**Sign.....Date.....**

**DR. ELIZABETH KATAM**

Lecturer, Department of Educational Management,  
Policy and Curriculum Studies,  
School of Education, Kenyatta University

## **DEDICATION**

To my cherished son, Alvin Muuo, who gave my academic work a new lease on life as I was penning this academic article.

## **ACKNOWLEDGEMENT**

From the beginning of this thesis through its completion, my supervisors, Dr Ephantus Kaugi and Dr Elizabeth Katam, have been a tremendous help. Furthermore, many thanks to the chairman and secretaries from Kenyatta University's School of Education. Thank you to the lecturers and examiners whose comments on the draft improved the final document's quality. Feel appreciated, too, to my mentors and fellow PhD students. Finally, special thanks to the Journal of Educational Research in Developing Areas (JEREDA), for agreeing to publish my research papers, which was a requirement for graduation. God's blessings to everyone.

## TABLE OF CONTENTS

<b>DECLARATION.....</b>	<b>ii</b>
<b>DEDICATION.....</b>	<b>iii</b>
<b>ACKNOWLEDGEMENT.....</b>	<b>iv</b>
<b>TABLE OF CONTENTS .....</b>	<b>v</b>
<b>LIST OF FIGURES .....</b>	<b>x</b>
<b>LIST OF TABLES .....</b>	<b>xi</b>
<b>LIST OF ACRONYMS AND ABBREVIATIONS .....</b>	<b>xiii</b>
<b>ABSTRACT.....</b>	<b>xiv</b>
<b>CHAPTER ONE: INTRODUCTION AND BACKGROUND TO THE STUDY .....</b>	<b>1</b>
1.1 Introduction .....	1
1.2 Background to the Study.....	1
1.3 Statement of the Problem .....	13
1.4 Purpose of the Study .....	14
1.5 Objectives of the Study .....	14
1.6 Research Null Hypotheses .....	15
1.7 Significance of the Study .....	15
1.8 Limitations of the Study.....	16
1.9 Delimitations of the Study.....	16
1.10 Assumptions of the Study .....	17
1.11 Theoretical Framework .....	18
1.12 Conceptual Framework .....	20
1.13 Operational Definition of Terms.....	22
<b>CHAPTER TWO: REVIEW OF RELATED LITERATURE.....</b>	<b>23</b>
2.1 Introduction .....	23
2.2 Teachers’ Content Knowledge in ICT Use and Achievement in Mathematics.....	23
2.3 Teachers’ Pedagogical Knowledge in ICT Use and Achievement in Mathematics .....	26
2.4 Teachers’ Technological Knowledge in ICT Use and Achievement in Mathematics.....	29
2.5 Teachers’ Perceptions on ICT Use and Achievement in Mathematics .....	31

2.6 Summary of the Key Research Gaps.....	34
<b>CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY .....</b>	<b>37</b>
3.1 Introduction .....	37
3.2 Research Design.....	37
3.3 Research Variables .....	39
3.4 Location of the Research.....	39
3.5 Target Demographic.....	40
3.6 Sampling Design .....	40
3.6.1 Sampling Techniques.....	40
3.6.1.2 Principals.....	42
3.6.1.3 Mathematics Teachers.....	42
3.6.1.4 Students .....	43
3.6.2 Sample Size.....	44
3.6.2.1 Secondary School Principals.....	44
3.6.2.2 Mathematics Teachers .....	44
3.6.2.3 Students.....	45
3.7 Instruments for Research.....	46
3.7.1 Interview Schedule for the Principals .....	46
3.7.2 Questionnaire for Mathematics Teachers .....	47
3.7.3 Focus Group Discussions for the Students .....	47
3.8 Pilot Study.....	48
3.9 Validity of the Study Instruments .....	49
3.10 Reliability of the Study Instruments.....	50
3.11 Data Collection Procedures .....	51
3.12 Data Analysis .....	53
3.13 Ethical and Logistical Considerations.....	58
3.13.1 Ethical Considerations .....	58
3.13.2 Logistical Considerations.....	59
<b>CHAPTER FOUR: PRESENTATION OF FINDINGS, INTERPRETATION AND</b>	
<b>DISCUSSION .....</b>	<b>60</b>
4.1 Introduction .....	60

4.2 Return Rates of Instruments .....	62
4.3 General and Demographic Information.....	62
4.3.1 Teachers’ Age and Gender.....	63
4.3.2 Teachers’ Professional Qualifications.....	64
4.3.3 Computer Proficiency Level .....	65
4.3.4 Type of School.....	66
4.3.5 Availability of ICT Complementary Facilities .....	68
4.4 Teachers’ Content Knowledge and ICT Use.....	69
4.4.1 Hypothesis Testing.....	76
4.4.2 Regression Model Summary on Teachers’ Content Knowledge in ICT and Students’ KCSE Achievement in Mathematics .....	78
4.4.3 Regression Standardized Residual .....	80
4.5 Teachers’ Pedagogical Knowledge and ICT Use.....	81
4.5.1 Hypothesis Testing.....	88
4.5.2 Regression Model Summary on Teachers’ Pedagogical Knowledge in ICT and Students’ KCSE Achievement in Mathematics.....	90
4.5.3 Regression Standardized Residual .....	91
4.6 Teachers’ Technological Knowledge and ICT Use.....	92
4.6.1 Hypothesis Testing.....	97
4.6.2 Regression Model Summary on Teachers’ Technological Knowledge in ICT Use and Students’ KCSE Achievement in Mathematics .....	100
4.6.3 Regression Standardized Residual .....	101
4.7 Teachers’ Perceptions and ICT Use .....	102
4.7.1 Hypothesis Testing.....	106
4.7.2 Regression Model Summary on Teachers’ Perception of ICT Use and Students’ KCSE Achievement in Mathematics .....	108
4.7.3 Regression Standardized Residual .....	109
4.7.4 Students’ Performance on Internal Tests in Mathematics.....	110
4.7.5 Multiple Regression Analysis on the Correlation between ICT Use and Students’ KCSE Achievement in Mathematics .....	114

4.7.6 Model Summary on Correlation between ICT Use and Students’ KCSE Achievement in Mathematics.....	114
4.7.7 Regression Analysis of Mathematics Achievement and Teachers’ ICT Use	115
<b>CHAPTER FIVE :SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>118</b>
5.1 Introduction .....	118
5.2 An Overview of the Study’ s Results .....	119
5.2.1 Teachers’ Content Knowledge in ICT Use and Achievement in Mathematics .....	119
5.2.2 Teachers’ Pedagogical Knowledge in ICT Use and Achievement in Mathematics .....	120
5.2.3 Teachers’ Technological Knowledge in ICT Use and Achievement in Mathematics .....	121
5.2.4 Teachers’ Perception of ICT Use and Achievement in Mathematics .....	122
5.3 Conclusions .....	123
5.4 Recommendations .....	124
5.4.1 Teachers’ Content Knowledge in ICT Use and Achievement in Mathematics .....	124
5.4.2 Teachers’ Pedagogical Knowledge in ICT Use and Achievement in Mathematics .....	125
5.4.3 Teachers’ Technological Knowledge in ICT Use and Achievement in Mathematics .....	125
5.4.4 Mathematics Achievement and Teachers’ Perception of ICT Use .....	125
5.5 Research Ideas for Further Studies.....	126
<b>REFERENCES.....</b>	<b>127</b>
<b>APPENDICES.....</b>	<b>138</b>
Appendix I: University Introduction Letter.....	138
Appendix II: Questionnaire for Mathematics Teachers.....	139
Appendix III: Focus Group Discussion Guide for Students .....	145
Appendix IV: Interview Schedule for the Principals .....	146
Appendix V: Questionnaire Validation Tool.....	147

Appendix VI: Krejcie and Morgan (1970) Guide for Sample Sizes .....	152
Appendix VII: Consent Letter For Interview .....	153
Appendix VIII: Student Consent Letter .....	154
Appendix IX: University Research Authorization .....	155
Appendix X: Research License from NACOSTI.....	156
Appendix XI: Request From TSC To Collect Data .....	157
Appendix XII: Research Authorization From County Director .....	158
Appendix XIII: Research Authorization By County Secretary .....	159
Appendix XIV: Research Authorization By County Commissioner .....	160
Appendix XV: Map of the Study Locale .....	161

**LIST OF FIGURES**

Figure 1.1: The Knowledge Components of the TPACK Framework..... 3

Figure 1.2: Conceptual Framework..... 20

Figure 3.1: Design Layout for gathering and analyzing information..... 38

Figure 4.1: Impact of Instructors’ Subject Knowledge in ICT use on Students’ KCSE  
Achievement in Mathematics ..... 80

Figure 4.2: Impact of Instructors’ ICT Pedagogical Competence on Students’ KCSE  
Achievement in Mathematics ..... 92

Figure 4.3: Impact of Educators’ Technological Knowledge in ICT Use on KCSE  
Achievement in Mathematics ..... 101

Figure 4.4: Impact of Teachers’ Perception of ICT Use on KCSE Achievement in  
Mathematics..... 110

## LIST OF TABLES

Table 1.1:	Candidates’ KCSE Achievement in Mathematics for Years 2015-2019	11
Table 1. 2 :	Randomly Selected Secondary Schools’ KCSE Achievement in Mathematics in Makueni County for years 2015-2019.....	12
Table 3.1:	Measurement Scales .....	39
Table 3.2:	Stratification and Sample of Schools .....	41
Table 3.3:	Target Population and Sample Sizes of Respondents .....	45
Table 3.4:	Data on Individual Items’ Dependability .....	51
Table 3.5:	Reliability Statistics for all Items .....	51
Table 3.6:	Likert Scale Responses and Interpretation .....	53
Table 4.1:	Teachers’ Age and Gender .....	63
Table 4.2:	Professional Credentials of Teachers .....	64
Table 4.3:	Computer Proficiency Level .....	65
Table 4.4:	Type of Institution.....	66
Table 4.5:	Cross-tabulation of School Types and ICT Use Rates.....	67
Table 4.6:	Availability of ICT Complementary Facilities.....	68
Table 4.7:	Teachers’ Content Knowledge in ICT Use .....	71
Table 4.8:	Correlation between Teachers’ Content Knowledge in ICT Use and Students’ KCSE Achievement in Mathematics.....	77
Table: 4.9:	Summary of the Regression Model.....	78
Table 4.10:	Teachers’ Pedagogical Knowledge in ICT Use.....	82
Table 4.11:	Correlation between Teachers’ Pedagogical Knowledge in ICT and Students’ KCSE Achievement in Mathematics.....	88

Table: 4.12:	Summary of the Regression Model.....	90
Table 4.13:	Teachers’ Technological Knowledge in ICT Use .....	93
Table 4.14:	Association between Teachers’ Technological Knowledge in ICT and Students’ KCSE Achievement in Mathematics.....	98
Table: 4.15:	Summary of the Regression Model.....	100
Table 4.16:	Instructors’ Perceptions Towards Use of Technology .....	103
Table 4.17:	Correlation between Instructors’ Perception of ICT Use and Students’ KCSE Achievement in Mathematics.....	107
Table: 4.18:	Summary of the Regression Model.....	108
Table 4.19:	Students’ Achievement in Terms of Mean Score.....	111
Table 4.20:	Mathematics Achievement in Grades .....	111
Table 4.21:	Model Summary .....	115
Table 4.22:	Regression Analysis of Teachers’ Use of Information Communications Technology and Students’ KCSE Achievement in Mathematics.....	116

## **LIST OF ACRONYMS AND ABBREVIATIONS**

<b>GOK</b>	Government of Kenya
<b>ICT</b>	Information and Communications Technology
<b>INSET</b>	In-service Education and Training
<b>KCSE</b>	Kenya Certificate of Secondary Education
<b>KESSP</b>	Kenya Education Sector Support Programme
<b>KNEC</b>	Kenya National Examinations Council
<b>MKT</b>	Mathematical Knowledge for Teaching
<b>MOEST</b>	Ministry of Education, Science and Technology
<b>PCK</b>	Pedagogical Content Knowledge
<b>STEM</b>	Science, Technology, Engineering and Mathematics
<b>TCK</b>	Technological Content Knowledge
<b>TPACK</b>	Technological Pedagogical and Content Knowledge
<b>TPK</b>	Technological Pedagogical Knowledge
<b>TSC</b>	Teachers' Service Commission
<b>USA</b>	United States of America

## ABSTRACT

The Technological, Pedagogical, and Content Knowledge (TPACK) paradigm improves teaching and learning by combining three components: content, pedagogy, and technology, as well as their connection. The study was inspired by a disturbing pattern of poor performance in Mathematics in national examinations among public secondary schools in Makueni County. The study's objectives were to determine the relationship between teachers' content knowledge in ICT use and students' achievement in Mathematics, establish the relationship between teachers' pedagogical knowledge in ICT use and students' accomplishment in Mathematics, assess the relationship between teachers' technological knowledge in ICT use and students' accomplishment in Mathematics, and discover the relationship between teachers' perceptions of ICT use and students' accomplishment in Mathematics. Based on the theoretical framework of Technological Pedagogical Content Knowledge (TPACK), the study used an explanatory mixed methods sequential design. There were 251 principals, 407 Math instructors, and 14,752 form three students in the target group, for a total of 15,410 responders. There were 25 principals, 42 teachers, and 375 students in the study. The study split the schools into three strata: extra-county, county, and sub-county, and then selected pupils from each stratum using simple random sampling. Finally, the population size of each group was used to sample the number of students in each stratum. Interviews, questionnaires, and focus group discussions were used to collect data. The study instruments' validity was improved by expert assessment and piloting. Cronbach's alpha was used to determine the trustworthiness of the devices. To examine quantitative data, the Statistical Package for Social Sciences (SPSS) version 23 was utilized, along with descriptive and inferential statistics. To categorize and analyze qualitative data, thematic analysis was performed. The analyzed data was presented using Pearson correlation tables, histograms, narrations, and verbatim quotes. The findings revealed that for every unit increase in teachers' content knowledge of ICT use, there was an 8.7% decrease in Math achievement, and for every unit increase in teachers' pedagogical knowledge of ICT use, there was a 10.0% decrease in Math accomplishment, and a very high increase of 81.0% in Math achievement for every unit increase in instructors' technological proficiency. According to the study, every unit rise in teachers' opinions of ICT use in teaching Mathematics resulted in a 14.4% fall in attainment. Except for technological knowledge, none of the content knowledge, pedagogical knowledge, or teacher opinions of ICT use were statistically significant at the  $\alpha = .05$  level. The study concluded that the usage of ICT in Mathematics instruction showed a direct relationship with student achievement. According to the study, government and schools should promote teachers' ICT training and use a variety of technologies that allow students to become active participants in a Mathematics session to increase students' achievement in the subject.

## **CHAPTER ONE**

### **INTRODUCTION AND BACKGROUND TO THE STUDY**

#### **1.1 Introduction**

Information on the study's background, problem statement, goal and objectives, research questions, and significance, is provided in this chapter. Assumptions, constraints, delimitations, and operational definitions of terminology are also offered, along with conceptual and theoretical frameworks.

#### **1.2 Background to the Study**

Conventional teaching process is enhanced with the integration of technological devices for communication known as Information and communication technology (ICT) (Bowers & Stephens, 2011). Teachers play a crucial role in implementing ICT into regular classes and preparing students for the digital world, resulting in a flexible and engaging learning setting (Arnseth & Hatlevik, 2012). In order to completely support the instruction of Mathematics, technology adoption is a multi-stage procedure rather than a one-off activity (Young, 2003). Instead of replacing competent teachers, computers and other technology are considered as supplements to them (Roschelle, 2010). The usage of ICT in education is essential because it enables training and education, even when instructors and tutees are geographically separated, in addition to environments other than classrooms.

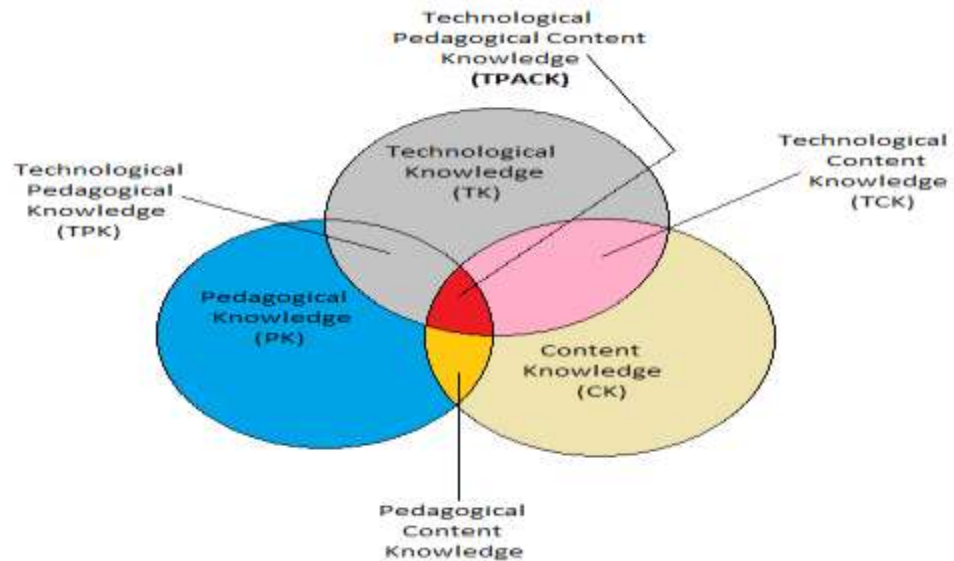
ICT connotes a wide collection of technological appliances and systems, as well as software that are used for communication as well as the generation, transmission, storage and management of information (Hamidi et al., 2011). ICT is utilized in instruction of

specific Mathematics curriculum to effectively and meaningfully employ computers and other resources. The seamless integration of technology to support and improve key competencies such as skills, knowledge, values, and attitudes is known as ICT utilization in instruction (Basic Education Act, 2013).

Technology has become increasingly incorporated into Mathematics instruction over the last two decades. In today's environment, it is widely held that introducing technology into the classroom improves students' academic achievement and attitudes toward learning. Mathematics is a subject with a wealth of technological resources. Dynamic geometry systems, computer algebra systems, graphing calculators, spreadsheets, and web applets are the most prevalent examples. Interactive whiteboards, and tablet PCs are among the unique resources used to facilitate the teaching of Mathematics (Robova, J, 2013). By utilizing these tools, students may work out and see mathematical connectedness more quickly, freeing up more of their mental resources for novel thought, understanding mathematical concepts, and solving more challenging mathematical problems (Li, Q & Ma, X., 2011). Mathematics teachers must be aware of when and how innovation may be utilized to improve students' knowledge acquisition in a correct and effective manner.

In order to achieve success in integrating ICT, it is important to prioritize the pedagogical aspect and provide a clear justification for the specific manner and purpose for which the technology is being used. Allocating learners a collection of websites applications does not constitute ICT use in education. A well-designed ICT integrated lesson combines technology with other essential educational elements including subject matter and methodology to create a cohesive whole. As a result, removing the ICT component from

the ICT-integrated lesson would reduce the lesson's quality (Williams, 2003). This investigation was thus founded on the premise that incorporating ICTs into the instruction and learning of Mathematics would result in performance that differed from arithmetic learning guided solely by a teacher using a blackboard and chalk or a whiteboard and marker pen. Subsequently, the research established whether or not using ICT into Mathematics learning might lead to enhanced achievement in Mathematics, using TPACK model as a guide.



**Figure 1.1: TPACK Frameworks Knowledge Elements**

TPACK was used based on the fact that incorporating all three components can improve the mathematical instruction and learning in secondary schools, depending on how much teachers can use them. Comprehension of subject matter, didactics and hi tech are the models three primary constituents. According to Koehler and Mishra's (2009), to fully leverage the advantages of using ICT, these elements must be in constant and dynamic interaction. The interplay of these three produces TPK, TCK, PCK and TPACK. Subject

matter comprehension involves the instructors knowledge of the topic, which includes ideas, and ideologies, organizational frameworks, comprehension of proof and verification, and established procedures and methods relating to creating such understanding. Multiple investigations have been conducted in various countries to assess impact of integrating content knowledge in Mathematics learning and instruction. Monica and Horacio (2017), for example, assessed the impact of integrating topic knowledge in Mathematics teaching with technology on mathematical abilities and beginning teacher education programs in Santiago, Chile. Instruction of Mathematics using up-to-date technology was found to result in a change in school dynamics, as per the research findings. Furthermore, the research indicated that content knowledge is an essential ability linked to significant mathematical processes. In Turkey, Melike and Fatma (2019) investigated the applicability of TPACK in assessing the degree of instructors mathematical expertise regarding TPACK components. In the field of Mathematics education, lecturing was deemed insufficient for effective learning.

Agyei and Voogt (2012) and Kafyulilo, Fisser, and Voogt (2014) utilized TPACK to train Mathematics and Science pedagogues in Africa who were new to incorporating technology in their classroom instruction. In Ghana, Agyei and Voogt (2012) encountered challenges such as limited access to software and large class sizes, so they introduced spreadsheets as a readily available software tool for Mathematics teachers. Pre-service teachers were taught to create Mathematics lessons with spreadsheets, using an activity-based teaching approach that is appropriate for large classrooms.

To effectively teach, educators must have created a coherent conceptual understanding that encompasses understanding of the topic. Teachers in Kenya gain content knowledge

during their professional training. Failure to possess such a broad basis of expertise about the topic might be excessively expensive; for example, learners may receive inaccurate information and develop misunderstandings about the subject (National Research Council, 2000). Niess (2005) stated that for technology to be effectively integrated into subject learning, educators must demonstrate an in-depth expertise of the topic in question as far as technology is concerned, which is in educational jargon known as known as Technological Content Knowledge (TCK), in addition to knowing how to teach with advanced technologies. The present investigation aimed at determining the association between academic accomplishments of pupils in Makeni County public secondary schools and the subject matter expertise of Math instructors when employing computers.

Pedagogical Knowledge (PK) means teachers' in-depth comprehension of the procedures and methods of learning and instruction. This broad category of knowledge involves awareness of how learners acquire knowledge, general skills for managing a classroom, instructional techniques, and student evaluation. Understanding cognitive, interpersonal, and developmental frameworks of learning, as well as how they relate to pupils in the classroom, are required for pedagogical knowledge (Hardman, 2015). ICTs are widely used in schools in developed countries, and the assumption underlying their use is that they improve student outcomes, particularly in Mathematics. The degree ICTs can attain this is dependent on how computers are used as tools for teaching and learning, that is, how they impact pedagogical approaches (Li & Ma, 2011; Hardman, 2015). Kaffash, Kargiban, and Ramezani (2010) observed in Asian countries that inclusion of ICT in classroom instruction led to prowess of complicated cognitive abilities that could not be

ascertained by simple testing methods. Incorporation of technology during Math instruction enhanced students' attainment of specific abilities to become more analytic in their exam responses.

In Sub-Saharan Africa and Tanzania in particular, several studies indicate that teachers should be proficient in utilizing ICT as a teaching resource in the process of instruction (Nihuka & Voogt, 2011; Bingmlas, 2009). In South Africa, Cassim (2010) argued that ICTs alter pedagogy constructively; and that ICTs can also change pedagogy negatively (Bosamia, 2013). Finally, research suggests that ICTs have a negative impact on pedagogy, which contradicts this finding (Hardman, 2015; Baker, 2019). Software and other instructional interaction agents, according to Kizlikaya and Askar (2008) were useful for facilitating social learning by providing interactive computer simulations that created an engaging instructional setting. When such software was employed in teaching, tutees received prompt feedback and motivation, resulting in better and faster learning, and improved retention when tested, compared to the control group, according to the investigation's results. Tamim et al. (2011) go on to claim that computer technology that aids in classroom learning is far more efficient than technology that provides specialized order, underlining the relevance of ICT pedagogical foundation.

In Kenya, Mbugua, Kibet, Muthaa, and Nkonge (2012) and Shikuku (2012) discovered that decision making is an activity that has to be based on Mathematics instruction, which this investigation expressed through utilization of technology in educational pedagogy. According to Ogwel (2008), using ICT necessitates an overhaul of the curriculum and a transition away from outcome pedagogy. As a result, incorporating ICT into education of

Mathematics was thought to benefit kids by inspiring them to learn, especially when the activities were demanding, multi-disciplinary, and multi-sensory. The use of technology in education not only simplifies abstract concepts but also provides practical applications to real-life situations, encouraging investigation and inquiry among learners. Furthermore, learners can apply the knowledge obtained to solve new problems instead of creating new ones, making it an effective teaching tool (GoK, 2006). Therefore, in this study, teachers' understanding of technological pedagogical knowledge can enhance students' knowledge and acquisition of content hence improving their performance. It was not clear to what extent Mathematics teachers in Makueni County incorporated pedagogical knowledge in their teaching of Mathematics with technology, a gap that was filled through this investigation.

Instructors ought to be technologically savvy in order to employ technology in the lecture halls, which involves using computer literacy effectively and adapting to new developments in information technology, among other things (Thompson & Mishra, 2009). European studies have demonstrated that pupils' Math outcomes may be impacted by how pedagogues incorporate technology in their daily instructional activities (Dalton, Tapper & Hegedus, 2016). Technology, in isolation, however, need not always guarantee that pupils will do better. Instructors' choices about technology usage while teaching helps determine whether students' outcomes are improved or not. Numerous investigations have demonstrated that ICTs contribute to pupils' arithmetic achievement (Chauhan, 2017 Demir & Basol, 2014; Cheung & Slavin, 2013).

According to Oyelekan and Aderogba (2011) in Sub-Saharan Africa, how well technology is utilized in education is an essential aspect of deciding which country will succeed in the future. According to the findings of Tamim et al. (2011) "average pupils attending schools where technology is often used will perform 12 percentile times greater" compared to a pupil in a more conventional teaching, that is, a less technologically advanced classroom. Technology-enriched learning environments empower students by enhancing their ability to see connections between graphic representations and formal definitions. Thus, the applet can be regarded as a cognitive tool because of its ability to enhance Math ideas (Cheng & Leung, 2015).

Finally, teachers' incorporation of technical expertise into classroom instruction should be evaluated for one basic reason; naming the present-day instructors' programs for systemic professional development in education and the classroom can benefit strategically from ICT instruction and studying techniques (Polly, McGee & Martin, 2010). In Tanzania, Ayoub, Petra, Jules, and Joke (2015) sought to blend ICT use in teacher education in order to improve technology pedagogical content understanding. According to the findings of the study, there were substantial modifications in the technologies-related components of TPACK prior to and after the results of the evaluation of pre-service educators' perceived comprehension and capacity to use instructional technology.

In Kenya, Kamau (2014) discovered that secondary school Mathematics teachers lacked technology skills in a study on factors associated with technological adoption. The survey results indicated that inadequate technology training and limited time to finish the

curriculum and create the technologies. The decision of teachers to incorporate technology in their instruction was hampered by integrated lessons. In spite of the ICT policy' s adoption in 2006, the current investigation suggests that it remains only on paper as teachers' proficiency in utilizing ICT as a teaching aid is still insufficient. Consequently, it can be argued that a substantial percentage of Kenyan educational institutions do not employ ICT extensively in their instructional practices. While some ICT use may exist in the study area, little has been done to establish a connection between teachers' ICT use and students' success in Mathematics national examinations, which was the focus of this study.

Another important aspect of using ICTs in the classroom to teach Mathematics is the teacher's perception (Forgasz, 2006). Teachers' perspectives of their technical knowledge, as well as their viewpoints on the helpfulness of ICTs for teaching in a classroom, have been demonstrated to be effective predictors of the intended and actual usage of these technologies in Australia (Stols & Kriek, 2011). Despite the fact that technology has an opportunity to improve learning and instruction in Mathematics (Dawson, Heathcote, & Poole, 2010), the results of student learning in Mathematics are not affected by the use of ICT tools, which are mainly used on low level projects like online practice (Cavanagh & Mitchelmore, 2011). Nurul and Zaleha (2008) also identified the attitudes and beliefs of teacher trainees on the Math TPCK elements. Studies on PCK and use of ICT in education either quantitatively or qualitatively were seen more towards showing that the technology is part of a pedagogical tool in education. However, this knowledge should be generated along with the content and pedagogical knowledge.

In order to better understand how instructors perceive using technology, content, and pedagogy in areas like internet use, a number of TPACK-related scales have been developed (Lee & Tsai, 2010), pre-service training (Schmidt et al., 2009), internet-based distant learning (Archambault & Crippern, 2009), and education in science (Graham et al., 2009). Using ICT for learning Mathematics may change students' perception of the subject, it provides exposure to various exam formats and question types, as well as access to a diverse range of data to address particular learning obstacles. According to Tsai (2012), the importance of comprehending mathematical principles is greater than simply following procedures and obtaining the correct answer. Tsai also proposed that an ICT-supported problem-solving approach in a collaborative learning setting could enhance students' confidence and interest in Mathematics.

Kenya's Ministry of Education in 2005 partnered with different organizations to establish a programme for supporting the Education Sector in Kenya (KESSP), with ICT being one of its primary focus areas. The aim was to achieve policy goals through the adoption and implementation of the Ministry's policy framework, as outlined in the national ICT policy that was approved in 2006. This plan gives an overview of what is necessary for ICTs to be effective as a teaching aid, as well as in bridging the digital divide (MOE, 2006).

Odhiambo (2012) conducted a study that resulted in the creation of 2012' s sessional document No. 12, which outlines the restructuring of Kenya's field of training and education, as well as the role of educational technology. Among core subjects, Mathematics has received the most research attention concerning the correlation between technology use and academic performance. Mathematics education has also had the

longest history of using technology into the classroom, with some amazing systems (Ungerleider & Burns, 2002).

According to various reports, Mathematics is a broad subject at the high school level that may not be sufficiently covered within the approved time frame (KIE, 2005). National examination results at form four level, continue to show poor performance in Mathematics (KNEC, 2020). Achievement in Mathematics nationally shows some variance as compared to that of Makueni County and Table 1.1 shows general achievement in Mathematics for the years 2015-2019.

**Table 1.1: Candidates’ KCSE Achievement in Mathematics for Years 2015-2019**

Year	Paper	Candidature	Maximum Score	Mean Mark	Standard Deviation	Mean Score
2015	1		100	25.53	20.39	
	2	520274	100	28.23	22.81	4.3743
	<b>Overall</b>		<b>200</b>	<b>53.76</b>	<b>40.87</b>	
2016	1		100	23.74	21.24	
	2	570398	100	17.84	21.09	3.3846
	<b>Overall</b>		<b>200</b>	<b>41.58</b>	<b>41.20</b>	
2017	1		100	24.49	22.03	
	2	609525	100	26.46	22.43	4.0590
	<b>Overall</b>		<b>200</b>	<b>50.95</b>	<b>43.46</b>	
2018	1		100	24.07	21.16	
	2	658904	100	28.82	20.85	4.2471
	<b>Overall</b>		<b>200</b>	<b>52.89</b>	<b>41.10</b>	
2019	1	694445	100	31.15	24.04	
	2	694347	100	23.93	20.90	4.4260
	<b>Overall</b>		<b>200</b>	<b>55.08</b>	<b>43.91</b>	

**Source:** KNEC Annual Reports (2015-2019)

National achievement in Mathematics in the years 2015-2019 in Table 1.1 shows major disparity compared to 2015-2019 for eight randomly selected schools in Makueni County in Table 1.2.

**Table 1. 1 : Randomly Selected Secondary Schools’ KCSE Achievement in Mathematics in Makueni County for years 2015-2019**

<b>Schools</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
Makueni Girls	8.0190	6.3771	7.6942	8.0235	7.4561
Ndauni Sec. School	2.7591	2.1034	2.1276	2.8371	2.6094
Mikuyuni Secondary	2.4913	2.5001	2.1927	2.1522	2.5117
Ndolo Boys	3.3962	3.2745	5.4121	4.1934	4.5047
Kyemundu Mixed	3.8312	2.6324	2.4821	3.1803	4.4210
Nthia Secondary	2.9021	1.5275	1.9317	2.3014	2.0760
Yimwaa Secondary	4.2750	2.6312	2.8893	3.4178	3.1909
Nguumo Girls	3.1243	1.8769	2.0123	3.2417	2.4218
<b>Mean Score</b>	<b>3.8498</b>	<b>2.8654</b>	<b>3.3428</b>	<b>3.6685</b>	<b>3.6490</b>

**Source:** Sub-county Director, Ministry of Education, Makueni County

Table 1.2 shows that KCSE Mathematics achievement for the sampled schools in Makueni County ranged from 3.8498 in 2015 to 3.6490 in 2019, that is, less than the national average of 4.3743 in 2015 and 4.4260 in 2019. Similarly, the KCSE combined mean score of 3.4751 for the eight randomly sampled schools across the five years, that is, 2015, 2016, 2017, 2018 and 2019 was lower than that of the combined KCSE mean score of 4.0982 over the same period. To address Kenya's poor performance, technology may be used in the classroom to teach Mathematics and to assist students in grasping ideas and facts that would otherwise be abstract to them. This study looked at teacher use

of ICT in Makueni County to see how it correlated to students' Math achievement on national exams.

### **1.3 Statement of the Problem**

Low achievement in Mathematics among learners in Makueni County's public secondary institutions is a significant source of concern among stakeholders in Kenya's education ministry. It is obvious that teachers' mastery of content, technological, and pedagogical knowledge is critical to effective technology-enhanced teaching. The incorporation of ICT into secondary school teaching can accelerate, enhance, and diversify skills, motivate and engage students in learning for extended periods, facilitate the connection between school and work practices, foster collaborative learning, support multiple forms of interaction, and bolster the teaching process. Despite ICT's crucial role in education, little is understood about the link between ICT utilization and students' performance in Mathematics in national exams.

Mathematics accomplishment nationally shows some variance as compared to that of Makueni County (Table 1.1) for the years 2015-2019. A close analysis of the data on national achievement in Mathematics in the years 2015-2019 shows a major disparity as compared to the period between years 2015-2019 for the eight randomly selected schools in Makueni County (Table 1.2). The Kenyan government launched an initiative to provide ICT resources to schools to improve students' academic achievement. In 2006, the Ministry of Education of Kenya took a step further by launching a national ICT policy in an effort to include ICT into classroom instruction. Additionally, Kenya's government through KICD came up with an ICT curriculum that has been distributed to

schools for implementation. Despite all these efforts intended at boosting academic performance in our public schools, little success has been realized in Mathematics.

#### **1.4 Purpose of the Study**

The study's intent was to examine the correlation between utilization of technology by teachers in Mathematics instruction and pupils' performance in national Mathematics in Makueni County public secondary institutions.

#### **1.5 Objectives of the Study**

- i. Determine correlation linking instructors' content proficiency in ICT use and students' KCSE achievement in Mathematics in Makueni County's public secondary schools.
- ii. Demonstrate correlation linking instructors' pedagogical expertise in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- iii. Assess the association between instructors' technological knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- iv. Find out the correlation between teachers' perception of ICT use and students' KCSE achievement in Mathematics in Makueni County's public secondary schools.

## **1.6 Research Null Hypotheses**

**H<sub>0</sub>1:** There is no statistically significant correlation between teachers' content knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.

**H<sub>0</sub>2:** There is no statistically significant correlation between teachers' pedagogical knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.

**H<sub>0</sub>3:** There is no statistically significant correlation between teachers' pedagogical knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.

**H<sub>0</sub>4:** There is no statistically significant correlation between teachers' perception of ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.

## **1.7 Significance of the Study**

The investigation's significance resides in its capacity to pinpoint effective strategies to raise the standards of Math instruction for both learners and instructors while utilizing ICT. The study's latest revelations could aid in determining the training and development needs of Arithmetic teachers, both current and future educators, which could shape curriculum development and enable educational institutions to offer professional development courses to teachers to help them successfully adapt to the constantly evolving technological and digital landscape. Additionally, policymakers could benefit greatly from the results of the research as science education is critical to Kenya's economic progress, and thus could help in achieving the objectives set forth in Kenya's

Vision 2030 blueprint. Lastly, the study has the ability to spark interest among pedagogues and stimulate further research into utilization of technology as an instructional and teaching aid in order to meet Kenya's Vision 2030 goals.

### **1.8 Limitations of the Study**

- (i) Since sampled schools were spread out geographically, the researcher had to make a lot of travel expenses and this part delayed the timely completion of data.
- (ii) Many educators were uneasy because they believed they were being graded based on their work. Nevertheless, the researcher gave them assurances that their answers would only be utilized for the study's aims and that their identities would remain a secret.
- (iii) Secondary school principals were expected to have busy schedules due to the demands of their jobs, and scheduling all of them for interviews that took between 45 and 60 minutes each person, was anticipated to stall the study's steady advancement.
- (iv) It was predicted that the probability of students exhibiting some symptoms of responder weariness would stall the study's conclusion.

### **1.9 Delimitations of the Study**

- (i) Use of ICT is a broad and hotly debated subject that affects numerous stakeholders in the field. However, this study was restricted to Mathematics instructors.

- (ii) A lot of factors influence students' mathematical achievement. Nonetheless, this study limited itself to the factors specified in the objectives, namely teachers' technology expertise, pedagogical abilities, subject knowledge, and perceptions. The study would also be limited to accomplishment based on KCSE Mathematics mean scores from 2015, 2016, 2017, 2018, and 2019.
- (iii) The research was limited to Makeni County's secondary schools. It will therefore be extremely prudent to exercise extreme caution when extrapolating its conclusions to other counties.

#### **1.10 Assumptions of the Study**

- (i) Kenya's Ministry of Education has enacted educational initiatives and programs that escalate use of technology in schools. As a result, sampled respondents will be able to give data that will aid in the study's objectives.
- (ii) ICT application in Mathematics teaching affects students' achievement in the subject, and that achievement is fairly judged by KCSE scores and grade.
- (iii) Mathematics teachers are well-versed in both content and pedagogy in order to make ICT use a reality.
- (iv) The statistical methods chosen were appropriate for determining correlation between the instructor's utilization of ICT and pupils' accomplishment in Mathematics. The data collection instruments were also adequate for gathering the required data.

### **1.11 Theoretical Framework**

The study's framework was the technical, pedagogical, content knowledge (TPACK) paradigm, which was created by Mishra and Koehler in 2006, and which emphasizes the interaction between subject matter expertise, technological proficiency and instructional practices, served as the studies foundation. The model offers valuable guidance to teachers grappling with challenges in incorporating educational technology in their classes by delineating the roles of CK and PK in technology integration. By highlighting the significance of comprehension of the art of teaching and subject matter in successful utilization of technology in teaching, the model offers useful approach in addressing these challenges. This is crucial because, in order to enhance students' educational experiences, the technology being installed must communicate the material while simultaneously complementing the pedagogy. The TPACK structure is an extensive collection of theories and assessments of how Mathematics Pedagogical Content Knowledge (PCK) evolves. (Hill, Ball & Schilling, 2008). As PCK has become more commonly used in teacher development research, a model based on knowledge for the teaching of Math (MKT) has arisen. (Hill, Blunk, et al., 2008). Most framing of MKT includes little in the way of intermediate and advanced algebra or of proof-based understandings, such as those found in college Mathematics.

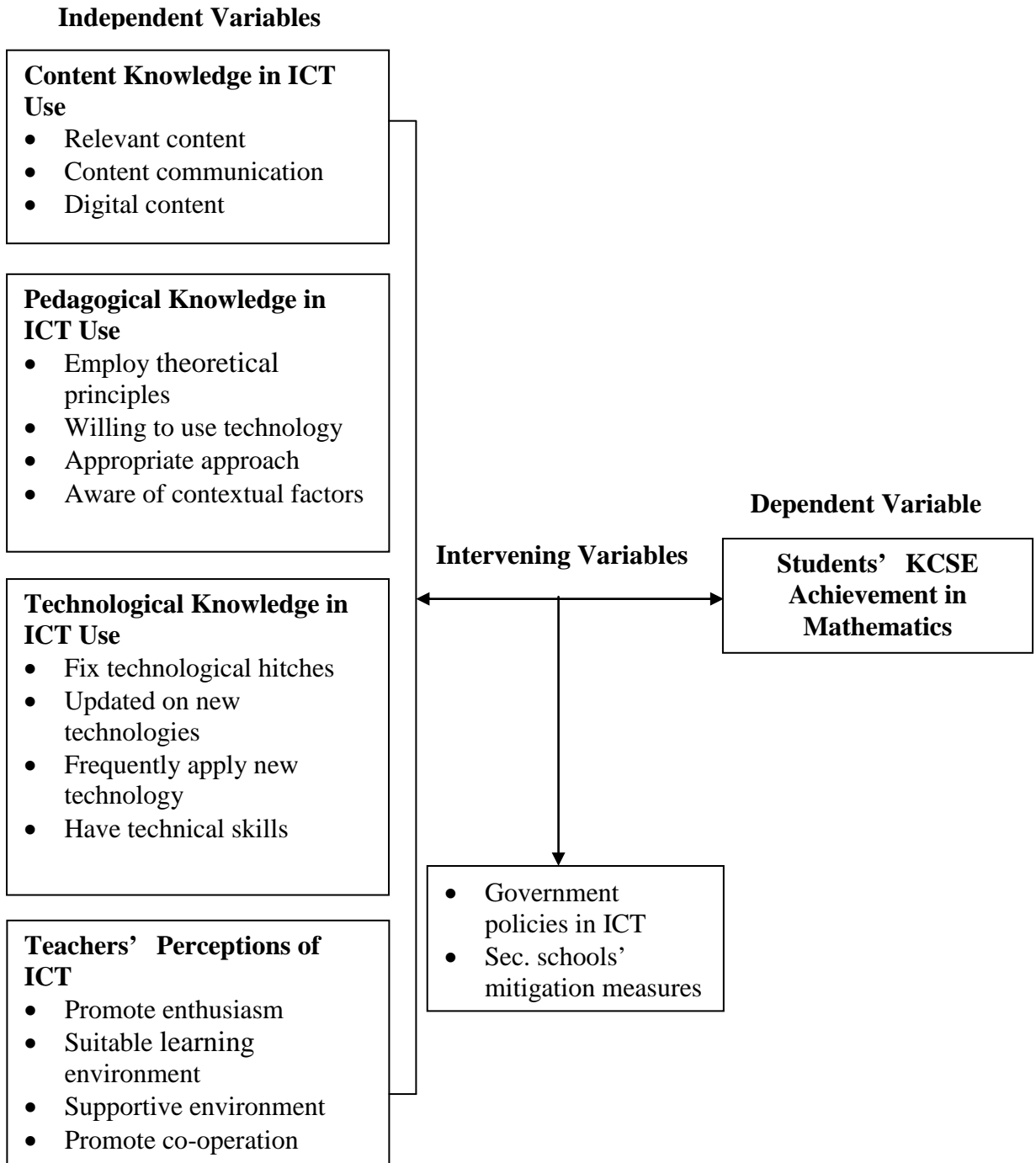
Stefan et al. (2006) employed the TPACK paradigm to conceptualize the art of instruction and information among secondary-level Mathematics teachers. They created tests based on this framework to measure these knowledge categories and administered them to a sample of German Math teachers. Their research intent was to demonstrate whether being equipped with the skill of the art of teaching and subject matter knowledge

could be differentiated and whether arithmetic skill impacts the average knowledge level and the degree of interconnection between the two knowledge categories. Instructors with extensive mathematical training outperformed teachers from other school types on both understanding categories and demonstrated a higher level of cognitive connectedness between the two knowledge categories, according to the findings.

The difference between teachers' understanding of teaching in an area and their area-specific topical expertise, has been broadly accepted by researchers in the setting of this study. The primary notion of PCK, as best expressed in the TPACK framework, is knowledge of how to present and design a topic so that others can grasp it, as well as an understanding about students' subject-specific ideas and misconceptions. Content knowledge, on the other hand, explains a teacher's comprehension of the structures of his subject. Teachers must not only comprehend that something is true, but also why it is true, which implies that the teacher's content knowledge must reflect a deep comprehension of the subject matter that students must master in order to perform well on a test. As a result, understanding proper mathematics-specific teaching techniques is a crucial part of Mathematics pedagogical topic knowledge.

The theory is also applicable to this research in that it invites teachers to demonstrate their understanding of technological knowledge in ICT use on Mathematics teaching and learning, to clarify or certify their knowledge by constructing previously obtained data as part of a new conclusion or functional specifications.

## 1.12 Conceptual Framework



**Figure 1.2: Conceptual Framework**

The conceptual basis was on different variables that affect ICTs used by teachers in teaching Mathematics, that is, technology knowledge which involves teachers having technology for Mathematics, fixing technological problems, being updated on new technologies, frequently apply new technology and have technical skills. Pedagogical knowledge, which includes; employing theoretical principles, willing to experiment, appropriate approach, identifying mathematical problems and being aware of contextual factors. Content knowledge is the other independent variable which includes; relevant content, content communication, student participation and digital content. The other independent variable is ‘ perception’ which include; promotion of enthusiasm, suitable learning environment, supportive environment and promoting co-operation, acquisition of skills. Student achievement in Mathematics in KCSE constituted the dependent variable. The intervening variables included government policies on ICT use and secondary schools’ mitigation measures.

### 1.13 Operational Definition of Terms

- Achievement:** Students' scores in Mathematics on a standardized national examination (KCSE).
- Content Knowledge:** Teachers' understanding of the material to be instructed in Mathematics in secondary schools.
- ICT Use:** Effective as well as meaningful application of software and hardware such as computers in instructing some given content in Mathematics.
- Learning Mathematics:** Secondary school students' acquisition of mathematical ability, capabilities, and behaviours.
- Perception:** Readiness, presumed limitation, and instructors' own reservations of using ICTs in learning and teaching Mathematics.
- Teaching Mathematics:** Procedure by which mathematical knowledge is passed from the teacher to the students.
- Technology:** Usage of electronic devices including mobile phones, computers, projectors and scientific calculators, and software applications.

## **CHAPTER TWO**

### **REVIEW OF RELATED LITERATURE**

#### **2.1 Introduction**

Review of theoretical and empirical work connected to utilization of ICT in the instruction of Mathematics versus achievement as defined by the study objectives is the main focus of this part. It concludes by summarizing the related literature evaluated and highlighting the weaknesses found.

#### **2.2 Teachers' Content Knowledge in ICT Use and Achievement in Mathematics**

To effectively use computers during instruction of some given content there is need to understand how it can transform the topic of instruction. Understanding the benefits and drawbacks of different technologies is necessary for these factoring pedagogical and developmental considerations. Researchers at the North Texas University in year 2012 conducted a study to assess the validity and reliability of the TPACK model as a method for evaluating pedagogues' ability in using computers during instruction. They synthesized results from several studies conducted between 2009 and 2011, using confidence intervals (CIs) to graphically represent mean TPACK estimates for pre-service teachers. Establishing the relationship between instructors' expertise in technical content knowledge, as demonstrated through their use of appropriate instructional methodologies, mathematical concepts, and technologies, was the major focus of the current investigation. The objective of the current investigation was to confirm whether teachers could successfully deliver essential information to students and colleagues using

technology as well as the correlation between these variables and students' achievement in Mathematics.

Monica and Horacio (2017), evaluated the impact of integrating topic knowledge in teaching Mathematics with technology on mathematical abilities and beginning teacher education programs in Santiago, Chile. Using technology into the Mathematics classroom caused a shift in school patterns. They also found that content knowledge appears to be a fundamental skill linked to important mathematical processes.

Giannakos et al. (2015) investigated teachers' confidence in terms of technological content understanding within the setting of K-12 instruction in computers in Greece. Researchers used persona approach to map the profile of a group of 636 instructors who instructs on algorithms and programming in Greece's schools. Giannakos and colleagues discovered that the development of the persona is dependent on instructors' abilities and requirements in three major areas, as defined by the technical, pedagogy, and range of subjects (TPACK). Accordingly, teachers understand that they need additional training on how to utilize instructional technology in addition to how to teach algorithms, both of which are related to PCK and TPACK. The research by Giannakos and colleagues also discovered that teachers achieve relatively low scores on the TPACK sub-scales in Mathematics teaching due to utilization of ICT. This research ascertained teachers' degree of ICT content knowledge and whether it had any relationship with students' achievement in Mathematics by determining the extent to which teachers choose technological tools that combine mathematics culture, technologies, and instruction techniques. The Makueni County study also sought to

determine whether teachers could choose technologies utilization in the classroom that improved what they taught, how they taught, and what students learned.

Peralta and Costa (2007) investigated the relationship between teachers' technological capabilities and self-belief in technology use in the classroom in Italy, Greece, and Portugal. Their study found that teachers in Italy had better trust in using ICT when they had higher technological abilities. In Greece, teachers placed more emphasis on pedagogical and personality characteristics as determinants of their trust in ICT use. In Portugal, creative teachers associated self-belief in ICT usage with a reduction in fear of damaging the computer while having control over it. However, they also emphasized the need for sufficient interaction with ICT, adequate support and training from experienced staff to gain confidence in ICT use. The current study aimed to investigate whether teachers' capabilities and self-belief in technology use could impact students' achievement in Mathematics exams.

Goal of this research was to discover if instructors' levels of content knowledge in ICT had any correlation with pupils' accomplishment in Makueni County secondary schools that were public, by determining whether teachers could utilize variety of tools to assist learners pursue their specific goals, and utilize variety of tools to allow them to become participative in a Mathematics lesson. This research sought to determine if teachers could provide equal availability of online Mathematics learning materials and tools, as well as whether teachers could promote inter-cultural comprehension by engaging students from other cultures through the use of technology. Furthermore, this research sought to ascertain if teachers could take part in virtual learning groups in order to investigate

innovative uses of technologies for improving student learning of Mathematics to establish teachers and their relationship with ICT use on Mathematics achievement.

Several research has shown that the caseloads of teachers affect their affirmation of technology in classroom settings. Neyland (2011) examined a study on variables affecting utilization of virtual courses in Sydney. The study enlisted the help of 26 computer coordinators. In a question and answer session, one coordinator commented that the rising volume of work of teachers was worrisome: "Requesting them to focus on another task on top of an already extremely crowded syllabus and incredibly busy schedule has pushed many educators to their breaking point, and in some cases beyond." The current study attempted to evaluate whether educators' lack of time for implementing ICT into their instruction constituted a barrier, and how this related to students' mathematical achievement. The outcomes of research carried out in Kenya by Ogachi (2015) revealed that teachers' level of knowledge and ICT adaptation methods was directly linked.

### **2.3 Teachers' Pedagogical Knowledge in ICT Use and Achievement in Mathematics**

ICT in terms of TPACK is an insight which results from interplay between content, pedagogy, and technological knowledge. It extends beyond content, pedagogy and technology and thus underscores the significance of skillful classroom instruction with technology, differs from understanding of all three concepts in isolation.

At Michigan State University in the United States, Koehler and Mishra (2009) discussed current issues in innovation and teacher preparation in order to establish technical content

expertise for educators. Koehler and Mishra's paper described a structure for effective teaching of technology use referred as knowledge of TPACK. It has been established that professional learning of TPACK is essential for successful technology instruction. The nature of innovations is discussed, and how incorporating technology into methodology complicates instruction. The current study sought to identify topical issues in advanced technologies and teacher preparation that may affect the application of ICT in instructing Mathematics, as well as to assess the extent to which teacher development of TPACK is significant in training with technology, particularly in the subject of Mathematics.

To successfully use computers in the classroom, ICT services and infrastructure must be available to schools, as stated in Plomp, Anderson, Law, and Quale's (2009) study. Computer accessibility must be possible for ICT to be introduced and used in education effectively. It is unlikely that teachers will use them if there aren't these resources available. Therefore, the presence of updated hardware, software, and computers is essential to ensure effective utilization of computers. In addition, according to research by Yildirim (2007), having access to computers is one of the best methods for instructors to incorporate technology into their lessons. Furthermore, 814 academic staff members of Turkish colleges were polled and most of those surveyed acknowledged to having accessibility to both computers and the internet; 82.5% and 81.2% of academic staff, respectively, were connected to both the internet and computers (Usluel, Askar & Bas, 2008).

Argentin, Comi, Gui, Origo, and Pagan (2015) did a survey to determine the correlation between ICT-related instructional norms and student accomplishment in Italian

secondary schools. Argentin et al. (2015) compared data from test scores on 10th grade student achievement to a unique student-teacher data-set containing a broad range of ICT-related variables on both ICT knowledge and ICT using teaching practices. According to data estimates, ICT-related instructional strategies increased student performance if they assisted the teacher in obtaining additional material for his/her lectures or if they channeled the transmission of teaching material used, and increased students' awareness in ICT. The study by Argentin and colleagues also found a beneficial connection between ICT and information exchange practices. Instead, a hurtful effect was found only for strategies that needed students to become more engaged in class when using ICT. The previous studies had a gap in that the yields on education using ICT were changing and students were gaining novel abilities and skills. This implies that students' achievement should be focused on ICT topics rather than specific topics and curricula.

Hare (2007) investigated the effective and acceptable use of ICTs in developing nations by conducting a survey of Tanzania's usage of computers in the classroom. Although the Tanzanian government had introduced technology in education as early as 2002, the survey indicated that instructors were using ICT in a sparse and ineffective manner. Tanzanian schools' computers were mainly utilized for administrative tasks and occasionally to teach fundamental computer adeptness, rather than as a means of delivering instruction.

In a research conducted in year 2010, Swarts and Wachira argue that teachers' limited adeptness in utilizing computers lead to low utilization of technology. Consequently, the goal of this examination was to pinpoint the adeptness and skills that pedagogues

required so as to successfully employ computers into their teaching, specifically during instruction of Mathematics, at the beginning of their teaching careers. It is crucial to have a comprehensive review that can provide information to support decision-making and the implementation of various initiatives. By investigating the association between various educational innovation strategies and secondary school tutees' academic success, this research sought to close a gap in the literature.

#### **2.4 Teachers' Technological Knowledge in ICT Use and Achievement in Mathematics**

Both knowledge and technology have a long history together. Recognizing the effect of technology on a discipline's procedures and expertise is essential to creating suitable technological resources for educational reasons. Willermark (2017) investigated how the TPCK structure is utilized to demonstrate the importance of teachers' TPACK. Results revealed a range of methodologies for examining teacher TPACK. The current study sought to ascertain whether teachers could critically examine their lessons in regard to theoretical concepts, provide target arithmetical input at an acceptable degree of complexity, and choose authentic arithmetical resources that satisfy the needs of their students.

Academic preparation, age, computer use for educational purposes, gender, level of education, and human perspectives for computers, are just a few of the personal traits that have been emphasized in prior study by (Schiller, 2003). Gender differences in ICT use have been noted in several studies. Research by (Volman & Van Eck, 2001) on gender and usage of ICT versus instructors' gender has revealed that female teachers utilize

computers at very subsidiary rates due to barriers related to access, proficiency and motivation. Compared to instructors who are women, male pedagogues employ more computers during instructional processes according to research by (Kay, 2006; Wozney et al., 2006). To address this issue, and for the purpose of examining how gender affects use of computers in the instruction of arithmetic, the present investigation gathered information on the gender of instructors of Mathematics.

According to earlier investigations, an educator's expertise level may have an impact on how successfully they use computers in the lecture halls. For instance, Gorder (2008) found that technology proficiency levels and the ability to customize training to instructor perceptions of students' needs were connected to efficient utilization of computers, both of which are influenced by teaching experience. However, Baek, Jong, and Kim (2008) argued that educators with more expertise could be less inclined to include ICT into their lessons. The US National Centre for Education Statistics discovered in 2000 that less experienced tutors were more likely than more experienced ones to employ technology into their lessons. Specifically, computer use by educators with less than three years of classroom experience was 48 per cent, compared to tutors with more than twenty years of experience teaching in a classroom, who employed computers for 33 per cent of the lesson time. This gap could be explained by newly hired teachers having more expertise with technology. To ascertain how Math instructors' usage of ICT and their teaching experience relate to one another, and ultimately, its impact on student achievement, was the main goal of the present investigation.

Previous research has shown that teachers' personal growth is crucial for employment of computers in education efficiently. Numerous investigations by (Wozney et al., 2006) and (Hew and Brush, 2007) have demonstrated that training programs involving employment of technology, whether for novice or experienced teachers, improve their computer competencies, influence how they feel about computers, and help them to redesign technology tasks and incorporate new technology tools into student learning (Plair, 2008). Wozney et al. (2006) discovered a link involving good technological training versus successful classroom employment of technology. Growth of one's career and ongoing support were identified as the most significant factors in successful ICT utilization among 400 pre-tertiary teachers. The present study aimed to gather information on teachers' levels of computer training to determine how it influences their ICT use and consequently the Mathematics achievement of their students.

Manduku, Kosgey, and Sang (2006) investigated whether ICT usage varied across day schools and residential institutions. Their findings revealed low ICT uptake in day schools due to insufficient ICT facilities. According to the findings of this study, boarding schools had modern ICT infrastructure and utilized ICT longer than day schools. The current survey sought to corroborate these outcomes and ascertain whether there was any correlation with students' achievement in Mathematics.

## **2.5 Teachers' Perceptions on ICT Use and Achievement in Mathematics**

Incorporation of technology has significantly contributed to the global revolution in education, and the contemporary digital era calls for instructors to be creative in how they use and incorporate technology in their classrooms. However, ICT integration success or

failure in education depends on stakeholders' perspectives, including how instructors view the use of computer in their daily classroom lessons.

An investigation of attitudes of prospective instructors regarding employment of computers in Singapore was done by Teo in 2008. Using a questionnaire that measured four variables, the perspectives of 139 prospective instructors towards computers was evaluated; enthusiasm, perceived value, sense of control, and usage of computers as a behaviour. According to the findings, instructors had favorable opinions of computers and intended to utilize them, though they had less favourable opinions of the control and utility of computers. The current study collected information on instructors' attitudes on ICT use in order to establish how they relate to technology use in teaching and, thus, student accomplishment.

Khokhar and Javaid (2016) in Pakistan, investigated "Student and Teacher Perceptions of ICT Utilization in Pakistani Classrooms". The examination explored students' and instructors' usage of ICT in daily life as well as their perceptions of how pedagogues use ICT for instruction, learning and evaluation. Study involved surveying novices drawn from secondary institutions and high school instructors using a questionnaire. Results revealed instructor and tutee discrepancies and regarding feelings of the appropriate technology to employ in the lecture hall and for what purposes. Study uncovered two opposing viewpoints: teachers believed they used ICT effectively, while students disagreed with their teachers' perspective regarding employment of computers in the lecture halls.

Mahdum et al. (2019) investigation looked into the viewpoints and goals of rural institution instructors on technological use in educational processes. Through a series of questionnaires, the investigation gathered information from 616 high school instructors in Indonesia. Using SPSS software's Cronbach alpha coefficient calculation, the reliability of the questionnaire was evaluated. Findings indicated that teachers were motivated and had a favourable attitude towards using ICT in instructional processes. However, they still encountered challenges related to facilities and technical skills. Although use of ICT in the classroom was welcomed by instructors in Indonesia's rural provinces, Mahdum et al. (2019) suggested that they should also follow the government's expectations regarding ICT-based curriculum.

Melisa (2018) investigated the utilization of ICT in Mathematics instruction and teachers' perspectives toward technology in chosen secondary institutions of Nigeria's Lagos State. 120 high school pedagogues were polled about their opinions about the importance of technology in Mathematics instruction, their desire to employ ICT resources, and how ready they thought they were to incorporate ICT into their teaching practices. The data was examined using descriptive statistics, and the relationship between instructors' perceptions of the value of technology and their desire to use ICT was investigated. Instructors' attitudes towards ICTs were usually favourable in far as Mathematics education was concerned as the investigation outcomes ( $M=3.85$ ,  $SD=0.38$ ), and they also reported being ready to use ICT ( $M=3.62$ ,  $SD=0.40$ ). Findings demonstrated that there was a substantial link ( $r = 0.534$ ) connecting prospective teachers' perceptions versus their willingness to employ ICT in their instructional practices.

Sulungai, Toili, and Amadalo (2014) conducted a study in Kenya to learn more about ICT use in classrooms by Math instructors. Their investigation focused on teachers in the Kakamega South District, and the researchers purposefully chose schools with computers to include in their sample. They ultimately surveyed 147 Mathematics teachers, stratifying the sample by gender and selecting participants randomly within each group. Data were gathered using interview schedules and checklists, and reliability was assessed using the split-half approach. The researchers discovered after reviewing the data that the majority of Math instructors were pro-computer in their teaching and believed that they could improve student learning. However, they also found that the instructor's technical abilities and expertise was the biggest obstacle to efficient ICT utilization.

Furthermore, Ang'ondi (2013) conducted a study in Kenya showed that, while instructors were excited about ICT use, they faced multiple obstacles that prevented them from employing ICTs to their full potential. The instructors highlighted several issues as key impediments to the efficient use of ICTs, including but not limited to inadequate facilities, a lack of knowledge and competency in using ICTs, and their own unfavourable thoughts and views regarding the curriculum. The present study investigated challenges not mentioned from the above studies that are still holding back both teachers and students from fully utilizing ICTs and whether these challenges are similar or unique from previous studies for specificity.

## **2.6 Summary of the Key Research Gaps**

- (i) Majority of studies reviewed were conducted in industrialized countries with well-established ICT infrastructure such as the United States, Pakistan, Italy and Greece.

The present examination sought information on how effectively instructors could communicate with students and co-workers using technology, as well as the relationship between this and student achievement, in the Kenyan context, in order to close this knowledge gap.

- (ii) Previous research has indicated a diverse set of approaches and instruments for assessing teacher TPACK, as well as a scarcity of data on teachers' knowledge and individual ability. Self-reporting is the most common approach for determining an instructor's TPACK model, although performance reviews of instructional activities are uncommon. The current study addressed this gap by gathering data to ascertain the knowledge and professional competency levels required of secondary school teachers to effectively incorporate ICT into their instruction, particularly in Mathematics subject. The present study further demonstrated the need for conducting a thorough assessment that can offer information useful in framing judgments and direct the application of different treatments. The current study fills a gap by examining the correlation between various educational technology interventions and secondary school students' academic achievement in Mathematics.
- (iii) Little documented evidence on the challenges that continue to prevent students and teachers from fully adopting ICTs, and whether these challenges are comparable to or different from those identified in prior studies. These inhibitors are linked to the extent to which teachers can design Mathematics courses around the requirements of the curriculum, awareness of the contextual factors that can inhibit/promote Mathematics teaching, among others. The current research filled the gap by seeking

information on the challenges prohibiting use of ICTs and its correlation to student academic achievement in Mathematics.

- (iv) For past research undertaken in industrialized countries, the data provided in each country should be considered as illustrative rather than complete, since majority of the surveys were not primary data collecting exercises. Second, use of ICT in education in Africa is at a particularly dynamic stage, which means that new innovations and announcements occur on a daily basis somewhere on the continent. The current study filled this void by collecting data from Kenyan Mathematics teachers to establish the extent to which their knowledge of current research in the field of Mathematics teaching, their awareness about emerging technologies, as well as their willingness to experiment with different methods of teaching, correlated to learner achievement in Mathematics.
- (v) Unlike most studies in the literature review, this study established whether use of ICT was academically beneficial in creating appropriate learning settings that appeal to a range of learning styles of students and how this correlated to students' achievement in Mathematics.

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1 Introduction**

An overview of the research design, study setting, target population and sampling strategies, research tools, validity and reliability, data collection methods, statistical data analysis, and ethical considerations are provided in this chapter.

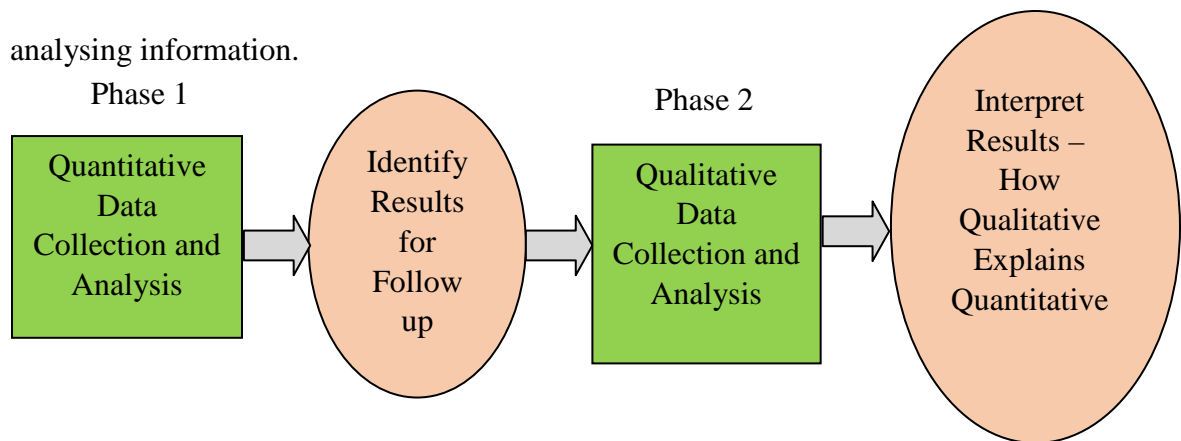
#### **3.2 Research Design**

In order to better comprehend the research problem, the study used an explanatory mixed methods sequential design that entails gathering and evaluating both qualitative and quantitative data inside a single study (Creswell, 2009; Teddlie and Tashakkori, 2003). Furthermore, the investigator intended to supplement the quantitative findings with the qualitative data in order to assess and clarify the conclusions of the quantitative data analysis. Through this approach, a deeper comprehension of the connection linking use of computers and students' Mathematics achievement in Makueni County government sponsored secondary institutions was developed. In addition, the mixed-method strategy allowed using a variety of tools to acquire data, including focus groups, surveys and interview schedules, which are not limited to qualitative or quantitative research methodologies.

The investigation was conducted in two parts: the initial part involved distributing questionnaires to Mathematics instructors and analyzing the quantitative data that resulted. The researcher obtained qualitative data in the second phase through focus groups with students and interviews with principals. In order to gain more understanding

of the quantitative results from the first part, the qualitative data was subsequently analyzed. During design study stage, the investigator blended quantitative and qualitative methodologies by presenting both quantitative and qualitative research questions. The findings from both phases were then incorporated by the researcher during the interpretation and discussion of the overall study's findings.

Figure 3.1 depicts the layout in which the design was employed for gathering and analysing information.



**Figure 3.1: Design' s layout for gathering and analyzing information**

Figure 3.1 depicts the two distinct phases of data gathering using an explanatory sequential model: Quantitative phase (where data were collected from Mathematics teachers using questionnaires) and the Qualitative phase (where data were collected by interviewing principals and FGDs with learners). Data from both strands of research were then validated and contrasted using quantitative and qualitative analysis and integrated results. The result of this convergence made a significant contribution to the study's discourse, inferences, and suggestions.

### 3.3 Research Variables

As illustrated in table 3.1, teachers' expertise in subject topic, pedagogical skills, technology skills, and ICT perceptions among educators served as the study' independent variables, while students' success in Mathematics in national examinations (KCSE) was the dependent variable.

**Table 3.1: Measurement Scales**

<b>Study Parameters</b>	<b>Category</b>	<b>Measurement Scale</b>
Pedagogical Knowledge	Independent Variable	Interval
Content Knowledge	Independent Variable	Interval
Technological Knowledge	Independent Variable	Interval
Teachers' Perceptions	Independent Variable	Interval
Achievement in Mathematics	Dependent Variable	Ordinal

### 3.4 Location of the Research

Makueni County in Kenya lower eastern region served as the study's location. The study location was selected for the following reasons: First, a close analysis of the data on achievement in Mathematics in the years 2015-2019 for the randomly selected schools showed poor, unsteady performance and a decline in mean aggregates in Makueni County (Table 1.1). Secondly, there have been concerted efforts to improve teaching of Mathematics in schools due to the critical role the subject plays in the development of an economy. Numerous technology-related approaches which are learner-centred have been proposed for implementation. Despite the fact that ICT has been acknowledged as a key instrument for enhancing academic performance, there is a dearth of data on the

relationship between instructors' use of ICTs and their impact on students' accomplishment in Mathematics on national exams, notably in Makueni County.

### **3.5 Target Demographic**

A total of 251 secondary educational institutions from Makueni County's six sub-counties was the study's audience in focus. The sub-counties and their corresponding number of schools are namely; (Nzaui 45, Makueni 46, Kibwezi 51, Mukaa 42, Makindu 31 and Mbooni 36), 251 principals, including 14,752 students in form three and 407 instructors of Mathematics, giving 15,410 people who responded to the study. The study's main respondents were school principals, Mathematics teachers, and form 3 students because they were best suited to provide the necessary data.

### **3.6 Sampling Design**

#### **3.6.1 Sampling Techniques**

School administrators, Mathematics instructors and form three students from Makueni County secondary public institutions participated in this study. Several sampling approaches including stratified, purposive, proportional, and simple random sampling, were employed in the investigation across different subgroups of the study population in order to generate a representative sample.

##### **3.6.1.1 Schools**

The sampled schools were chosen using stratified sampling. Schools were chosen at random from extra-county, county and sub-county categories based on their classification. Random sampling with stratification was deemed appropriate because it helps to ensure that the means of the sampled groups are more representative of the

overall population (Fraenkel & Wallen, 2010). The county director of education in Makeni County availed a list of public secondary schools that were categorized as extra-county, county, and sub-county schools in order to choose the sample for this research. For each stratum, the sample size was calculated using the proportionate allocation technique, based on its proportion to the total population (Orodho, 2016). From the total 251 public secondary schools, 25 schools (10% of the total) were chosen in order to ensure full representation. Schools were further stratified by counties and then distributed across the three strata (extra-county, county, and sub-county categories). The number of schools to be chosen from each stratum was afterward determined using Kothari's (2013) proportional allocation technique. Sampling fraction was first calculated as:

$$f = \frac{25}{251} = 0.0996.$$

The sampling fraction was then multiplied by the overall number of

schools for every given stratum. School stratification and samples are displayed in Table 3.2.

**Table 3.2: Stratification and Sample of Schools**

<b>Strata</b>	<b>Sub-population</b>	<b>Strata Sample Sizes</b>
Extra-county Schools	26 × 0.0996	3
County Schools	84 × 0.0996	8
Sub-county Schools	141 × 0.0996	14
<b>TOTAL</b>	<b>251</b>	<b>25</b>

Furthermore, the method of selection included drafting the labels of each school in a narrow category on small paper slips, crumpling them, and stacking them in a basket. Just

after papers were mixed up, the required number of papers was chosen at random. The sample for that category was created by the names of the schools on the randomly picked papers. Through this process, 25 public secondary schools across the three strata were sampled.

### **3.6.1.2 Principals**

The research selected high school principals from the sampled schools through random sampling, as they were deemed to possess specific characteristics that would be useful in achieving the study objectives (Orodho, 2004). The principals were considered important respondents since they were responsible for school administration and curriculum implementation, and would therefore be able to provide valuable data to help establish the relationship linking students' success on national exams and utilization of computers during Mathematics instruction.

### **3.6.1.3 Mathematics Teachers**

The purposive method was utilized to choose 42 Mathematics teachers from the secondary schools sampled. These are the teachers who responded to the Questionnaire on Technology Integration (TIQ). Purposive sampling was done on the basis of the teachers' ages, gender, ICT skills and knowledge, and length of service in their teaching career. These were important factors since they were directly related to the extent Mathematics teachers used ICT in their teaching. The research selected Mathematics teachers from the sampled schools using purposive sampling, as they were deemed to possess specific characteristics that would help achieve the study objectives (Orodho, 2004). Mathematics teachers from all sampled schools made up the study's participant pool, with the number of educators selected from each institution being proportionate to

the total number of Mathematics teachers available. The research selected individual teachers randomly by writing their names on pieces of paper, folding them, and placing them in a box. After that, the papers were jumbled and chosen at random. Mathematics teachers were chosen for two reasons: first, the subject they taught was compulsory and examined at KCSE and secondly, they were thought to be in a good position to provide data for answering research questions about learning environments, content, pedagogy, and technology by incorporating ICT into Mathematics instruction.

#### **3.6.1.4 Students**

The study's sample included form three pupils from each of the identified schools. The form 3 class was chosen because at this level, students had covered more than half of the secondary school curriculum and hence would have the intellectual skills required of focus group discussions. Form one and two classes could not be included in the study since they had not covered substantial part of the curriculum while form four students were revising for KCSE examination.

A straightforward random selection technique was used to choose individual students for the investigation. With this strategy, there is an equal chance that any member of the target audience will be chosen to participate in the sample (Orodho, 2004). It eliminates bias again from selection process and yields representative samples. First, the overall sample size of students was categorized by gender. The group was then proportionately split into boys and girls based on student count. The papers given to each gender were marked ' YES' on one side and ' NO' on the other, and were placed in a box to be picked at random. Participants in the study were recruited from those who selected the

options marked ‘ YES’ . In all of the sampled schools, a similar strategy was used to entice the students in order to contribute in the investigation.

### **3.6.2 Sample Size**

25 secondary school principals, 42 instructors of Mathematics, and 375 form three learners made up the investigation’ s sample size of 442 respondents. A sample of 10 percent was considered appropriate for principals and Mathematics teachers for the research (Gay, 1992). To sample the students, the study was guided by Krejcie & Morgan (1970) (Appendix VI) table.

#### **3.6.2.1 Secondary School Principals**

Out of 251 Makueni County secondary school principals, the investigation chose 25, representing ten percent of the audience in focus. According to Gay (1992), a size of a sample of at least 10% is considered a good representation for large demographics. Due to a number of factors that could make analyzing the entire audience in focus difficult, the researcher opted to focus on a sample. The chosen sample size of 10% was deemed sufficient for this study's objectives. The principals' inclusion was vital as they provided reinforcement and clarification on issues raised by students during FGDs and teachers' responses in the questionnaire.

#### **3.6.2.2 Mathematics Teachers**

42 Mathematics teachers were selected for this study, representing 10% of the 407 instructors of Mathematics in Makueni County. The choice to include these teachers was made because they were responsible for implementing the Mathematics curriculum in real Kenyan classrooms.

### 3.6.2.3 Students

Using Krejcie and Morgan (1970) (Appendix VI) sampling guide table, a total of 375 students out of 14,752 form three students formed the investigation' s sample. From the table, a population (N) of 14,752 corresponds to a sample size (S) of 375. This gives a sampling constant of  $\frac{375}{14752} = 0.02542$ , which when multiplied by 14,752 gives 375 students. To calculate the sample size of pupils from each sub-county, the same sampling constant was employed. Students couldn' t be omitted in this study because they are the consumers of Mathematics content in the actual Kenyan classrooms. A compression of the respondents' sample sizes from the six sub-counties as well as the audience in focus is displayed in Table 3.3

**Table 3.3: Target Population and Sample Sizes of Respondents**

Sub-county	No. of Schools	No. of Principals		No. of Teachers		No. of Students	
		Populatio n	Sample	Populatio n	Sample	Populatio n	Sample
Nzaui	45	45	4	75	8	2657	68
Makueni	46	46	5	78	8	2806	71
Kibwezi	51	51	5	86	9	2907	74
Mukaa	42	42	4	72	7	2352	60
Makindu	31	31	3	40	4	1593	40
Mbooni	36	36	4	56	6	2437	62
<b>Total</b>	<b>251</b>	251	<b>25</b>	407	<b>42</b>	14752	<b>375</b>

Table 3.3, indicates that a total of 442 respondents made up the investigation's sample size, which had a target population of 15,410 respondents. It was anticipated that the conclusions generated from participants' responses would reflect the association between computer use in Mathematics instruction and students' accomplishment in the subject, in accordance with the investigation's aims.

### **3.7 Instruments for Research**

The investigator polled Mathematics instructors with surveys, conducted focus group talks with learners, and interviewed the principals.

#### **3.7.1 Interview Schedule for the Principals**

Interviews enable the exchange of information between a number of individuals about a topic of mutual interest to them, and they are the best tool to use because of their versatility and capacity to interrogate and get the respondents' opinions (Gay, 1996). The researcher conducted 25 interviews with principals from Makueni County's sampled public secondary schools. The interview questions focused on principals' perceptions towards ICT use in teaching of Mathematics, their assessment on teachers' ICT skills and knowledge, their opinions on ICT and students' achievement and the support they gave teachers in using ICT.

Respondents actively took part in the questionnaire and freely provided their opinions, which aided in computing the correlation linking learners' accomplishment in Mathematics and usage of computers in the classroom. The study's findings were added after the evaluation of their responses. The interview subjects were guaranteed anonymity and confidentiality both during the interviews and when the results were reported. The

interviews were held to provide clarification on the survey questionnaires, and quotes from these interviews were used to corroborate quantitative data.

### **3.7.2 Questionnaire for Mathematics Teachers**

Questionnaires were employed to gather data from Mathematics teachers by asking them to respond to variables regarding the application of ICT to the instruction of Mathematics. The questionnaire was deemed ideal because it could gather a substantial amount of information in an acceptable duration of time, anonymity was possible, questions could be standardized so that each respondent was subjected to the same questions, and the questions could be easily analyzed. The study adopted self-assessed development of TPACK developed by Christensen and Knezek (2000) and modified by (Mishra & Koehler, 2006). The first part addressed demographic profile about the teachers, followed by 37 items measuring teachers' self-assessments of the four TPACK domains.

### **3.7.3 Focus Group Discussions for the Students**

FGDs were conducted with students. The researcher created a non-threatening environment so that participants could feel free to talk openly and give their views, opinions and perceptions with regard to the variables that led to the computation of the factors' relationship with one another.

The FGDs had six students in each group as participants. Krueger (1994) opines that a focus group works well with 6 to 8 participants. The researcher however invited 8 participants per group in case some did not show up at the sessions. For each session, the researcher would begin by welcoming participants to the group, after which a form of

consent was given to them to sign to show they had attended and agreed to participate in the study. This would then be followed by setting the ground rules. The researcher asked specific questions listed in the discussion guide and probed responses to questions. Audio recording of each session was done, but upon agreement from all the participants, as a way of documenting the FGD for analysis of the data. The researcher facilitated all of the discussions.

It was decided in advance that the conversations should take place at a mutually convenient time, ideally in the late afternoon following the final lesson at 4 p.m. This was done to prevent disruption of the regular school activities. It was however difficult to conduct the FGDs since they took a lot of time and some students were too exhausted from the day's activities to participate. This obstacle was nevertheless surmounted by commencing the discussions on time and explaining to the students that the study's goal was intended to produce helpful data for improving their mathematical proficiency.

### **3.8 Pilot Study**

To ascertain the language utilized and the precision of research tools, a pilot study is needed (Mugenda and Mugenda, 1999; Baker, 1994). The principals' interview guide, teachers' questionnaire, and student focus group discussion schedule were tested in three secondary public schools located in three sub-counties of Makeni County. Because of their small size and gender, pilot schools represented every type of school except national schools. The actual study did not include the pre-test schools. The pilot study included three principals, three Mathematics teachers, and six students from each school category per discussion group, for a total of 24 respondents.

The piloting had the dual goals of determining whether the items in the data collecting tools were suitable, as well as how the respondents interpreted them in relation to the various school categories. The pre-test also aided in making an accurate time estimate for each tools administration so that actual data collection could be planned accordingly. Some of the items in the data collecting tools had poor wording, which was discovered by the pilot survey, and those items were changed. The pilot study also found that in order to conduct the FGDs and interviews, prior agreements with the respondents and visits to the locations of data collection were required.

### **3.9 Validity of the Study Instruments**

Authenticity of the tools used to gather information was assessed for both content and construct by expert judgment from other researchers who had conducted similar studies to determine the appropriateness of the content, which included vocabulary, grammatical structures, and questions, for all subgroups of intended respondents (Fraenkel & Wallen, 2010). According to content validity, a tools features must be relevant to and reflective of the intended construct in order to serve a certain purpose (Yussof, 2019). Questionnaire items were reviewed by six curriculum experts to decide whether or not they are relevant to the goals of the investigation. Each item was assigned a score by the experts, who also provided written or verbal feedback to increase its relevance to the targeted domains. A 4-point ordinal scale was used to score the relevance of each item, with 1 denoting no relevance and 4 denoting great relevance (Davis, 1992). The Item Content Validity (I-CVI) was computed by dividing the total number of experts by the number of experts who awarded an item a score of 3 or 4, and the result was 0.83 (5 out of 6 raters), which is above the recommended I-CVI threshold of 0.78 for six or more raters (Lynn, 1986).

The irrelevant elements were removed, and some of the remaining components were amended and added to the study instruments. The study ensured that all data gathering methods aligned with the study objectives to maintain validity.

### **3.10 Reliability of the Study Instruments**

A survey tool's consistency in producing results is referred to as its reliability. In this investigation, the internal consistency and dependability of the instructor's questionnaire was evaluated using Cronbach's coefficient alpha, which measures the test's internal consistency by averaging the inter-item correlation (Hardy & Bryman, 2009). This method is commonly employed when a researcher has a scale made up of several Likert questions and wants to determine the dependability of the scale. Since the questionnaire in this study used a 5-point Likert scale with the options “strongly agree” and “strongly disagree”, it satisfied this requirement.

In order to assess the reliability of the questions, SPSS version 23 was used to calculate a Cronbach alpha ranging from ‘zero’ to ‘one’. The survey questionnaire items are more reliable when the coefficient value is higher. According to Gay (1992), a coefficient correlation of 0.7 is considered reliable. Table 3.4 presents a coefficient alpha value of 0.8690, indicating that the survey items had a high degree of internal consistency.

**Table 3.4: Data on Individual Items' Dependability**

<b>Variables</b>	<b>Cronbach's Alpha</b>	<b>Cronbach's Alpha Based on Standardized Items</b>	<b>Number of Items</b>
<b>Content Knowledge</b>	0.910	0.915	9
<b>Pedagogical Knowledge</b>	0.856	0.860	11
<b>Technological Knowledge</b>	0.805	0.806	9
<b>Teachers' Perception</b>	0.925	0.928	5
<b>Total Items</b>	<b>0.8690</b>	<b>0.977</b>	<b>34</b>

Cronbach's alpha coefficient was calculated for each item by the researcher, and the results are displayed in Table 3.5.

**Table 3.5: Reliability Statistics for All Items**

<b>Cronbach's Alpha</b>	<b>Cronbach's Alpha Based on Standardized Items</b>	<b>Number of Items</b>
0.939	0.940	34

Cronbach's coefficient alpha was 0.939, as evidenced by dependability data in Table 3.5, indicating that the aforementioned sample's magnitude had a considerable degree of internal consistency.

### **3.11 Data Collection Procedures**

Three key steps of data collection were used in this investigation:

#### **(i) Pre-field Logistics Phase**

This stage ensured that the research instruments, which included questionnaires, focus group discussion schedules, and interview schedules, were accurate and straightforward.

The researcher obtained an introduction letter from Kenyatta University's graduate school, which he presented to the National Commission for Science, Technology, and Innovation (NACOSTI) in order to obtain a research authorization permit. Following that, the researcher went to the Makueni County Education Office to obtain permission to visit the selected sample schools and collect data.

**(ii) Fieldwork Logistics Phase**

This was the actual data collection stage. The researcher made preliminary site visits and interacted with participants at the schools. First, the researcher informed school principals in advance of the intended study so that they were aware and hence grant permission. The principals of the schools provided distinct and specific dates for data collecting. Respondents' consent was sought during data collection after they were notified on what was anticipated of them and guaranteed of their privacy and anonymity. They were also told that they could choose whether or not to take part in it.

Students to be subjected to the FGDs and principals to be interviewed were informed in advance and the estimated time for each session communicated. Each interview was conducted at the respondents' convenience at their workplace. Before beginning the interviews, the interviewer requested for permission to record the conversation. After one week, questionnaires were collected from the schools that had been sampled. The return rate for the questionnaires distributed to Mathematics teachers was 34 of the 42 targeted sample, or 81 percent.

### (iii) Post-field Logistics Phase

The information gathered in the field was organized, labeled, and transcribed at this stage in preparation for analysis.

### 3.12 Data Analysis

The researcher collected quantitative data first and then qualitative data in two phases. Mathematics teachers were given questionnaires to collect quantitative data, which were analyzed based on the study's goals, using both inferential statistics (such as multiple regression analysis and Pearson correlation) and descriptive statistics (like frequencies, percentages, averages, and standard deviation). The Statistical Package for Social Sciences or SPSS version 23 was employed to quantitatively analyze the data. Histograms and tables of Pearson correlation were used to display the data. On a Likert scale with five response possibilities, Mathematics teachers were asked to rate certain statements that were included in the questionnaire: "Strongly Disagree (1)", "Disagree (2)", "Undecided (3)", "Agree (4)", and "Strongly Agree (5)".

**Table 3.6: Likert Scale Responses and Interpretation**

<b>Mean Range</b>	<b>Weighting</b>	<b>Interpretation</b>	<b>Overall Decision</b>
1.00-1.80	1	Strongly Disagree	Disagreement to a Statement
1.90-2.60	2	Disagree	
2.70-3.40	3	Neutral	
3.50-4.20	4	Agree	Agreement to a Statement
4.30-5.00	5	Strongly Agree	

**Source: Said (2014)**

The researcher assessed the strength of the responses in relation to the range of means presented in Table 3.6. Said (2014) suggests that a score between 3.50 and 5.00 denotes concurrence with a proposition, while a score between 1.00 and 2.60 denotes dissent. Additionally, the survey items' standard deviation was determined. Standard deviation shows how far or close to the average the response values are. If the survey responses are diverse, then a substantial standard deviation is likely (i.e., a heterogeneous sample), with the responses being similar in the case of a small standard deviation (i.e. a homogeneous sample).

In contrast, inferential statistics allowed the investigator to make conclusions regarding the information gathered. Principal interviews and focus group talks with learners in form three from the sampled schools served as the main techniques for gathering data in the second, qualitative phase. Transcribing the audio files, identifying data meanings and patterns, creating codes that represented the meanings and patterns, extracting excerpts, collating codes with supporting excerpts, grouping all the codes into themes, and writing narrations to describe the data were all used to analyze qualitative data. As a result, the qualitative data was presented through narrations and verbatim reports. The researcher linked the quantitative and qualitative phases when developing 'focus groups and interview' questions for the collecting of qualitative data in order to corroborate the preceding phase' s quantitative findings.

The study's independent variables (instructors' subject matter expertise, pedagogical knowledge, technological proficiency, perceptions) and the dependent variable (students' achievement) were correlated using Pearson correlation analysis at  $\alpha = 0.05$  level of

significance, allowing the researcher to assess the relationship between them. In Makueni County's public secondary institutions, multiple regression analysis was also employed to determine the association linking instructors' use of technology in the classroom and learners' success in Maths. The equation  $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$ , was used in the study, where  $Y$  = Math achievement,  $\beta_1 - \beta_5$  = coefficients of the independent variables, and  $X_1 - X_5$  = indicators of teachers' use of ICT. Given that the regression analysis model had more than one predictor variable, the adjusted R-squared was used to calculate how much variation the model explained. The hypotheses were tested for significance, and the findings were presented in tables and histograms. The following objectives guided the data analysis;

**Research Objective One:** Public secondary school instructors of Mathematics in Makueni County were given a self-assessment questionnaire to complete in order to indicate their scale of concurrence with assertions regarding their knowledge of ICT. This was done to ascertain the connection linking instructors' knowledge of technology and learners' performance on the KCSE in Mathematics. A Likert scale was employed, with "strongly disagree" denoted by 1 and "strongly agree" denoted by 5. Descriptive and inferential statistics, including averages, standard deviation, percentages, and frequencies, were utilized to statistically analyze data from the instructors' questionnaire. Principals' interviews and conversations in focus groups with students in form three were employed to obtain qualitative data. The researcher aimed to evaluate the proficiency of use of computers by instructors of Mathematics, particularly in development, assessment, and implementation of ICT-integrated Mathematics

curriculum. The findings were presented via narrative and verbatim reports after the qualitative data was analyzed and organized into themes to complement the quantitative investigation. The hypothesis tested if there was a statistically substantial connection between secondary school students' Mathematics accomplishment in Makueni County and instructors' comprehension of ICT material, with Pearson correlation analysis used at a significant level. A regression model summary was created to evaluate how much variation in ICT content knowledge influenced Mathematics achievement, and the results were presented in tables and histograms.

**Research Objective Two:** As far as the investigation's second goal was concerned, public secondary school instructors of Mathematics in Makueni County were given a self-assessment questionnaire to complete in order to indicate their scale of concurrence with assertions regarding their knowledge of use of computers during Math instruction. This was done in order to investigate the relationship linking instructors' pedagogical knowledge of ICT use and learners' performance on the KCSE in Mathematics. A Likert scale was employed, with "strongly disagree" denoted by 1 and "strongly agree" denoted by 5. Descriptive and inferential statistics, including averages, standard deviation, percentages, and frequencies, were utilized to statistically analyze data from the instructors' questionnaire. Principals' interviews and conversations in focus groups with students in form three were used to obtain qualitative data. During interviews, principals were asked about the extent to which teachers had developed TPACK and the importance of effectively teaching Mathematics with technology. The hypothesis tested if there was a statistically substantial connection between secondary school students' Mathematics accomplishment in Makueni County and instructors' comprehension of

knowledge of pedagogy. Pearson correlation was used at the  $\alpha = .05$  level of significance. The summary of a regression model was created to determine how much diversity in pedagogical knowledge in ICT use influenced secondary school Mathematics KCSE achievement in Makueni County. The analysis results were presented in tables and histograms.

**Research Objective Three:** The study asked Mathematics instructors to rate their self-assessments on technological expertise in order to investigate the correlation between instructors' technological proficiency in technology employment and learners' Mathematics accomplishment on the KCSE national exams in Makueni County. A Likert scale was employed, with "strongly disagree" denoted by 1 and "strongly agree" denoted by 5. Descriptive and inferential statistics, including averages, standard deviation, percentages, and frequencies, were utilized to statistically analyze data from the instructors' questionnaire. Principals' interviews and conversations in focus groups with students in form three were used to obtain qualitative data. Students' thoughts on whether schools' lack of competent and assured teachers contributed to a lack of enthusiasm in computer utilization in Mathematics curricula were solicited during focus group talks. The hypothesis tested if there was a statistically substantial connection between secondary school students' Mathematics accomplishment in Makueni County and instructors' technological knowledge of ICT use. Pearson correlation was used at the  $\alpha = .05$  level of significance. The summary of regression model was extracted to determine the variability of achievement in Mathematics, which was based on teachers' technological knowledge in ICT use.

**Research Objective Four:** A survey was conducted to investigate the relationship linking instructors' perceptions towards the use of ICT and the KCSE Mathematics achievement of students in Makueni County's public secondary schools. Instructors of Mathematics were issued with a self-assessment questionnaire to complete. A Likert scale was employed, with "strongly disagree" denoted by 1 and "strongly agree" denoted by 5. Descriptive and inferential statistics, including averages, standard deviation, percentages, and frequencies, were utilized to statistically analyze data from the instructors' questionnaire. Qualitative data was obtained by conducting interviews with principals and holding conversations in focus groups with students in form three. During the interviews, principals were asked if they believed that teachers achieved high scores on the TPACK sub-scales in Mathematics teaching as a result of ICT use. An FGD was conducted with the students to obtain their perspectives on ICT use in Mathematics learning. Pearson correlation was used at the  $\alpha = .05$  level of significance. Additionally, a regression model summary was generated to ascertain the extent of variability in Mathematics achievement that could be attributed to instructors' opinions regarding use of computers into Mathematics lessons.

### **3.13 Ethical and Logistical Considerations**

#### **3.13.1 Ethical Considerations**

In order to get the participants' approval to take part in the study, the researcher employed consent forms. Investigation's participants were not obligated to disclose personal details such as their names or contact information when providing data, either verbally or in writing. They were guaranteed complete confidentiality regarding their participation in the research, and were assured that no personal harm would result from

providing information. The study's participants were advised that they could discontinue participation at any moment if they so desired, that and participation was entirely optional.

### **3.13.2 Logistical Considerations**

Before commencing the examination in the selected schools, the investigator first obtained research authorization letters from the National Commission for Science, Technology, and Innovation (NACOSTI) and Kenyatta University. The investigator also asked the TSC county education offices in Makueni County for a letter authorizing their investigation. To establish rapport with the participants and become familiar with the geographic area, the researcher conducted reconnaissance visits.

## CHAPTER FOUR

### PRESENTATION OF FINDINGS, INTERPRETATION AND DISCUSSION

#### 4.1 Introduction

The section following is split into two sections: Section one presents study's objectives, hypotheses, questionnaire response rate, and demographic information of the participants. The research findings, analyses, interpretations, and conclusions are presented in the second section in accordance with the objectives of the investigation. This involved exploring the connection between teachers' utilization of ICT in teaching Mathematics and students' KCSE achievement in the subject at Makueni County's public secondary schools. The study's objectives were:

- i. Determine the correlation between teachers' content knowledge in ICT use and students' KCSE achievement in Makueni County's secondary public schools.
- ii. Substantiate the correlation between teachers' pedagogical knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- iii. Assess the correlation between teachers' technological knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- iv. Find out the correlation between teachers' perception of ICT use and students' KCSE achievement in Mathematics in Makueni County's secondary public schools.

The following null hypotheses also guided the study:

- H<sub>0</sub>1:** There is no statistically significant correlation between teachers' content knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- H<sub>0</sub>2:** There is no statistically significant correlation between teachers' pedagogical knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- H<sub>0</sub>3:** There is no statistically significant correlation between teachers' technological knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- H<sub>0</sub>4:** There is no statistically significant correlation between teachers' perception of ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.

These alternate hypotheses served as the study's guiding principles:

- H<sub>a</sub>1:** There is a statistically significant correlation between teachers' content knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- H<sub>a</sub>2:** There is a statistically significant correlation between teachers' pedagogical knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.
- H<sub>a</sub>3:** There is a statistically significant correlation between teachers' pedagogical knowledge in ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.

**H<sub>a</sub>4:** There is a statistically significant correlation between teachers' perception of ICT use and students' KCSE achievement in Mathematics in public secondary schools in Makueni County.

#### **4.2 Return Rates of Instruments**

In total, 42 questionnaire forms were given to Mathematics teachers, out of which 34 were completed and returned, resulting in 80.9% return rate that was deemed excellent for the study's credibility. An appropriate response rate for research and reporting, according to Mugenda and Mugenda (2003) is 50%, 60% is usually sufficient, and more than 70% is excellent. Kothari (2004) also considers a response rate of over 70% to be satisfactory. The interviews were attended by all 25 principals from the sampled schools. Out of the Focus Group Discussions (FGDs) conducted with students, each group comprised of 6 students from Form 3. The goal of these focus groups, which received 100% participation, was to provide the researcher with information regarding ICT use in Mathematics learning and its correlation with students' achievement in national examinations.

#### **4.3 General and Demographic Information**

Using questionnaires, the researcher sought demographic information from Mathematics teachers. The study sought information on teachers' gender, age, professional qualifications, level of computer training, and the types of schools in which they taught, among other things. These respondents' background characteristics were deemed critical because they would influence utilization of ICT in teaching.

### 4.3.1 Teachers' Age and Gender

Table 4.1 illustrates the findings of a survey sent to Mathematics teachers asking for their age and gender.

**Table 4.1: Teachers' Age and Gender**

<b>Age</b>	<b>Male</b>		<b>Female</b>	
Below 25 Years	2	9.1%	-	-
26-30 Years	6	27.3%	-	-
31-40 Years	7	31.8%	5	41.7%
41-50 Years	5	22.7%	5	41.7%
51-60 Years	2	9.1%	2	16.6%
<b>Total</b>	<b>22</b>	<b>100</b>	<b>12</b>	<b>100</b>

As indicated in Table 4.1, over two-thirds of the Mathematics teachers, 22 out of 34 (64.7%), were male, while a third, 12 out of 34 (35.3%), were female. In terms of age, the data revealed that slightly more than a quarter (6 out of 22; 27.3%) of male teachers were between the ages of 26 and 30, and 2 out of 22 (9.1%) were under the age of 25, while none of the female teachers were under the age of 31. The study also revealed that 7 out of 12 (41.7%) males and 5 out of 12 (41.7%) females were between the ages of 31 and 40; 5 out of 22 (22.7%) males and slightly above a third, that is, 5 out of 12 (41.7%) females were between the ages of 41 and 50, and 2 out of 22 (9.1%) male teachers and 2 out of 12 (16.6%) female teachers were between the ages of 51 and 60. Data regarding the ages of the respondents were deemed necessary as young teachers were likely to embrace ICT compared to old teachers. Older and more seasoned instructors were less

receptive to utilizing ICT in the classroom than younger teachers, in line with Baek, Jong, and Kim (2008) research. On the contrary, old teachers are likely to be more experienced in teaching and hence better in lesson delivery (pedagogy) compared to their young counterparts. The collection of data on teachers' gender was deemed important as it was suspected that female teachers may have contributed to poor performance among students, given their lower likelihood of using ICT. Research by Volman and Van Eck (2001) supports this suspicion as relative to their male colleagues, they discovered that female teachers used computers at a lesser rate, which was attributed to limited access to technology, lack of skills, and less interest in technology.

#### 4.3.2 Teachers' Professional Qualifications

Table 4.2 provides information about the instructors' academic credentials.

**Table 4.2: Professional Credentials of Teachers**

<b>Professional Qualification</b>	<b>Male</b>		<b>Female</b>	
Masters Degree in Education	2	9.1%	-	-
Bachelors in Education	15	68.2%	7	58.3%
Diploma in Education	5	22.7%	5	41.7%
<b>Total</b>	<b>22</b>	<b>100</b>	<b>12</b>	<b>100</b>

Two out of the 22 male instructors (9.1%, according to Table 4.2) possessed Masters' degrees, while no female teacher had a Masters' degree qualification; 15 of the 22 male teachers (68.2%) and 7 of the 12 female teachers (58.3%) had Bachelor of Education degree level of education. The results also showed that 5 out of 22 (22.7%) males and 5 out of 12 (41.7%) of the female teachers had Diploma level of education. On the other

hand, in terms of professional qualification, majority were male with higher educational level as high as Masters' degree (2 out of 22; 9.1%) as compared to the females who did not have Masters degree qualification. Information on teachers' educational qualifications was important because according to past research, instructors who have higher education are more inclined to the use of computers in the classroom more frequently, thus shaping students' achievement depending on who is teaching. According to Ogachi (2015), the higher a teacher's educational qualifications, the more he or she embraces ICT.

### 4.3.3 Computer Proficiency Level

Table 4.3 displays the outcomes from a request that Mathematics instructors indicate their computer proficiency levels.

**Table 4.3: Computer Proficiency Level**

<b>Literacy Level</b>	<b>Frequency</b>	<b>Percentage</b>
Proficiency	10	33.3
Certificates	18	60.0
Diploma	1	3.3
Others	1	3.3
<b>Total</b>	<b>30</b>	<b>100</b>

More than fifty percent of the respondents according to Table 4.3, that is, 18 out of 30 (60.0%) had certificate level of computer training, a third of the Mathematics teachers, that is, 10 out of 30 (33.3%) had proficiency level of computer training, and 1 out of 30 (3.3%) had a Diploma in computer training and other forms of training. Obtaining information on the computer training levels of Mathematics teachers was essential because those who possess computer skills tend to have a positive attitude towards ICT

use, as well as self-efficacy, and are more inclined to use ICT in comparison to those who lack computer skills. According to Wozney et al. (2006), training programs that focus on ICT enhance teachers' competencies in computer use.

#### 4.3.4 Type of School

Teachers of Mathematics were requested to declare the sort of institution where they worked at, and the information is shown in Table 4.4

**Table 4.4: Type of Institution**

<b>Type of Institution</b>	<b>Frequency</b>	<b>Percentage</b>
Boys' boarding school	8	23.5
Girls' boarding school	8	23.5
Mixed day school	14	41.2
Boys' day school	2	5.9
Girls' day school	2	5.9
<b>Total</b>	<b>34</b>	<b>100</b>

According to Table 4.4, the study found that 14 out of 34 (41.2%) Mathematics teachers taught in mixed day schools, 8 out of 34 (23.5%) in boys' boarding schools and girls' boarding schools, and 2 out of 34 (5.9%) in boys' day and girls' day schools. To provide relevant information, the present study required data on the type of school since boarding schools tend to have better and more accessible ICT facilities compared to day schools, which might result in differences in academic performance among students. Research conducted earlier by Manduku, Kosgey, and Sang (2006) revealed that boarding schools had superior ICT facilities and had been using ICT for a more extended period than day

schools. Additionally, the teachers from various types of schools were questioned about how often they used ICT during Mathematics instruction; Table 4.5 lists the answers they provided.

**Table 4.5: Cross-tabulation of School Types and ICT Use Rates.**

Types of Schools		Weekly	Monthly	Others	Total
Boys' Boarding	Count	3	3	2	8
	% of Total	9.1%	9.1%	6.1%	24.2%
Girls' Boarding	Count	1	6	1	8
	% of Total	3.0%	18.2%	3.0%	24.2%
Mixed Day school	Count	0	5	8	13
	% of Total	0.0%	15.2%	24.2%	39.4%
Boys' Day	Count	0	0	2	2
	% of Total	0.0%	0.0%	6.1%	6.1%
Girls' Day	Count	0	1	1	2
	% of Total	0.0%	3.0%	3.0%	6.1%
Total	Count	4	15	14	33
	% of Total	<b>12.1%</b>	<b>45.5%</b>	<b>42.4%</b>	<b>100.0%</b>

Less than fifty percent of the schools displayed in Table 4.5, that is, 15 out of 33 (45.5%), used ICT on a monthly basis and 4 out of 33 (12.1%) on a weekly basis. According to the study, 14 out of 33 (42.4%) people either did not use ICT at all or used it after a one-month break. The study also found that girls' boarding schools had the highest monthly frequency of ICT use at 18.2% (6 out of 33), followed by mixed day at 15.2% (5 out of 33), and both boys' and girls' day schools hardly employed computers into their Mathematics lessons. These might be attributed to lack of computer laboratories in these schools as only 2.9% of the boys' day schools and 5.9% of girls' day schools

had computer laboratories in their respective schools as compared to 23.5% in both girls' and boys' boarding schools and 16.7% in mixed day schools respectively (see Table 4.6). The second reason was perhaps due to lack of internet connectivity as the study revealed that both boys' , girls' and mixed day schools had 0% for boys' day, 6.5% for girls' and 0% for mixed day schools internet connectivity respectively. Finally, there was lack of technical assistants to fix computer related problems. The study could not explicitly relate the types of schools to the frequency with which they used ICT in their respective schools. Data on frequency of ICT use was deemed necessary as it could have a direct correlation with achievement in Mathematics.

#### **4.3.5 Availability of ICT Complementary Facilities**

Table 4.6 shows the results of a survey that asked respondents to list the categories if ICTs accessible in their respective institutions.

**Table 4.6: Availability of ICT Complementary Facilities**

<b>ICTs Available</b>	<b>Frequency</b>	<b>Percentage</b>
Overhead Projector	6	17.6
White Boards	14	41.2
Computers	22	64.7
Scientific Calculators	32	94.1
Mobile Phones	12	35.3
Mathematics Charts	27	79.4

Table 4.6 show that most schools, that is, 32 out of 34 (94.1%) had scientific calculators, more than three quarters, 27 out of 34 (79.4%) which had mathematical charts, more than half, 22 out of 34 (64.7%) with computers and slightly less than half, 14 out of 34 (41.2%) with whiteboards. The results also revealed that about a third, 12 out of 34 (35.3%) had smart phones and 6 out of 34 (17.6%) with overhead projectors which were used in the teaching of Mathematics. This means that secondary schools were fairly using simple ICT devices in the teaching of Mathematics, though the magnitude to which this corresponds to Math achievement is founded on the results of the goals of the study, which are presented in the sections following. Data on available ICT resources was critical because schools with ICT resources, such as hardware and software, had higher probability of employing computers into Mathematics curricula. According to Hare (2007), one of the most efficient means for educators to incorporate technology into their pedagogical practices is by having access to technology resources.

#### **4.4 Teachers' Content Knowledge and ICT Use**

To determine the correlation between teachers' content knowledge in ICT use and students' KCSE achievement in Mathematics in Makueni County public secondary schools, the study used specific statements related to teachers' content knowledge in ICT. Regarding their own assessments of ICT content understanding, instructors were requested to rate how much they agreed or disagreed with each statement. The investigation employed a scale from 1 to 5, with 1 denoting 'strongly disagree', 2 denoting 'disagree', 3 denoting 'neutral', 4 denoting 'agree', and 5 denoting 'strongly agree'. Analysis was done on the responses' weighted averages and standard deviations. Weighted averages between 3.50 and 5.00 denoted concurrence to a proposition, whereas

1.00 and 2.60 denoted dissent. According to a weighted average, 'strongly disagree' was denoted by a score between 1.00 and 1.80, 'disagree' by a score between 1.90 and 2.60, 'neutral' by a score between 2.70 and 3.40, 'agree' by a score between 3.50 and 4.20, and 'strongly agree' denoted by a score between 4.30 and 5.00. The standard deviation was also calculated for the questionnaire items to express how far or close the given response is to the calculated mean. The examinations outcomes are illustrated in Table 4.7.

**Table 4.7: Teachers' Content Knowledge in ICT Use**

<b>Statement</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Mean</b>	<b>SD</b>
Am capable of delivering lessons that integrate technological advancements, mathematical concepts, and instructional strategies.	14.7%	23.5%	17.6%	38.2%	5.9%	2.97	1.2
I have the ability to choose technologies that blend mathematics culture, technology and educational methods	2.9%	50.0%	29.4%	17.6%	-	2.62	0.8
By utilizing technology in the classroom, I can improve the lessons I deliver, the way I deliver them, and the knowledge my pupils gain.	20.6%	29.4%	20.6%	20.6%	8.8%	2.68	1.3
Am proficient at using technology to share pertinent information with students and co-workers.	2.9%	44.1%	32.4%	14.7%	5.9%	2.76	1.0
I can use a wide range of tools to assist students in achieving their own objectives.	9.1%	39.4%	27.3%	18.2%	6.1%	2.73	1.1
In order to make pupils actively participate in a Maths lesson, I can employ a range of technologies.	14.7%	38.2%	11.8%	32.4%	2.9%	2.71	1.2
I can make sure all learners have access to virtual arithmetic learning materials and tools on an equitable basis.	26.5%	35.3%	23.5%	11.8%	2.9%	2.29	1.1

By using technology to engage students, I can help them comprehend other cultures	33.3%	36.4%	12.1%	15.2%	3.0%	2.18	1.2
I have the ability to join online learning forums to learn about new ways of using technology to help students learn Mathematics more effectively	26.5%	38.2%	14.7%	17.6%	2.9%	2.32	1.1
<b>TOTAL</b>	<b>16.8%</b>	<b>37.2%</b>	<b>21.0%</b>	<b>20.7%</b>	<b>4.3%</b>	<b>2.58</b>	<b>1.1</b>

Data in Table 4.7 illustrates that teachers provided neutral responses to several statements related to their self-assessment of content knowledge in ICT use. For instance, they acknowledged their lack of confidence in their capacity to deliver lessons that successfully integrate mathematical ideas, technologies, and instructional strategies (average = 2.97, standard deviation = 1.2), choose acceptable technologies that integrated mathematical culture, technologies, and educational methodologies (average = 2.62, standard deviation = 0.8), and identify classroom technologies that enhanced their teaching in terms of what they taught, when they taught, and how they taught. Additionally, teachers reported indecision about their ability to utilize technology to communicate pertinent information to students and colleagues (average = 2.76, standard deviation = 1.0), employ a variety of technologies to aid learners in achieving their individual learning objectives (average = 2.73, standard deviation = 1.1), and employ various technologies to foster active participation among students during Mathematics lessons (mean = 2.71, standard deviation = 1.1). Chile, Monica, and Horacio (2017) investigated the relationship between integrating technology and subject matter expertise

to teach Maths and performance, and discovered that visualization of technologies and mathematical concepts was a basic competence associated with key mathematical processes in terms of content, and discovered that teachers had the obligation to efficiently transmit essential information to pupils and fellow teachers. As per the investigation's findings, the greatest percentage of instructors, that is, (20.6%) were capable of selecting appropriate classroom technologies that enhanced their teaching and the subject matter. In addition, 32.4% of educators were proficient in using technology to communicate relevant information to both students and fellow teachers.

In addition, the study found that teachers did not agree with the statement that they could provide equal access to digital tools and resources for college student teachers to learn Mathematics. They also disagreed that prospective teachers needed knowledge of subject matter to create Mathematics lessons that incorporated spreadsheets using an activity-based approach suitable for large classrooms ( $M=2.29$ ,  $SD=1.1$ ). Content Knowledge (CK) is required for pre-service teachers to develop Mathematics courses using spreadsheets and an activity-based learning method suitable for large classes, according to (Agyei & Voogt, 2012).

Teachers could hardly even expedite cultural awareness by engaging learners from various cultures through technology ( $M=2.18$ ,  $SD=1.2$ ) and could participate in digital learning communities range of technology content to communicate and explore applications of technology to improve student learning of Mathematics ( $M=2.32$ ,  $SD=1.1$ ). Melike and Fatma (2019) agree that Mathematics teachers' knowledge levels in TPACK components in terms of range of technology content to effectively

communicate relevant information, is necessary for the teachers to performing the lectures. Table 4.7 shows that teachers were successful at delivering classes that effectively included mathematical concepts, technologies, and instructional methodologies with a variation of (1.2); however, teachers were unsuccessful in facilitating inter-cultural understanding by engaging students with different cultures by using technology. In public secondary schools, instructors' mastery of ICT material had a below-average effect on pupils' achievement in Mathematics (M=2.58). It was clear that employing technology to interact with pupils with diverse cultures could aid educators in fostering intercultural understanding. Access to digital Maths learning resources and tools for instructors was made equally available (11.8%), demonstrating that teachers were successful in offering courses that correctly integrated mathematical ideas, technology, and instructional techniques.

The study found that teachers (17.6%) had a reasonable understanding of the capabilities and limitations of various technological tools, and were able to connect this understanding to appropriate designs and strategies for teaching, demonstrating content knowledge. The National Research Council (2000) states that effective teaching requires an integrated knowledge structure that includes subject matter knowledge gained through professional training. The purpose of this investigation was to ascertain how learners' success on the KCSE in public secondary schools related to instructors' ICT usage understanding. Doukakis and Pappas (2015) suggest that the development of a persona depends on teachers' competencies and needs in subject matter expertise, instructional methodology, and proficiency in use of technology.

Principals were interviewed by the researcher to determine how well-versed in ICT-based Maths instruction the educators were, specifically their ability to create, evaluate, and implement ICT-based curricula. The usage of technology by teachers was evaluated based on five levels: entrance, adoption, adaptation, infusion, and transformation. Among the 25 respondents, 23 agreed that their teachers were at the Entry Level, which means that students may not have direct access to technology during lessons that involve technology. As to what digital tools to employ, how to utilize them, and when to apply them are decisions that fall under the purview of instructors. One principal from Makueni sub-county gave their opinion on teachers' ICT competency in teaching Mathematics as follows;

*Teachers have ideas of ICT as tools that make it easier to present content, communicate and convey information. There is digitization of class content such as moving from paper to digital copies. Teachers ought to possess CK (content knowledge about the subject matter/content to be taught), PK (knowledge about the process and practice or methods of teaching) and TK (knowledge about information technology, apply it properly, identify useful technologies and continually adapt to changes in technology and TPACK (an understanding of an interaction of content, pedagogy and technology knowledge).*

In terms of instructors' skills and comfort levels in employment of technology in the classroom, the outcomes of this investigation are consistent with that of Peralta and Costa's (2007) study. According to this investigation, instructors' confidence in utilizing technology in Italy was significantly influenced by how technologically savvy they were. This data supports the claim that instructors who are tech savvy are competent and at ease using technology when teaching. ICT teacher training must therefore be given

top priority in schools. Incorporation of technology into the lessons could help to enhance Math performance in Makueni County.

To effectively instruct in their classrooms, educators must combine their subject matter expertise with their understanding of instructional methodology and technology. Additionally, Niess (2005) suggests that teachers need to have an awareness of how technology can be utilized to teach particular subject matter. This entails a comprehensive awareness of the various ways in which computers can be employed to enhance the teaching and learning procedures.

#### **4.4.1 Hypothesis Testing**

**H<sub>0</sub>1:** There is no significant correlation linking teachers' content understanding of ICT use and students' Mathematics achievement on the KCSE in Makueni County public secondary schools.

**H<sub>a</sub>1:** There is a significant correlation linking teachers' content understanding of ICT use and students' Mathematics achievement on the KCSE in Makueni County's public secondary schools.

Table 4.8 shows the findings of a Pearsons moment correlation coefficient investigation into a potential connection between instructors' ICT topic understanding and students' KCSE Maths accomplishment in Makueni county secondary public schools. The analysis combined all indicators related to teachers' content knowledge in ICT, including facts, concepts, ideas, theories, and principles.

**Table 4.8: Correlation between Teachers’ Content Knowledge in ICT Use and Students’ KCSE Achievement in Mathematics.**

		<b>Achievement</b>	<b>Content Knowledge</b>
<b>Performance</b>	Pearson Correlation	1	.281
	Sig. (2-tailed)		.114
	N	33	33
<b>Content Knowledge</b>	Pearson Correlation	.281	1
	Sig. (2-tailed)	.114	
	N	33	33

\*\*Relationship is Significant at the 0.01 Level (2 tailed).

The investigation discovered a moderately positive association, as shown by the data in Table 4.8 ( $r = .281$ ) between teachers' ICT content knowledge and students' achievement in Mathematics in Makeni County public secondary schools. With a probability value of less than 0.114 and a 99% confidence level with 31 degrees of freedom, the correlation was not statistically significant, nonetheless. A probability value (p-value) of (0.114) was above the 0.05 alpha and hence did not exhibit statistical significance. This suggests that just 5% of the findings from the two variables, that is, teachers’ subject understanding of ICT and achievement in Mathematics could have been the result of chance. The study 99% confidence level indicates that the parameters it found fell between a specified range of values with a high degree of certainty. The study null hypothesis ( $H_0$ ) was accepted in light of the findings, which showed that there was no statistically significant association between instructors’ ICT usage and students’ KCSE Maths achievement in Makeni County’ s public secondary institutions. The alternative hypothesis ( $H_a$ ) that stated that there was substantial association linking instructors’ understanding of ICT and students' achievement in Mathematics in Makeni County public secondary institutions was

rejected. These findings align with previous research conducted by Cassim (2010), demonstrating that the influence of instructors’ understanding of technology on pupils’ achievement is insignificant. In light of these findings, it is critical for teachers to recognize that having knowledge of ICT use is not enough; actualizing it in the classroom is what can potentially boost students' performance.

#### 4.4.2 Regression Model Summary on Teachers’ Content Knowledge in ICT and Students’ KCSE Achievement in Mathematics

The study’ goal was to ascertain how ICT use in secondary school Mathematics in Makueni County was impacted by the variety of topic knowledge. This was discovered using a regression model summary as Table 4.9 illustrates.

**Table: 4.9: Summary of the Regression Model**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.281 <sup>a</sup>	.079	.049	1.210

a. Predictors: (Constant), Content Knowledge

b. Dependent Variable: Achievement

The model summary for the regression analysis of subject knowledge and Maths accomplishment in Makueni County is shown in Table 4.9. The R-value ( $r=.281$ ) indicates a weak but positive relationship between teachers' ICT content knowledge and students' Math achievement. The R-Squared value, ( $R^2 =.079$ ), shows the amount of variance in students’ achievement in Mathematics that could be accounted for by instructors’ proficiency in technology. The adjusted R-squared value is used to assess the quality of the model in multivariate regression. Given that there was only one

predictor variable in this model, the study used the  $R^2$  value to determine the percentage of achievement in Mathematics that could be accounted for by teachers' content knowledge in ICT use. As a result, the model summary findings in Table 4.9 show that secondary school Mathematics achievement is high in Makueni County were explained by 7.9% (0.079 multiplied by 100) of the variability on teachers' content knowledge in ICT use, while other elements not taken into account by this model due to data unavailability, explained the remaining 92.1% of the variability in Mathematics achievement. The small effect size of  $R^2=0.079$  suggested that teachers' content knowledge in ICT use during Mathematics instruction had very little impact on students' performance.

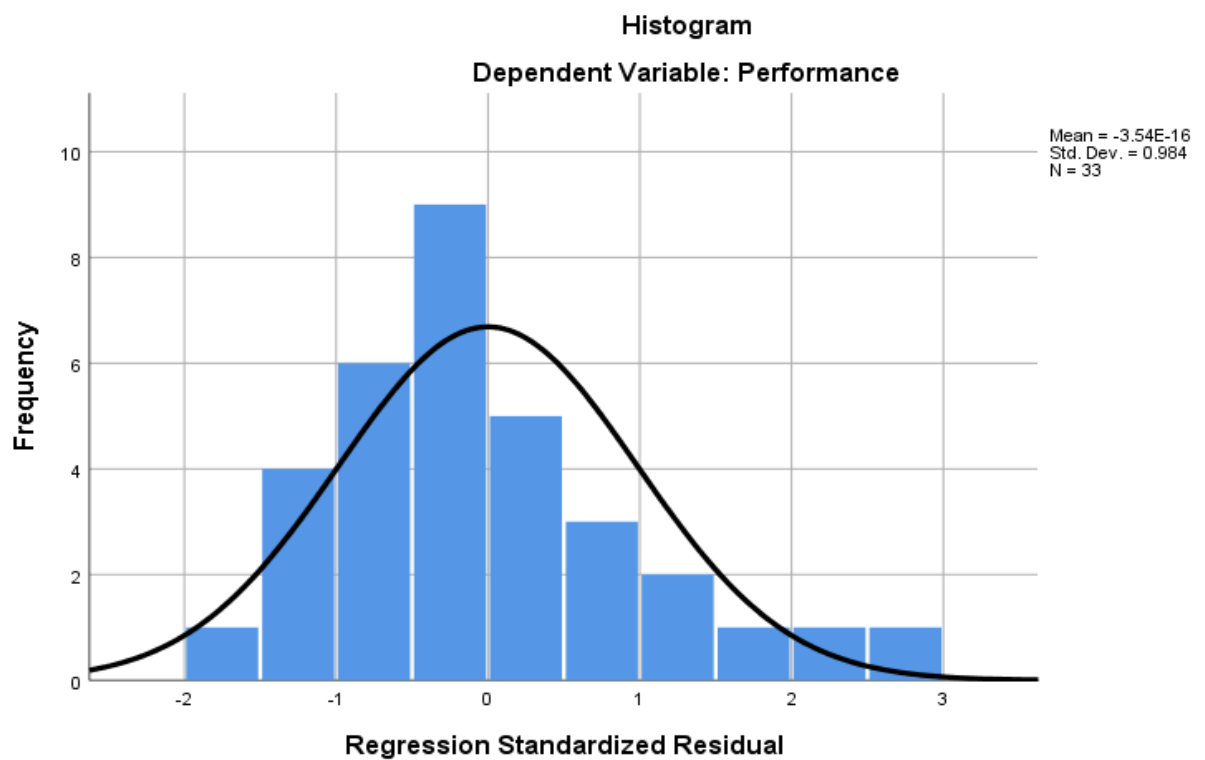
From table 4.9, the study results showed that employing technology to engage students might assist teachers in promoting mathematical knowledge. Courses that appropriately combined mathematical principles, technology, and instructional approaches were successfully offered by teachers. Teachers' content knowledge, which is a grasp of how certain technologies employed in specific ways may affect the content of teaching and learning, slightly improved the achievement of students.

Findings however differ with past research carried out by Monica and Horacio (2017) who evaluated the impact of integrating topic knowledge in teaching Mathematics with technology on mathematical abilities and teacher education programs in Santiago, Chile. According to their study findings, content knowledge appears to be a fundamental skill linked to important mathematical processes. Even though teachers' content knowledge in ICT use does not significantly impact on students' achievement, as per the current

study, it is still crucial since it may equip teachers with the relevant knowledge required in ICT use. As a result, it is critical for schools to guarantee that teachers are furnished with subject knowledge as a catalyst for ICT use in the classroom.

#### 4.4.3 Regression Standardized Residual

Figure 4.1 depicts an examination of the average score of the impact of instructors' subject-matter expertise while using ICT to teach Mathematics.



**Figure 4.1: Impact of Instructors' Subject Knowledge in ICT use on Students' KCSE Achievement in Mathematics**

As shown in Figure 4.2, the average (Mean, M) score was (M=3.54) obtained from students' achievement in Mathematics in KCSE from a total of 33 schools, with a

standard deviation (SD) of (0.98) was as a result of teachers' content knowledge in ICT use. As presented in the figure, the achievement in Mathematics was normally distributed. Most scores fall around the mean (middle of the distribution). The shape is roughly symmetrical.

#### **4.5 Teachers' Pedagogical Knowledge and ICT Use**

The second goal of this investigation was to look into how students' KCSE Mathematics achievement correlated with instructors' pedagogical understanding of using technology. Regarding their own assessments of ICT content understanding, the degree to which each statement was concurred or dissented with by the educators was asked to be rated. The investigation employed a scale from 1 to 5, with 1 denoting 'strongly disagree', 2 denoting 'disagree', 3 denoting 'neutral', 4 denoting 'agree', and 5 denoting 'strongly agree'. Analysis was done on the responses' weighted averages and standard deviations. Weighted averages between 3.50 and 5.00 denoted concurrence to a proposition, whereas 1.00 and 2.60 denoted dissent. According to a weighted average, 'strongly disagree' was denoted by a score between 1.00 and 1.80, 'disagree' by a score between 1.90 and 2.60, 'neutral' by a score between 2.70 and 3.40, 'agree' by a score between 3.50 and 4.20, and 'strongly agree' denoted by a score between 4.30 and 5.00. The standard deviation was also calculated for the questionnaire items to express how far or close the given response is to the calculated mean. The examination results are displayed in Table 4.10.

**Table 4.10: Teachers’ Pedagogical Knowledge in ICT Use**

<b>Statement</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Mean</b>	<b>SD</b>
I can incorporate technology to evaluate my own teaching in terms of theoretical principles	-	23.5%	29.4%	47.1%	-	3.24	0.8
I can use technology to deliver suitable level of difficulty target mathematical input	2.9%	26.5%	20.6%	47.1%	2.9%	3.21	1.0
I can choose authentic technological mathematics resources to meet the needs of my students	5.9%	20.6%	35.3%	32.4%	5.9%	3.12	1.0
I can choose digital learning activities that help learners gain a better understanding of their cultures	9.1%	30.3%	48.5%	12.1%	-	2.64	0.8
I am capable of selecting the best digital methods for teaching Mathematics to students	2.9%	14.7%	14.7%	61.8%	5.9%	3.53	0.9
Am able to schedule when and how I will employ target language to teach Mathematics using technology	5.9%	38.2%	44.1%	11.8%	-	2.62	0.8
I am able to use technology to recognize arithmetic difficulties that students experience	14.7%	5.9%	5.9%	58.8%	14.7%	3.53	1.3
I can use technology to create mathematics courses that are tailored to meet curriculum needs	11.8%	41.2%	35.3%	5.9%	5.9%	2.53	1.0
I am cognizant of the environmental factors that hinder or facilitate learning of Mathematics	17.6%	14.7%	20.6%	41.2%	5.9%	3.03	1.2
I am up-to-date on current digital research in the field of Mathematics education	21.2%	48.5%	18.2%	12.1%	-	2.21	0.9

I can try out different teaching digital approaches for Mathematics	23.5%	26.5%	5.9%	41.2%	2.9%	2.74	1.3
<b>TOTAL</b>	<b>10.5%</b>	<b>26.4%</b>	<b>25.3%</b>	<b>33.8%</b>	<b>4.0%</b>	<b>2.94</b>	<b>1.0</b>

The study asked Mathematics teachers to evaluate their level of agreement with their own assessment of their pedagogical understanding in ICT use. The investigation employed a scale from 1 to 5, with 1 denoting 'strongly disagree', 2 denoting 'disagree', 3 denoting 'neutral', 4 denoting 'agree', and 5 denoting 'strongly agree'. The outcomes of this evaluation are presented in Table 4.10. The term “ pedagogical knowledge” relates to teaching techniques and procedures, notably as an academic field or conceptual idea.

Table 4.10 reveals that a large number of teachers (47.1%) could critically analyze their instruction in the context of theoretical principles using technology (M=3.24, SD=0.8), that teachers might offer target mathematical input at an appropriate level of difficulty (M=3.21, SD=1.0), and that the majority of them (47.1%) could choose authentic mathematical digital resources to meet the needs of their students (M=3.12, SD=1.0). Hardman (2015) established that pedagogical knowledge necessitates a comprehension of intellectual, social, and developmental frameworks of learning and the manner in which they employ to students in classrooms in relation to theoretical principles that enhance learners' inter-cultural awareness, and that teachers could select authentic mathematical resources.

This study's findings also revealed that instructors of Mathematics were neutral about whether they could choose digital activities that increased learners' inter-cultural awareness (M=2.64, SD=0.8), as well as select a suitable digital approach to teach

Mathematics to learners ( $M=3.53$ ,  $SD=0.9$ ), and schedule whenever and how to utilize the target language, such as meta-language, during instruction ( $M=2.62$ ,  $SD=0.8$ ). These findings are consistent with Li and Ma's (2011) research on the extent to which ICTs can boost accomplishment. The study concluded that the way a computer is utilized during classroom instruction substantially impacts on academic accomplishment, specifically how it affects pedagogical practices and how students plan to use language, including meta-language, in the classroom. Li and Ma (2011) suggest that Mathematics teachers can choose activities that enhance students' intercultural understanding. These findings lead the study to the conclusion that Mathematics courses should be tailored to abide by the curriculum's demands.

The investigation also found that teachers agreed (58.8%) with the assertion that they could identify digital mathematical problems encountered by learners ( $M=3.53$ ,  $SD=1.3$ ), disagreed with the assertion that they could design digital Mathematics courses around curriculum requirements ( $M=2.53$ ,  $SD=1.0$ ), and expressed neutrality about their awareness of the contextual elements that could either hinder or support the teaching of digital Mathematics ( $M=3.03$ ,  $SD=1.2$ ). The present investigation's results are compatible with earlier work by Kaffash et al. (2010) in which it was discovered that incorporating ICT in pedagogy helped students develop advanced cognitive skills that cannot be easily evaluated through standard testing. It was therefore expected that students' concrete skills and analytical abilities in test-taking would be enhanced by incorporation of technology into instruction of Mathematics. According to Kaffash et al. (2010), instructors were able to understand mathematical challenges that students were experiencing and were also aware of contextual aspects that could hinder or enhance

Mathematics instruction. The findings of Kaffash et al. (2010) highlight the importance of teacher training institutes and universities in providing instructors with pedagogical understanding in technology utilization.

Educators further reported dissatisfaction with the fact that they were aware of current digital studies in the realm of Mathematics education ( $M=2.21$ ,  $SD=0.9$ ) and were eager to experiment with different digital techniques of Mathematics teaching ( $M=2.74$ ,  $SD=1.3$ ). According to Nihuka and Voogt (2011), in order to successfully teach Mathematics in secondary schools when using ICT as a medium for instruction, educators ought to be skilled in its utilization. Additionally, they argue that teachers should keep themselves informed about the latest research in Mathematics education and be open to exploring and adopting various teaching methods. Teachers agreed that they were successful in selecting a suitable strategy to teach Mathematics to learners with a variation of 0.9; that they were also successful in identifying mathematical problems encountered by learners with a variation of 1.3; but that they performed poorly (12.1%) in their awareness of current digital studies in the realm of Mathematics teaching.

The current study's results align with those of Kizlikaya and Askar (2008), who found that the usage of software and other pedagogical interface agents facilitated social learning, and enabled interactive learning environments through computer simulations. The literature on the impact of technology on education has reached three conclusions, although the facts are contradictory. First, some studies suggest that ICTs have no effect on pedagogy (Cassim, 2010); second, several studies suggest that modern technologies have a detrimental impact on teaching (Bosamia, 2013); third, there is data that contends that ICTs harm pedagogy (Hardman, 2015; Baker, 2019). Nevertheless, Tamim et al.

(2011) came to the conclusion that using the technology of computers to reinforce the instruction of Mathematics is far much efficient compared to using it to deliver instruction directly, emphasizing the significance of a pedagogical basis for classroom implementation of information, communication technologies.

Implication of these findings for practice were that when principals endeavour to facilitate their teachers in ICT training, this will likely assist in fostering of teachers' pedagogical practices and consequently improve students' academic improvement. The question of whether or not teachers had acquired the ICT skills and knowledge required to use ICT into teaching was raised to the interviewees. All the 25 respondents universally agreed that most of their teachers had the basic ICT knowledge. They however cited several barriers that were holding them back such as inadequate time for technology-integrated lessons due to high workloads. A principal, from Makindu sub-county, was asked to state whether Mathematics teachers in his school had ICT skills and knowledge, and he had this to say:

*Majority of teachers have sufficient ICT skills for everyday and routine working practices though many of them have difficulties in finding a meaningful use of ICT in teaching and learning due to challenges related to limited timeframes and lack of necessary ICT infrastructure.*

*Majority of teachers have undergone “one-off training” and lack the ongoing exposure to ICT. Few teachers have broad expertise in using ICTs in their teaching.*

The interview schedule also intended to determine whether principals were in a position to evaluate the degree to which instructors developed TPACK and how important it was to effectively teach Mathematics with technology. Twenty-two of the twenty-five

respondents said they could conduct the evaluation. The individuals in question considered TPACK as a versatile structure that enables the assessment of the expertise of instructors needed to develop a curriculum and deliver teaching that emphasizes getting pupils ready to use technology to think about and understand Mathematics, ultimately leading to improved student achievement in the subject. In an interview, a principal from Kibwezi sub-county expressed the following viewpoint:

*I was able to assess and evaluate development of TPACK by teachers and realized that some teachers demonstrated more strategic instructional planning skills using ICT technologies upon completion of the training programs organized by the school. If teachers were to teach Mathematics using technology, they needed to have knowledge in ICT, give students a sample of questions and get them to formulate answers on the topic chosen, have background knowledge and level of comfort his/her students have with the technology being used.*

*Teachers who had undergone training demonstrated better understanding of planning inquiry based activities. Scenario based (lesson observation) seemed promising in examining changes in teachers' planning and problem solving skills with technology. The challenges however being limited time frames. The method is however compatible with the conceptual framing of TPACK as it attempts to examine TPACK from a holistic perspective, considering the interaction between the knowledge domain in a specific classroom context.*

Therefore, teachers with pedagogical skills can provide quick feedback and encouragement to students, allowing them to pick up information more quickly, more effectively, and with greater recall when a test is given. These findings support previous research by Argentin et al. (2015) on association between pupils' accomplishments and ICT-linked instructional techniques in Italian secondary schools. According to data estimations, ICT-related teaching approaches improved student performance by assisting

the teacher in gathering more material for his/her lectures. The relevance of these discoveries for educational practice was that when teachers integrate ICT into their instruction, pupils' academic achievement will likely improve.

#### 4.5.1 Hypothesis Testing

**H<sub>0</sub>2:** There is no significant association linking teachers' instructional methodology proficiency of ICT use and students' Mathematics achievement on the KCSE in Makueni County public secondary institutions.

**H<sub>a</sub>2:** There is a substantial association linking teachers' instructional methodology proficiency of ICT use and students' Mathematics achievement on the KCSE in Makueni County public secondary institutions.

Examining the probable association between teachers' ICT pedagogical knowledge and Mathematics achievement among public secondary school students was necessary; which was done by merging all indicators related to teachers' pedagogical knowledge in ICT use such as teaching approaches, classroom management abilities, lesson preparation, and student evaluation. Table 4.11 condenses and presents the results of this analysis.

**Table 4.11: Correlation between Teachers' Pedagogical Knowledge in ICT and Students' KCSE Achievement in Mathematics.**

		<b>Achievement</b>	<b>Pedagogical Knowledge</b>
<b>Achievement</b>	Pearson Correlation	1	.145
	Sig. (2-tailed)		.421
	N	33	33
<b>Pedagogical Knowledge</b>	Pearson Correlation	.145	1
	Sig. (2-tailed)	.421	
	N	33	33

\*\*Association is Significant at the 0.01 Level (2 tailed).

The strength and direction of the association linking the two variables are shown in Table 4.11. There was a moderately positive association linking instructors' pedagogical competence in ICT use and students' achievement ( $r(33) = .145, p = .421$ ) with 31 degrees of freedom at 99% confidence level but no statistical significance. A p-value (probability value) of (.421) was greater than the 0.05 alpha, indicating that there was no statistical significance. The study discovered that there was only a 5% possibility that the association between instructors' pedagogical expertise of ICT use and mathematical achievement was only a coincidence. The study 99% confidence level indicates that the parameters it found fell between a specified range of values with a high degree of certainty, proving that there was no substantial connection linking teachers' instructors' pedagogical expertise in using ICT and students' KCSE achievement in Mathematics in Makueni County public secondary schools, the null hypothesis ( $H_0$ ) was accepted. The alternative hypothesis ( $H_a$ ) which claimed that instructors' instructional methodology expertise of ICT use and learners' KCSE achievement in Mathematics in Makueni County public secondary schools were significantly correlated, was rejected. These results contradict with those of Mbugua et al. (2012) and Shikuku (2012), who stressed that Mathematics teaching should emphasize problem-solving activities that incorporate the use of ICT. While teachers' pedagogical knowledge in ICT use may not be directly linked to students' academic achievement, it is essential as it equips teachers with relevant instructional skills.

#### 4.5.2 Regression Model Summary on Teachers’ Pedagogical Knowledge in ICT and Students’ KCSE Achievement in Mathematics

To determine the impact of diversity in pedagogical knowledge in ICT use on Mathematics achievement in Makueni County, the current study aimed to conduct a regression analysis. An overview of the model for regression applied to this investigation may be found in Table 4.12.

**Table: 4.12: Summary of the Regression Model**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.145 <sup>a</sup>	.021	-.011	1.274

a. Predictors: (Constant), Pedagogical Knowledge

b. Dependent Variable: Achievement

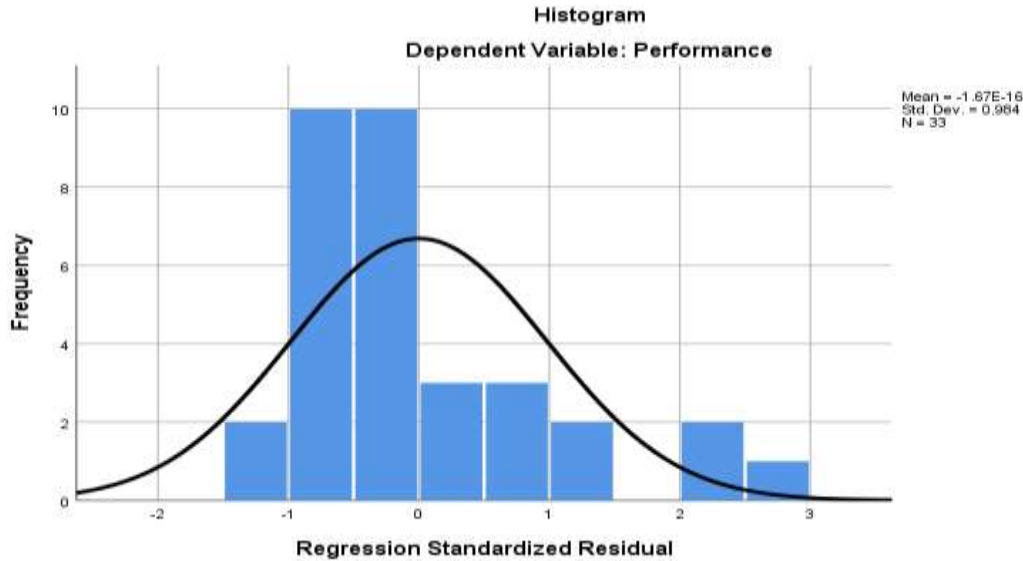
Table 4.12 displays the model summary for regression analysis on pedagogical knowledge and Mathematics achievement in Makueni County. The R value ( $r=.145$ ) indicates that few facts are available regarding the relationship between students’ accomplishment in Mathematics and instructors’ ICT pedagogical competence. R-square score ( $R^2=0.021$ ) represents the extent of variability in students' Math success that can be explained by instructors' pedagogical expertise of ICT use. However, because this model was based on a single variable, the  $R^2$  value was used to determine the percentage of students' achievement in Mathematics that could be gauged by instructors' understanding of ICT use. Table 4.12 further shows that 2.1% of the diversity in educators’ pedagogical knowledge in ICT use was responsible for the achievement in Mathematics in Makueni County’s secondary public institutions ( $R^2=.021$ ) while the rest 97.9% unexplored variation can be ascribed to other factors that determine achievement

in Mathematics but not incorporated in this model due to unavailability of data. The small effect size of  $R^2=.021$  meant that teachers' pedagogical knowledge in ICT had little impact, though contributed, on learners' success in Mathematics in public secondary schools in Makueni County. This finding supports Ogwel's (2008) research results that using ICT during Mathematics instruction has the benefit of encouraging pupils to learn, particularly in situations where activities are demanding, multidisciplinary, and multisensory. Additionally, it had the advantage of connecting abstract concepts to concrete situations, encouraging inquiry and investigation, and allowing students to use what they had learned to solve current issues rather than create new ones.

Mathematics is more successful when technology is used since it allows for simpler education, highlighting the relevance of the pedagogical foundation of ICT use. As a result, teachers with pedagogical abilities may provide students with immediate feedback and encouragement, helping them to learn better and quicker and retain more information when a test is administered.

#### **4.5.3 Regression Standardized Residual**

The study also estimated the mean score of how much teachers' pedagogical knowledge in the use of ICT for instructing Mathematics influenced their accomplishment in Makueni County secondary public institutions. Figure 4.2 presents the analysis' results.



**Figure 4.2: Impact of Instructors’ ICT Pedagogical Competence on Students’ KCSE Achievement in Mathematics**

As shown in Figure 4.2, the average (Mean, M) score was (M=1.67) obtained from students KCSE scores in Mathematics from a total of 33 schools, with SD of (0.98), which was as a result of teachers’ pedagogical knowledge in ICT use. As presented in the Figure 4.2, the scores of Mathematics achievement were normally distributed. Most scores fall around the mean (middle of the distribution). The shape is roughly symmetrical.

#### **4.6 Teachers’ Technological Knowledge and ICT Use**

The study asked Mathematics instructors in Makueni County to indicate their concurrence scale on given statements about their technological proficiency in ICT use in order to investigate the third objective, which aimed at exploring the association between teachers' technological competence in ICT use and secondary school Maths students’ academic accomplishment. The investigation employed a scale from 1 to 5, with 1 denoting ‘strongly disagree’, 2 denoting ‘disagree’, 3 denoting ‘neutral’, 4 denoting ‘agree’, and 5 denoting ‘strongly agree’. Analysis was done on the responses’ weighted

averages and standard deviations. Weighted averages between 3.50 and 5.00 denoted concurrence to a proposition, whereas 1.00 and 2.60 denoted dissent. According to a weighted average, ‘strongly disagree’ was denoted by a score between 1.00 and 1.80, ‘disagree’ by a score between 1.90 and 2.60, ‘neutral’ by a score between 2.70 and 3.40, ‘agree’ by a score between 3.50 and 4.20, and ‘strongly agree’ denoted by a score between 4.30 and 5.00. The standard deviation was also calculated for the questionnaire items to express how far or close the given response is to the calculated mean. The examination’s findings are displayed in Table 4.13.

**Table 4.13: Teachers’ Technological Knowledge in ICT Use**

<b>Assertion</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Mean</b>	<b>SD</b>
Am conscious of technologies I can employ in the classroom to teach Mathematics	2.9%	23.5%	17.6%	50.0%	5.9%	3.52	0.7
Am aware of technologies that I can utilize to better comprehend and do Math	8.8%	23.5%	14.7%	50.0%	2.9%	3.53	0.8
I am capable of resolving my own technological issues	11.8%	50.0%	20.6%	17.6%	-	2.44	1.1
I can quickly pick-up technology and use to teach Mathematics	5.9%	14.7%	35.3%	44.1%	-	3.18	0.9
I stay abreast of new technology as they emerge	33.3%	39.4%	12.1%	9.1%	6.1%	2.15	1.2
While teaching Mathematics, I constantly experiment with technology	52.9%	29.4%	-	14.7%	2.9%	1.85	1.1
I am well-versed in the many technologies used in teaching Mathematics	8.8%	41.2%	14.7%	32.4%	2.9%	2.79	1.1
I know how to use computers, and I have the necessary technical skills.	14.7%	32.4%	8.8%	41.2%	2.9%	2.85	1.2
A variety of technologies have allowed me to interact with them.	50.0%	20.6%	8.8%	14.7%	5.9%	1.78	1.0
<b>TOTAL</b>	<b>20.0%</b>	<b>30.6%</b>	<b>14.7%</b>	<b>30.4%</b>	<b>3.4%</b>	<b>2.64</b>	<b>1.1</b>

Table 4.13 demonstrates that half of teachers (50%) consented with the statement that they understood about innovations that could be utilized for instructing Mathematics ( $M=3.52$ ,  $SD=0.7$ ), 50% agreed with the statement that they understood about technologies that could be used for understanding and doing Mathematics ( $M=3.53$ ,  $SD=1.1$ ), but disagreed with the statement that they knew how to fix their own technical problems ( $M=2.44$ ,  $SD=0.9$ ). Thompson and Mishra (2009) have stated that a teacher's ability to effectively use computers in both their professional and personal lives, their aptitude to judge when using technology can help or hinder learning objectives, and their ability to frequently adapt to new technologies are all examples of technological expertise. Teachers who are familiar with technology, according to Thompson and Mishra (2009), may readily utilize it to teach Mathematics and improve their students' grasp of the subject.

The study also discovered that 44.1% of teachers can learn technology easily to teach Mathematics ( $M=3.18$ ,  $SD=0.9$ ), few teachers (9.1%) agreed with the statement that they kept being updated with new emerging technologies ( $M=2.15$ ,  $SD=1.2$ ) and a relatively small percentage (15.6%) accepted that they frequently played around with the technology while teaching Mathematics ( $SD=1.85$ , 1.2). According to Hegedus, Tapper, and Dalton (2016), teachers' usage of ICT in a Mathematics classroom had an influence on student results since teachers could quickly learn technology to teach Mathematics. They also claimed that professors with technological expertise were always brought up to date on new developing technologies. This underscores the benefit of teachers having ICT knowledge.

The study also found that 32.4% of teachers consented that they had gained knowledge about the various technologies utilized when teaching Mathematics (M=2.79, SD=1.1), 41.2% agreed that they had the technical abilities to use technology (M=2.85, SD=1.2), and the majority (50%) strongly disagreed that they were given opportunities to work with diverse technologies (M=2.06, 1.1). Results in Table 4.13 meant that instructors with a variation of (1.0) performed well in understanding about the technologies they used to teach Mathematics, while those with a variation of (1.2) had dismal performance in ensuring that they regularly interacted with technology while teaching Mathematics. The adoption of ICTs, according to Cheung and Slavin (2013), has a favourable impact on secondary school learners' academic success.

During interviews, the researcher sought principals' opinions regarding teachers' ICT knowledge and skills. Twenty three out of the 25 respondents universally agreed that majority of their teachers had basic ICT skills. They however expressed views that this knowledge was implemented at the Entry Level, with students at the receiving end and teachers were dominating the ICT-integrated lessons. In reacting to the same question, a principal from Makindu sub-county had this to say:

*Majority of teachers are able to log into the designed Learning Management System (LMS) with the ability to give marks immediately (immediate feedback) which can be given individually or as a group.*

*Assessments are at times not hand marked (this saves time and makes results more reliable) marks go directly to the grade centre (meaning students can track their performance in that subject). The Learning Management System (LMS) can therefore save the questions from various tests to form a question bank.*

*Majority of teachers' ICT competency is at the Entry Level where students only listen or watch content delivered through technology with no or little access to technology being used by the teacher. The instructor makes decisions regarding how and when to employ technology tools, as well as which technologies to use, at this level.*

Moreover, during interviews principals were asked to give their opinions as to whether technological content knowledge of teachers had any relationship with achievement in Mathematics. A principal from Mukaa sub-county commented as follows:

*Whether frequent use of technology is related to academic achievement is unclear to me because my school does not teach with technology after all due to challenges related to lack of the required ICT infrastructure.*

*In my view, technology usage can and might produce comparatively more significant increases in academic achievement than would non-usage (traditional learning).*

*Combination of both words and images (which technology enables) makes learners learn considerably better as technology increases their comprehension of content and development of skills in such areas as analytical reasoning, problem-solving, information evaluation and creative thinking.*

*Using technology would support the active learning of students in an educational environment designed to help learners achieve meaningful skills which in turn would result in positive, cumulatively progressive gains in learning outcomes.*

During focus group talks, learners were prompted to declare whether or not they agreed with the assumption that; “ due to a dearth of qualified and assured teachers, schools are not interested in implementing ICT into their mathematical curricula” . In response, most

students differed with that assertion and pointed out that challenges such as lack of enough computers, lack of internet connectivity, weak schools' ICT policies, among others, as major reasons limiting the ability of schools to use ICT when instructing Mathematics. These outcomes are consistent with Neyland (2011) examination on the variables influencing the adoption of virtual education in Sydney high schools. According to the report, heavy workloads are a key barrier to incorporation of technology into the curricula. School principals ought to take measures necessary to arrest such challenges in order to pave way for ICT-integrated curriculum.

#### **4.6.1 Hypothesis Testing**

**H<sub>0</sub>3:** There is no significant association linking instructors' technological proficiency of ICT use and students' Mathematics achievement on the KCSE in Makueni County public secondary institutions.

**H<sub>a</sub>3:** There is a significant association linking instructors' technological proficiency of ICT use and students' Mathematics achievement on the KCSE in Makueni County public secondary institutions.

All the variables of instructors' technical expertise were integrated in order to analyze the association between their performance in teaching Mathematics in secondary institutions and their understanding of ICT. Table 4.14 gives an overview of the results.

**Table 4.14: Association between Teachers’ Technological Knowledge in ICT and Students’ KCSE Achievement in Mathematics.**

		<b>Achievement</b>	<b>Technological Knowledge</b>
<b>Achievement</b>	Pearson Correlation	1	.369*
	Sig. (2-tailed)		.034
	N	33	33
<b>Technological Knowledge</b>	Pearson Correlation	.369*	1
	Sig. (2-tailed)	.034	
	N	33	33

\*\*Association is Significant at the 0.05 Level (2 tailed).

Table 4.14 displays the degree and direction of the connection that existed between the two variables. The data demonstrated a moderately good link between instructors' technology knowledge and their performance in ICT and accomplishment  $r(33) = .369$ ,  $p < .034$ ) with a statistical significance threshold of 95% and 31 degrees of freedom. The probability value (p-value) of 0.034 was below the 0.05 alpha hence had statistical significance. That means that teachers’ technological knowledge in ICT and achievement in Mathematics was not a random occurrence. The confidence level indicates that the investigation had a 95% level of confidence in its findings and was positive that they fell inside a specified range of values. In conclusion, the investigation refuted the null hypothesis ( $H_0$ ) that there was no link joining teachers' technological proficiency in using ICT and students' KCSE achievement in Mathematics in Makueni County's public high schools. On the other hand, the alternative hypothesis ( $H_a$ ) that there was a substantial statistical link involving teachers' technological expertise in using

technology and learners' achievement in Mathematics in Makueni County secondary schools was accepted.

According to Handal, Cavanagh, Wood, and Petocz (2011), two considerations should motivate the evaluation of instructors' technological aptitude in the classroom. First, in order to guarantee that learners can attend to an educational program that makes use of the instructional potential offered by technologies, it is crucial to uphold high standards for education in schools. Second, recognizing the strategic value of the present instructors' ICT teaching and learning abilities and systemic professional development initiatives (Polly, McGee & Martin, 2010).

Ayoub, Petra, Jules, and Joke (2015) discovered that pre-service educators' perspectives regarding their understanding and proficiency with using technology in the classroom considerably increased after taking part in pre- and post-assessment evaluations of the TPACKs technological aspects. Meanwhile, Kamau (2014) reported that instructors' poor technology training and inadequate time to finish educational programmes and create tech-savvy classes are obstacles to the incorporation of technology in education.

Educators' incorporation of technical talents into classroom instruction should be assessed by maintaining high-quality teaching standards in schools and guaranteeing that students have access to a curriculum that is relevant to them. It also detects existing teachers' ICT learning and teaching skills, which is useful in developing secondary school professional development programs.

#### 4.6.2 Regression Model Summary on Teachers’ Technological Knowledge in ICT Use and Students’ KCSE Achievement in Mathematics

The results in Table 4.15 of the investigation which intended to ascertain how the variability of mathematical accomplishments depended on technological proficiency in using ICT, are summarized. Table 4.15 shows the model overview for the regression analysis of technological knowledge in ICT and mathematical achievement in Makueni County.

**Table: 4.15: Summary of the Regression Model**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.369 <sup>a</sup>	.136	.109	1.197

a. Predictors: (Constant), Technological Knowledge

b. Dependent Variable: Achievement

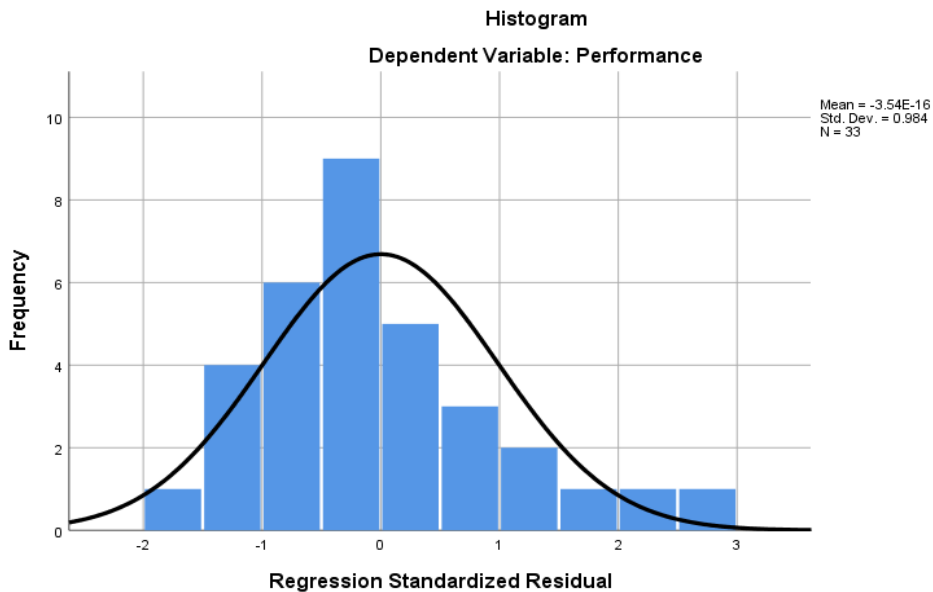
Table 4.15 displays the R value ( $r=.369$ ), indicating a somewhat positive association between instructors' technological competence in ICT use and students' Math achievement. The coefficient of determination,  $R^2=.136$ , demonstrates the magnitude of variation in students' Math achievement that can be explained by instructors' technological understanding in ICT use. The adjusted R-squared value is used to assess the effectiveness of the multivariate regression model. Because the regression model was based on a single variable, the researchers calculated the percentage of students' accomplishment that could be accounted for by instructors' technological competence in ICT use using  $R^2$  values.

Table 4.15's overview of the model demonstrates that Mathematics accomplishment in Makueni County secondary public institutions was explained by 13.6% of the variability on teachers' technological knowledge in ICT use ( $R^2=0.136$ ), with the remaining 86.4%

attributed to other factors affecting Mathematics achievement that were not included in this model due to a lack of data. The usage of ICT by educators during the teaching of Mathematics had a reasonably significant impact on learners' success in the subject because of the relatively big effect size of  $R^2=0.136$ .

#### 4.6.3 Regression Standardized Residual

The study also estimated the mean score of the amount to which teachers' technological competence in ICT integration in Mathematics education influenced students' achievement in Makueni County secondary public institutions. Figure 4.3 displays the analysis' s outcomes.



**Figure 4.3: Impact of Educators' Technological Knowledge in ICT Use on KCSE Achievement in Mathematics**

As shown in Figure 4.3, the average (Mean, M) score was (M=3.54) obtained from students KCSE scores in Mathematics from a total of 33 schools, with a standard deviation SD of (0.98) arising from teachers' technological knowledge in ICT use. As

presented in the figure, the score of Mathematics achievement was normally distributed. Most scores fall around the mean (middle of the distribution). The shape is roughly symmetrical.

#### **4.7 Teachers' Perceptions and ICT Use**

Examining the link joining instructors' opinions of ICTs and learners' accomplishment on the KCSE in Mathematics in Makueni County secondary public institutions was the investigation fourth goal. The investigation asked Mathematics instructors in Makueni County to indicate their concurrence scale on given statements about the opinions they held towards use of computers in the classrooms. The investigation employed a scale from 1 to 5, with 1 denoting 'strongly disagree', 2 denoting 'disagree', 3 denoting 'neutral', 4 denoting 'agree', and 5 denoting 'strongly agree'. Analysis was done on the responses' weighted averages and standard deviations. Weighted averages between 3.50 and 5.00 denoted concurrence to a proposition, whereas 1.00 and 2.60 denoted dissent. According to a weighted average, 'strongly disagree' was denoted by a score between 1.00 and 1.80, 'disagree' by a score between 1.90 and 2.60, 'neutral' by a score between 2.70 and 3.40, 'agree' by a score between 3.50 and 4.20, and 'strongly agree' denoted by a score between 4.30 and 5.00. The researcher also calculated the standard deviation for the questionnaire items, which indicates how much the response deviates from the computed mean. A high standard deviation suggests a broad and diverse response (heterogeneous sample), while a low standard deviation indicates that the replies were similar (homogeneous sample). Table 4.16 displays the analysis outcomes.

**Table 4.16: Instructors’ Perceptions towards Use of Technology**

<b>Assertion</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Mean</b>	<b>SD</b>
Academically, technology use can help students develop a passion for Mathematics	11.8%	14.7%	17.6%	41.2%	14.7%	3.62	0.9
ICT use is beneficial in creating appropriate learning settings suitable for a diversity of student learning modalities/styles	5.9%	26.5%	11.8%	52.9%	2.9%	3.61	0.8
The use of ICT is beneficial in encouraging students to collaborate	5.9%	26.5%	14.7%	50.0%	2.9%	3.58	0.8
By utilizing ICT, learners’ concentration spans can be increased.	5.9%	20.6%	20.6%	50.0%	2.9%	3.54	0.7
Use of ICT is beneficial in assisting teachers in covering content in a timely manner	8.8%	23.5%	14.7%	50.0%	2.9%	3.56	0.8
<b>TOTAL</b>	<b>7.7%</b>	<b>22.4%</b>	<b>15.9%</b>	<b>48.8%</b>	<b>5.2%</b>	<b>3.58</b>	<b>0.8</b>

According to Table 4.16, fostering learners’ interest in Mathematics can be accomplished by incorporating technology into the curricula (M=3.62, SD=0.9), the study additionally showed that teachers’ utilization of technology can help create environments for learning that are appropriate for multiple students’ learning preferences, and ICT usage is beneficial for encouraging student collaboration (M=3.58, SD=0.8). According to Forgasz (2006), it has been shown that instructors’ opinions of their technological abilities and perspectives on the usefulness of ICTs for classroom education are good predictors of how these technologies will be used. Forgasz (2006) agrees that using ICT to increase students’ interest in Mathematics and to develop

educational settings that cater to a variety of learning styles benefits both students and teachers.

Teachers informed this study that use of ICT is supportive in making learners concentrate for longer durations of time while learning ( $M=3.54$ ,  $SD=0.7$ ) and also indicated that use of ICT is useful in helping teachers cover some given subject matter within a short period of time ( $M=3.56$ ,  $SD=0.8$ ). Cavanagh and Mitchelmore (2011) agree that, ICT tools are frequently utilized for low-level tasks like online practice, which have minimal impact on student learning accomplishments in Mathematics, despite the fact that technology has the ability to increase learning and instruction in Mathematics curricula. According to Cavanagh and Mitchelmore (2011), learners' concentration spans can be stretched further through incorporation of technology into instruction. It is also critical to highlight that while ICT use was academically beneficial in increasing students' appreciation for Mathematics, it was strongly contested that ICT use was beneficial in assisting teachers to cover syllabus on time.

During interviews, principals were asked whether they believed teachers achieved high scores on the TPACK sub-scales in teaching Mathematics as a result of ICT use. Each of the 25 respondents firmly concurred that educators should be knowledgeable about technology, TPACK, pedagogy, and content. When asked about the same topic, a principal from Mbooni sub-county stated:

*Teachers' understanding of TPACK is crucial in accomplishing successful technology use in teaching. Teachers understanding of the relationship between technology, content and pedagogy may influence their classroom practices.*

*Teachers' positive attitude have positive effects on students' achievement (results in increased retention, makes learning more enjoyable), using technology effectively in classrooms reduces teaching time (timely coverage of syllabus).*

*Curriculum based on the use of computers yields to better performance compared to those years when traditional teaching methods (use of blackboards, chalk and lecture methods) were used.*

*Technology increases students' levels of confidence, encourages collaborative learning, makes school work easier and arouses interest and attentiveness among learners.*

Although teachers were excited about using ICT, a few hurdles kept them off from fully utilizing the technology. During focus group discussions, students' views were sought regarding their perception on ICT in learning of Mathematics. Majority felt that use of ICT would prolong their concentration span, make learning more enjoyable and hence result in improved scores in Mathematics. Some students had this to say:

*Computers are impacting positively on our academic success, academic access and other curricular issues. Despite challenges such as under-utilization of ICTs by our teachers, I perceive ICT in my learning as useful (Student, Makueni sub-county). My perception is that the usage of ICT will prolong my concentration span, make learning more enjoyable and hence improve my score in Mathematics (Student, Mukaa sub-county). I disagree with the argument that use of ICT in our learning is a waste of time and I do not fear interacting with digital technologies (Student, Nzau sub-county).*

Although most schools had computers, it was noticed during focus group conversations with learners that they were only available in a few places, such as the principal office and the main typing pool. According to the survey, the availability of proper ICT tools for students was low and even in schools with computers, there were high student-to-

computer ratios ranging from 5:1 and above. The purchase of ICT infrastructure was made possible with the aid of various parties including parents, government, NGOs, and private organizations. The students felt that they received little or no support from the school administration in using ICT for Mathematics education as many teachers acquired ICT tools like scientific calculators and smart phones at their own cost.

Other students appeared to agree with the statement that Mathematics instructors received assistance from school principals to use ICT into teaching, particularly in schools with free Wi-Fi and laptops, in just a few situations during focus group talks. Tsai (2012) argued that incorporating technology into Mathematics instruction can positively affect how students feel about the subject and their attitudes towards it. This is as a result of the accessibility of various resources that help them to overcome specific learning challenges, access to a wider range of test questions beyond what their teacher may provide, and exposure to diverse learning experiences.

#### **4.7.1 Hypothesis Testing**

**H<sub>0</sub>4:** There is no significant connection joining instructors' perceptions towards ICT use and students' KCSE Mathematics achievement in Makueni County public secondary institutions.

**H<sub>a</sub>4:** There is a significant connection joining instructors' perceptions towards ICT use and students' KCSE Mathematics achievement in Makueni County public secondary institutions.

All indicators relating to teachers' perception of ICT use (beliefs or opinions) were combined, and the variables were subjected to Pearson's moment correlation coefficient

analysis to ascertain any meaningful connection joining instructors’ perception of ICT use and learners’ accomplishment in Mathematics in Makueni County public secondary schools. Table 4.17 displays the analysis outcomes.

**Table 4.17: Correlation between Instructors’ Perception of ICT Use and Students’ KCSE Achievement in Mathematics.**

		Achievement	Teachers’ Perception
<b>Achievement</b>	Pearson Correlation	1	.087
	Sig. (2-tailed)		.626
	N	34	34
<b>Teachers’ Perception</b>	Pearson Correlation	.087	1
	Sig. (2-tailed)	.626	
	N	34	34

\*\*Association is Significant at the 0.01 Level (2 tailed).

The magnitude and direction of the link that existed between instructors’ opinions of using ICT and students’ accomplishment in Mathematics are illustrated in Table 4.17. The results demonstrated a slight association linking instructors' perceptions of ICT use and students' achievement in Mathematics ( $r(34) = .087, p = .626$ ) with 32 degrees of freedom at 99% confidence level, but without statistical significance. A p-value (probability value) of (.626) was greater than the 0.05 alpha, indicating that there was no statistical significance. That is, there was only a 5% chance that the two variables, teachers' impression of ICT use and achievement in Mathematics, happened by chance. The study accepted the null hypothesis ( $H_0$ ) that there is no significant connection joining instructors’ perceptions towards ICT use and students’ Mathematics achievement on the Kenya Certificate of Secondary Education (KCSE) in Makueni County secondary public institutions. On the other hand, the alternative hypothesis ( $H_a$ ), which posits a

significant connection joining instructors' perceptions towards ICT use and students' Mathematics achievement on the Kenya Certificate of Secondary Education (KCSE) in Makueni County's public secondary institutions, was rejected.

Secondary school Mathematics instructors who had a favourable attitude towards computers said that computers may help with Mathematics instruction and learning. For computer technology to be successfully incorporated into teaching and learning, technical expertise and computer proficiency are prerequisite, making them the most important criteria in encouraging its usage in Mathematics instruction.

#### **4.7.2 Regression Model Summary on Teachers' Perception of ICT Use and Students' KCSE Achievement in Mathematics**

The aim of this investigation was to determine how much educators' opinions about the use of technology in the classroom has impacted on the variability of students' Mathematics achievement. Table 4.18 illustrates the regression analysis model summary for Mathematics achievement in Makueni County and teachers' perception of ICT use.

**Table: 4.18: Summary of the Regression Model**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.087 <sup>a</sup>	.007	-.024	1.26499

a. Predictors: (Constant), Teachers' Perception

b. Dependent Variable: Achievement

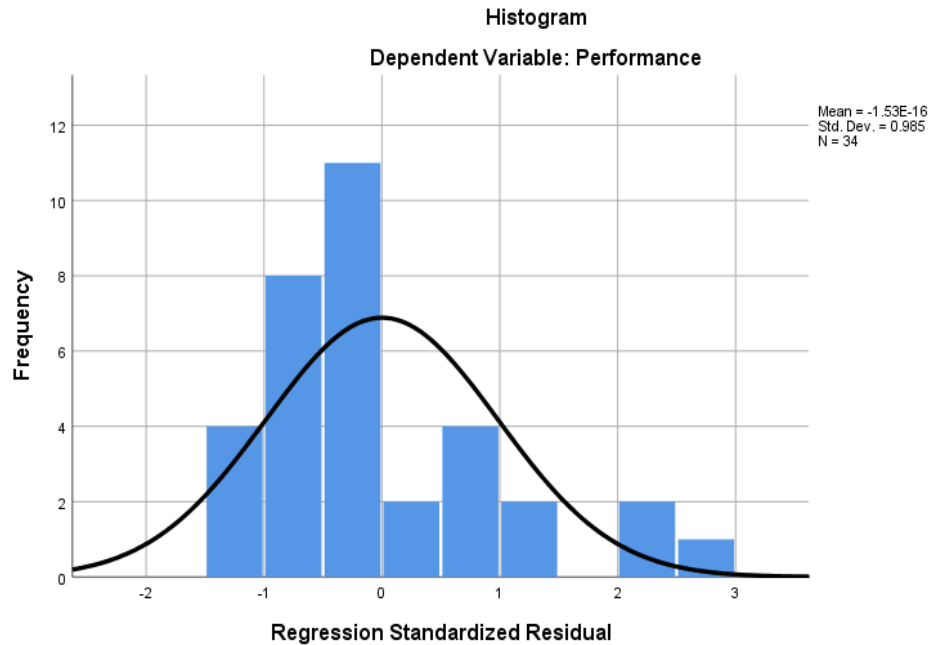
The value of R ( $r=.087$ ) indicates a weak positive association between instructors' perceptions of ICT use and students' KCSE Mathematics success. The R-square value of .007 reveals the amount of variability in students' achievement in Mathematics that can

be explained by teachers' perception of ICT use. The adjusted squared value of R is used to judge the appropriateness of multivariate regression model. However, because this model was based on only one variable, this study used  $R^2$  value to determine the percentage of students' Math achievement that could be gauged by instructors' opinion of ICT use. Table 4.18's model summary results reveal that in Makueni County, 0.7% of the variation in students' Mathematics accomplishment depended on how instructors' perceived the usage of ICT ( $R^2=.007$ ), while the remaining 99.3% unaccounted for variation, can be explained by other factors that influence Mathematics achievement in government sponsored secondary institutions which were not included in this model due to data unavailability. The small effect size of  $R^2=.007$  suggested that teachers' perception of ICT use during instruction of Mathematics had very little impact on students' achievement in Mathematics.

#### **4.7.3 Regression Standardized Residual**

The study also estimated the mean score of the amount to which opinions of educators towards incorporation of technology into Mathematics lessons influenced students' KCSE achievement in Mathematics in Makueni County public secondary institutions.

Figure 4.4 gives the outcomes of the examination.



**Figure 4.4: Impact of Teachers’ Perception of ICT Use on KCSE Achievement in Mathematics**

As shown in Figure 4.4, the average (Mean, M) score was (M=1.53) obtained from students’ KCSE scores in Mathematics from a total of 34 schools, with a standard deviation SD of (0.99) resulting from teachers’ perception of ICT use. Most scores fall around the mean (middle of the distribution). The shape is roughly symmetrical. It can therefore be concluded that Mathematics scores were normally distributed.

#### **4.7.4 Students’ Performance on Internal Tests in Mathematics**

In as far as assessing students' academic achievement is concerned, the researcher tallied the mean scores of the first and second terms earned by students in Mathematics, as well as their respective mean grades. As a result, teachers were asked to fill in the mean Mathematics score earned by their particular pupils in both the first and second terms, and Table 4.19 shows the outcomes.

**Table 4.19: Students' Achievement in Terms of Mean Score**

<b>Achievement</b>	<b>First Term Mean Score</b>	<b>Second Term Mean Score</b>	<b>Mean Score</b>
<b>Mean</b>	3.3727	3.5060	3.4394
<b>Standard Deviation</b>	1.2499	1.2627	1.2563
<b>Minimum</b>	1.7120	1.9230	1.8175
<b>Maximum</b>	6.5670	6.7230	6.6450

According to Table 4.19, the average achievement in Mathematics was an average score of 3.4394, which is equivalent to a grade D with a variation of 1.26 from the mean; the best score was an average score of 6.5670, which is equivalent to a grade C+, and the worst score was 1.7120, which is equivalent to a grade D-. Table 4.20 shows results of Mathematics achievement in grades.

**Table 4.20: Mathematics Achievement in Grades**

<b>Grades</b>	<b>Frequency</b>	<b>Percentage</b>
<b>C+</b>	1	2.9
<b>C</b>	2	5.9
<b>D+</b>	7	20.6
<b>D</b>	10	29.6
<b>D-</b>	14	41.2
<b>TOTAL</b>	<b>34</b>	<b>100</b>

Table 4.20 shows that nearly half, 14 out of 34 (41.2%) of the students performed poorly in Mathematics by scoring grade D-, followed by nearly a third; 10 out of 34 (29.6%) who scored grade D plain and below, a quarter; 7 out of 34 (20.6%) who scored grade D+

in Mathematics. It was interesting to note that only 1 out of 34 (2.9%) of the students attained grade C+ and 2 out of 34 (5.9%) scoring grade C plain, which generally showed poor performance.

During the interviews, principals were asked to comment on whether teachers' confidence in the utilization of ICT improves students' achievement in Mathematics. More than half of the respondents (14 out of 25) expressed their disappointment that although majority of their teachers had basic ICT skills, they had techno-phobia. All the 25 respondents however unanimously underscored the pivotal role teachers' confidence plays towards ICT use. In 2007, Peralta and Costa undertook a study on the competencies and self-belief of 20 instructors when it comes to employing technology in the classroom. They discovered that technological proficiency among instructors in Italy contributes to greater comfort with using ICT.

This therefore means that schools should endeavour to facilitate teachers in ICT training programs to equip them with ICT skills. This would consequently boost their conviction and enable them to employ ICT in the classroom, perhaps resulting to improved performance in academics. When interviewed on this subject, a principal from Nzau sub-county had this to say:

*Few teachers are confident users of ICTs and the limited confidence adversely affects the way lessons are conducted resulting to poor performance in Mathematics. However, improved access to ICTs, teacher motivation and on-going teacher training can boost their confidence while utilizing resources and technical tools, resulting to enhanced performance in Mathematics.*

During focus group discussions with the students, the study discovered that 30% of the students fell in the 0 percent to 7 percent bracket in Mathematics achievement, while 60% lay in the 8 percent to 50 percent range. The students also reported that only 10% of them achieved performance percentages ranging from 50% to 100%. The prohibitive cost of bringing new technology into the classroom, tension from teachers confiscating ' personally owned' students' devices, difficulties in accessing power socket outlets, and when students find information online that contradicts what the teacher is teaching, were the challenges that hampered technology utilization into Mathematics lessons. Unavailability of suitable infrastructure, such as computer laboratories, insufficient machines, and legitimate software, as well as a lack of both technical and administrative assistance, were noted as barriers by the students. Due to lack of competent and confident teachers, students indicated that not all teachers believed in using digital technologies and so failed to alter courses, fit with learning goals, and incorporate technology into curricular material.

The survey also established that there was a need for more teachers to safeguard students' online conduct (safety, legal hazards, and privacy) as well as in the classroom (theft and locking of devices). In addition, students said that certain educators had an adverse viewpoint and perception about computer use, which resulted in a lack of computer-related classroom management; they cited lack of time-tabling structure that could accommodate technology-integrated lessons to avoid being distracted by computer games or watching videos as an example. Students proposed that schools offer suitable ICT equipment and utilize technology by creating a virtual learning calendar with due dates,

assessment dates, and activities that students may sync to their phones to address these difficulties.

The principals interviewed suggested that teacher colleges should emphasize constructivism and student-centered education in programmes meant for training of teachers. In an effort geared towards impacting teacher opinions favorably and raising the teacher-pupil ratio to allow customized ICT education, it is necessary to equip teachers with proper training before the commencement of school ICT programs, concentrating on curriculum content and delivery techniques (pedagogy). They advised that the government should ensure that all schools are linked to a reliable and appropriate electricity supply.

#### **4.7.5 Multiple Regression Analysis on the Correlation between ICT Use and Students' KCSE Achievement in Mathematics**

The investigation looked at the link between ICT use by instructors and students' Mathematics attainment in national assessments in Makueni County secondary public institutions using multiple regression analysis. The model summary R-square value was additionally calculated by the researcher. The analysis used the following model to establish connections between the dependent and independent variables:

#### **4.7.6 Model Summary on Correlation between ICT Use and Students' KCSE Achievement in Mathematics**

Table 4.21 presents the results the study's model summary for regression analysis of the link between instructors' usage of ICT and students' attainment on the Mathematics KCSE exam.

**Table 4.21: Model Summary of the Regression Analysis**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.384 <sup>a</sup>	.147	.021	1.24515

a. Predictors: (Constant), Teachers' Perception, Content Knowledge, Pedagogical Knowledge, Technological Knowledge

b. Dependent Variable: Achievement

Calculating the R-square value allowed the investigator to ascertain the percentage of the dependent variable's (Mathematics achievement) variance that the independent variable (instructors' use of technology) could account for, as presented in Table 4.21. Specifically, the R Square column in Table 4.21 shows that the value of 0.147, which represents 14.7%, explains the variability in Mathematics achievement by secondary school students related to the combination of pedagogical, technological, and topic knowledge in Mathematics instruction. In other words, 14.7% of the variation in students' KCSE achievement in Mathematics in Makueni County could be attributed to teachers' use of ICT, while other factors accounted for the remaining variability.

#### **4.7.7 Regression Analysis of Mathematics Achievement and Teachers' ICT Use**

A group of statistical techniques known as regression analysis are used to estimate the relationships between or among the variables under investigation. It can be applied to determine the degree to which variables are connected, as well as to predict how connected they will be in the future. The  $Y = \lambda_0 + \lambda_1 X_1 + \lambda_2 X_2 + \lambda_3 X_3 + \lambda_4 X_4$  regression analysis model was employed.

Where; Y = Achievement in Mathematics;  $\lambda_1$ - $\lambda_4$ , coefficients of the independent variables and X<sub>1</sub>, X<sub>2</sub>, X<sub>3</sub>, and X<sub>4</sub>= indicators of teacher use of information communications technology. In connection with modifications to the independent variables, change is manifested by the alpha ( $\lambda$ ) coefficient (slope). Table 4.22 displays the results.

**Table 4.22: Regression Analysis of Teachers’ Use of Information Communications Technology and Students’ KCSE Achievement in Mathematics**

		Coefficients <sup>a</sup>				
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.769	1.155		1.532	.137
	Content Knowledge	-.087	.449	-.059	-.194	.114
	Pedagogical Knowledge	-.100	.528	.052	.190	.421
	Technological Knowledge	.810	.537	.449	1.510	.034
	Teachers’ Perception	-.144	.344	-.111	-.418	.626

a. Dependent Variable: Achievement

Table 4.22, which depicts the regression analysis equation, details how the dependent variable’ s value (Math accomplishment) changed in relation to the independent variables’ unit changes that is equivalent to the independent variables’ unit change. The equation for regression analysis generated from this output was represented as:  $Y = (1.769) - (0.087) X_1 - (0.100) X_2 + (0.810) X_3 - (0.144) X_4 + \epsilon$

Where: Y = Achievement in Mathematics.

X<sub>1</sub> = Content Knowledge

X<sub>2</sub> = Pedagogical Knowledge

X<sub>3</sub> = Technological Knowledge

X<sub>4</sub> = Teachers’ Perception;  $\epsilon$  = error term

The constant (1.769) represents the y-intercept. The error term quantifies the amount of variance that the intercept as well as the slope terms do not predict. Table 4.22's results demonstrate a forecast that there is a comparable 8.7% decline in students' KCSE achievement in Mathematics for every unit increase in instructors' topic understanding of ICT use, there was a 10.0% decline in students' KCSE achievement in Mathematics for every unit that instructors' pedagogical expertise of ICT use increased, and for every unit increase in teachers' perception towards use of ICT, there was a corresponding 14.4% decrease in students' KCSE achievement in Mathematics. A fascinating finding of the investigation was that students' KCSE Mathematics achievement increased by a very high comparable rate of 81.0% for every unit increase in instructors' technological competence in ICT use. This suggests that incorporating instructors' technological expertise into ICT was the only practical strategy to enhance students' achievement in Mathematics.

Table 4.22 demonstrates that the variables; subject matter expertise, pedagogical expertise, and teachers' perception towards use of technology, were not statistically significant predictors of students' KCSE achievement in Mathematics, except for technological knowledge, which was significant at  $\alpha = 0.05$ . Based on the correlation direction and statistical significance, regression analysis was appropriate in determining which ICT integration variables were important and which could be disregarded, as well as how those variables interacted with each other to improve Mathematics achievement in the public secondary schools studied. The study found that technological knowledge in ICT use was the primary significant predictor of students' KCSE achievement in Mathematics, while the other variables were not significant.

## CHAPTER FIVE

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Introduction

An overview of the investigation findings and recommendations made in light of them is provided in this chapter. Last but not least, based on the study' s findings, suggestions for policy and practice are provided, along with suggestions for future research.

This investigation sought to determine the association linking instructor' s ICT use and students' achievement in Mathematics on national exams in Makueni County public secondary schools. In the field of pedagogical ICT use, the goal was to offer direction for future practice and policy. Four specific objectives were set out: The first objective aimed at determining the correlation between instructors' content expertise in ICT use and learners' KCSE achievement in Mathematics in Makueni County government owned secondary institutions. The second goal sought to confirm the correlation between educators' pedagogical proficiency in ICT use and pupils' KCSE achievement in Mathematics in Makueni County government owned secondary institutions. The third goal was to evaluate the correlation linking instructors' knowledge of technology in ICT use and students' KCSE achievement in Makueni County government owned secondary institutions. Last but not least, the fourth goal was to assess the correlation linking teachers' perception of ICT use and students' KCSE achievement in Makueni County government owned institutions.

The study used explanatory mixed methods sequential design. 25 school administrators from Makueni county secondary public institutions were selected as the study research participants, along with 42 Mathematics instructors, and 375 form 3 students. To gather

comprehensive quantitative and qualitative data, focus groups, questionnaires, and other data gathering tools were employed by the researcher. This approach ensured that the data was reliable and provided an in-depth understanding of the connection between ICT usage and Maths student accomplishment. To accomplish the goals of the study and test the hypotheses, data were analyzed using descriptive statistics like mean and standard deviation as well as inferential statistics like correlation and regression analysis. Furthermore, qualitative data were coded and grouped into topics for thematic analysis so as to address the objectives of the research. The chapter also highlights the study's findings, conclusions, and recommendations.

## **5.2 An Overview of the Study's Results**

### **5.2.1 Teachers' Content Knowledge in ICT Use and Achievement in Mathematics**

According to the teachers' responses, they expressed confidence in their proficiency to effectively incorporate mathematical concepts, technologies, and pedagogies in their lessons. They also reported being capable of selecting suitable technologies that aligned with mathematical culture, teaching approaches, and learning objectives. In addition, they stated that they could utilize classroom technologies that complemented their instructional strategies and facilitated student learning.

According to the study's results, computers were successfully utilized by instructors to convey important information to students and colleagues to a significant degree. They were also found to be capable of utilizing various technologies to assist students in pursuing their individual goals and participating actively in Mathematics lessons.

The study also revealed that educators could guarantee that all students had fair access to digital materials and tools for studying Mathematics, facilitate inter-cultural

understanding by engaging students with different cultures through technology, and explore innovative technological solutions that enhance students' mathematical learning by taking part in online learning groups.

The results showed that instructors were successful in delivering courses that effectively incorporated mathematical ideas, technologies, and teaching methodologies, but were unsuccessful in enabling inter-cultural learning through engaging students with diverse backgrounds. A slight positive correlation between students' achievement in Mathematics and instructors' content understanding of using ICT was discovered by the study, however the multiple regression analysis indicated that statistical significance for the correlation was not met since the probability value (p-value) was more than 0.05

### **5.2.2 Teachers' Pedagogical Knowledge in ICT Use and Achievement in Mathematics**

The investigation's second goal was to find a link connecting instructors' pedagogical expertise in usage of ICT and students' KCSE Mathematics achievement in Makueni County secondary public institutions.

- i. The study's results demonstrated that instructors may use computers to evaluate their instruction in light of theoretical principles, offer customized mathematical input at an appropriate level of complexity, and select real-world mathematical digital resources that catered for their students' requirements.
- ii. The findings also showed that Mathematics teachers could select digital activities which enhanced the learners' inter-cultural awareness, they could as well choose an appropriate digital approach to teach Mathematics to learners and could plan

when and how to use the target language, including meta-language they needed in the classroom.

- iii. The investigation in addition manifested that instructors could identify mathematical problems experienced by learners, teachers could also design Mathematics courses around the requirements of the curriculum and were as well aware of the contextual factors that could inhibit/promote the teaching and learning of Mathematics.
- iv. Additionally, it was demonstrated that pedagogues were open to experimenting with novel methods of Mathematics instruction despite not being well-versed in current digital research in the field. Furthermore, teachers agreed that they were successful in selecting appropriate digital techniques to teach Mathematics to students, as well as in detecting mathematical challenges encountered by students.
- v. The results of the investigation indicated a marginally beneficial association linking tutees' proficiency in Mathematics and the instructors' expertise of ICT use for pedagogy. However, multiple regression analysis model showed the probability value being more than 0.05 ( $0.421 > 0.05$ ), indicating that the instructors' pedagogical knowledge in ICT use was not a significant predictor of the students' Math achievement.

### **5.2.3 Teachers' Technological Knowledge in ICT Use and Achievement in Mathematics**

The third objective examined the connection linking instructors' technological proficiency in ICT use and students' KCSE Mathematics accomplishment in Makeni County secondary public institutions.

- i. Teachers knew about technologies that they could use to teach Mathematics.
- ii. The study further revealed that teachers could learn technology easily to teach Mathematics and kept being updated with new emerging technologies, though the level of using ICT in instructing Mathematics was low.
- iii. According to the study, there is a moderately substantial positive link connecting instructors' ICT usage prowess and students' Math achievement. The multiple regression analysis model yielded a probability value of  $0.034 < 0.05$ , manifesting that students' performance in Mathematics was significantly predicted by instructors' technological proficiency in ICT use.

#### **5.2.4 Teachers' Perception of ICT Use and KCSE Mathematics Achievement**

The investigation's fourth goal was to see how pedagogues' views on utilization of ICT related to students' KCSE achievement in Mathematics in Makueni County secondary public institutions.

- i. The examination's findings demonstrated that teachers' incorporation of technology is academically beneficial in developing students' excitement for Mathematics; the study also highlighted that teachers' use of ICT is beneficial in establishing acceptable studying settings that accommodate a range of student learning styles and that usage of ICT aids in encouraging student cooperation.
- ii. Teachers informed this study that the usage of ICT is beneficial in assisting teachers to cover classwork in a short amount of time, as well as in assisting students to stretch their focus spans further.

iii. The analysis found a marginally positive link connecting instructors' views towards usage of ICT and achievement of students in Mathematics, with  $\alpha = .05$  being the threshold of significance, the analysis discovered a weak positive association between teachers' perceptions towards ICT usage and achievement of students in Mathematics. The multiple regression analysis model produced a probability value of  $0.626 > 0.05$ , manifesting that instructors' opinions of ICT was not a significant predictor of students' Math achievement.

### **5.3 Conclusions**

The investigation's primary objective was to determine how instructors' ICT proficiency and students' Math achievement in Makuni County government owned secondary institutions linked to one another. According to this investigation, instructors ought to be familiar with TPACK model components in terms of the technical content range in order to fulfill their teaching obligations. This includes understanding the potential and constraints of various technological instruments in connection to instructional designs and tactics suitable for the field and the students' developmental stage.

The study's second goal was to ascertain the connection between students' KCSE achievement in Mathematics in Makueni County government owned secondary institutions and instructors' expertise of ICT use. ICT could enhance students' cognitive skills according to the study's hypothesis, when used to teach Mathematics, which cannot be assessed through traditional exams, making them more proficient and analytical in their test responses.

The investigation's third goal was to determine how students' achievement on their KCSE Mathematics at Makueni County government owned secondary institutions was

related to instructors' technological proficiency in using ICT. According to the findings, pupils' outcomes are enhanced when teachers use ICT into their instruction.

The final objective aimed to determine the correlation between teachers' attitudes towards ICT use and their students' KCSE achievement in Mathematics in Makueni County government sponsored secondary institutions. According to the inquiry, it can be concluded that opinions and views of instructors towards technology as a tool for improving performance are crucial factors that must be considered for successful ICT integration in teaching.

#### **5.4 Recommendations**

The following suggestions are given in light of the investigation's findings:

##### **5.4.1 Teachers' Content Knowledge in ICT Use and Achievement in Mathematics**

This investigation offers the following suggestions in relation to the first objective;

- i. Teachers ought to make sure that they teach concepts that include mathematical ideas appropriately, as well as teaching approaches and classroom technologies that improve the content they teach, the manner in which they teach, and what pupils learn.
- ii. To incorporate content knowledge, teachers should use technological advances effectively to convey relevant knowledge to students and colleague teachers; in order to assist students in pursuing their unique aspirations, they should also make use of a variety of technology; alternatively, they could make use of a range of technological tools that encourage participation from the students during Maths lessons.

#### **5.4.2 Teachers' Pedagogical Knowledge in ICT Use and Achievement in Mathematics**

The investigator offered the following suggestions in relation to goal two;

- i. Teachers ought to critically analyze their teaching based on theoretical ideas, by providing target mathematical input at a suitable level of complexity and select authentic mathematical resources that suit student needs.
- ii. To enhance teachers' pedagogical knowledge, teachers should identify mathematical problems experienced by learners and Mathematics courses should be designed around the curricula needs, and teachers should be aware of the contextual aspects that may restrict or enhance Mathematics education.
- iii. Mathematics teachers should be informed of current developments in the area of Mathematics education and be willing to try out new approaches of teaching Mathematics.

#### **5.4.3 Teachers' Technological Knowledge in ICT Use and Achievement in Mathematics**

The outcomes of the third goal were used to inform the following suggestions;

- i. Secondary schools ought to invest in different technologies used in instructing Mathematics.
- ii. Government should connect all public secondary schools with electricity.

#### **5.4.4 Mathematics Achievement and Teachers' Perception of ICT Use**

Using the fourth objective as a foundation, study's recommendations are as follows;

- i. To change teachers' perception of ICT use, principals should give teachers incentives, provide adequate technological facilities and ensure that ICT is used to assist the provision of suitable instructional settings.
- ii. Teacher training colleges should offer programs that emphasize constructivism and student-centered education. Before the commencement of school ICT programmes begin, it is essential to equip instructors with the right training so that they can feel confident using technology in the classroom.

### **5.5 Research Ideas for Further Studies**

- i. In order to generalize the study's findings more broadly, similar studies should be conducted in more Kenyan counties.
- ii. Comparable investigation should be conducted to ascertain whether classroom ICT use is associated with learner outcomes other than academic success.
- iii. To compare and contrast the study findings, a similar research should be conducted in privately owned secondary schools.

## REFERENCES

- Agyei, D., & Voogt, J. (2012). Developing Technological Pedagogical Content Knowledge in Pre-service Mathematics Teachers, Through Teacher Design Teams. *Australasian Journal of Educational Technology*, 28(4), 547-564.
- Ang' ondi, E. (2013): Teachers Attitudes and Perceptions on the Use of ICT. World on Computers in Education. July 2-5; Torun, Poland.
- Archambault, L. M., & Crippen, K. (2009). Examining TPACK among K-12 Online Distance Educators in the United States. *Contemporary Issues in Technology and Teacher Education*, 9(1), 71-88.
- Argentin, G., Comi, S., Gui, G. Origo, F. & Pagani, L. (2015). *Is It the Way They Use It? Teacher, ICT and Student Achievement*: University of Milano Bicocca, Bergamo.
- Arnseth, H. C., & Hatlevik, O. E. (2010). Challenges in Aligning Pedagogical Practices and Pupils' Competencies with the Information Society's Demands: The case of Norway. In S. Mukerji & P. Tripathi (Eds.), *Cases on Technological Adaptability and Transnational Learning: Issues and Challenges*. Hershey: IGI global.
- Ayoub, K. Petra, F., Jules, P. & Joke, P. (2015). ICT Use in Science and Mathematics Teacher Education in Tanzania: Developing Technological Pedagogical Content Knowledge: *Australasian Journal of Educational Technology*, 2015, 31(4).
- Baek, Y.G., Jong, J., & Kim, B. (2008). What Makes Teachers Use of Technology in the Classroom? Exploring the Factors Affecting Facilitation of Technology with a Korean Sample. *Computers and Education*, vol.50, no. 8, pp. 224-234.
- Baker, T. L. (1994). *Doing social research* (2<sup>nd</sup> Ed.). New York: McGraw. Hill Inc.
- Baker, J. (2019). 'Major Distraction': Australian Primary School Dumps iPads, Returns to PaperTextbooks. <https://www.stuff.co.nz/technology/digital-ng/111691580/major-distraction-australian-primary-school-dumps-ipads-returns-to-paper-text-books>.
- Beavers, S., Lounsbury, W., Richards, K., Huck, W., Skolits, J. & Esquivel, S. (2013). *Practical Considerations for Using Exploratory Factor Analysis in Educational Research*. *Practical Assessment Research & Evaluation*, 18(6), 1– 13.
- Bingimlas, K. A. (2009): Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of the Literature. *Eurasia Journal of Mathematics, Science and Technology Education*, Vol.5 (3), 235-245.

- Bosamia, S. R. (2013). Factors Affecting Teachers' Use of ICT: A Review of Literature, *Journal of Information Technology for Teacher Education* 9 (3), 319-342.
- Bowers, J. S., & Stephens, B. (2011). Using Technology to Explore Mathematical Relationships: A framework for Orienting Mathematics Courses for Prospective Teachers. *Journal of Mathematics Teacher Education*, 14, 285– 304.
- Cavanagh, M., & Mitchelmore, M. (2011). Learning to Teach Secondary Mathematics Using an Online Learning System. *Mathematics Education Research Journal*, 23, 417-435.
- Cassim, V., (2010). *The Pedagogical Use of ICTs for Teaching and Learning Within Grade 8 Classrooms in South Africa*. Unpublished Masters Thesis. University of the Northwest, Potchefstroom.
- Chauhan, S., (2017). A Meta-analysis of the Impact of Technology on Learning Effectiveness in Elementary Schools. *Computer Education* 105, 14– 30.
- Cheng K, & Leung A. (2015). A Dynamic Applet for the Exploration of the Concept of the Limit of a Sequence. *Int J Math Educ SciTechno*; 46(2): 187– 204.
- Cheung, A. C. K., Slavin, R. E., (2013). The Effectiveness of Educational Technology Applications for Enhancing Mathematics Achievement in K-12 Classrooms: A Meta-analysis. *Educ. Res. Rev.* 9, 88– 113.
- Christensen, R. & Knezek., (2000). Refining best Teaching Practices for Technology Integration: KIDS Project Findings for 1999-2000. Denton, TX: Institute for the Integration of Technology into Teaching and Learning (IITTL).
- Creswell J. W. & Clark P. & Vicki L (2003). *Designing and Conducting Mixed Methods Research*, London: Sage Publications
- Creswell, J. W. (2009). Research design: Qualitative, quantitative and mixed methods approach. California: Sage Publications, Inc.
- Davis, L.L. (1992). Instrument Review: Getting the Most from your Panel of Experts. *Applied Nursing Research*, 5, 194– 197.
- Dawson, S., Heathcote, L., & Poole, G. (2010). Harnessing ICT Potential: The Adoption and Analysis of ICT Systems for Enhancing the Student Learning Experience. *International Journal of Educational Management*, 24(2), 116-128.

- Delen, E., & Bulut, O., (2011). ‘ The Relationship between Students’ Exposure to Technology and their Achievement in Science and Math.’ . TOJET: The Turkish Online Journal of Educational Technology – July 2011, 10(3), 187-193
- Demir, S., & Basol, G., (2014). Effectiveness of Computer-assisted Mathematics Education (CAME) over Academic Achievement: A Meta-Analysis Study. *Educ. Sci. Theor. Pract.*14 (5), 2026– 2035.
- Field, A. (2009). *Discovering Statistics Using SPSS*. London: Sage
- Forgasz, H. (2006). Factors that Encourage or Inhibit Computer Use for Secondary Mathematics Teaching. *Journal of Computers in Mathematics and Science Teaching*, 25, 77-93.
- Fraenkel, J. R. & Wallen, N. E. (2010). *How to Design and Evaluate Research in Education*. New York: McGraw Hill.
- Gay, L. (1992). *Educational Research: Competencies for Analysis and Application*. New York: Macmillan Publishing Company.
- Giannakos, M., Doukakis, S. & Pappas, O. (2015). Investigating Teachers’ Confidence on Technological Pedagogical and Content Knowledge: An Initial Validation of TPACK Scales in K-12 Computing Education Context. *Journal of Computers in Education*, 2, (1) pp. 43– 5
- GoK (2006). *National Information and Communication Strategy (ICT) for Education and Training*. Nairobi: Government Printers.
- GoK (2013). *Basic Education Act. National Council for Law Reporting*, Nairobi. <http://www.techtargget.com/contributor/Margaret-Rousehttps://mystudentoices.com/what-exactly-is-student-centered-learning-8f01b37600https://www.youtube.com/watch?v=7NwxMyqUyJw> on 14th November, 2018.
- Gorder, L. M. (2008). A Study of Teacher Perceptions of Instructional Technology Integration in the Classroom. *Delta Pi Epsilon Journal*, vol. 50, no. 2, pp. 63-76.
- Graham, C. R., Burgoyne, N., Cantrell, P., Smith, L., St Clair, L., & Harris, R. (2009). Measuring the TPACK Confidence of In-service Science Teachers. *Tech Trends*, 53(5), 70-79.

- Hamidi, F., Meshkat, M., Rezaee, M., & Jafari, M. (2011). Information Technology in Education. *Procedia Computer Science*, 3, 369-373.
- Handal, B. et al (2011). 'Factors Leading to the Adoption of a Learning Technology: The Case of Graphics Calculators', *Australasian Journal of Education Technology*, vol. 27, no. 2, pp. 343-360.
- Hardman, J. (2015). Pedagogical Variation with Computers in Mathematics Classrooms: A Cultural Historical Activity Theory Analysis. *PINS* 48, 47– 76.
- Hardy, B. & Bryman, L. (2009). *Educational Research: Quantitative, Qualitative and Mixed Approaches* (2nd Ed.). Boston, MA: Pearson A and B.
- Hare, H. (2007). Survey of ICT in Education in Tanzania. In G. Farrell, S. Isaacs, & M. Trucano (Eds.). *Survey of ICT and Education in Africa* (Vol. 2: 53 Country Reports. Washington, DC: infoDev / World Bank.
- Hegedus, S., Tapper, J., & Dalton, S. (2016). Exploring how Teacher-related Factors Relate to Student Achievement in Learning Advanced Algebra in Technology-enhanced Classrooms. *Journal of Mathematics Teacher Education*, 19(1), 7-32.
- Hew, K. F., & Brush, T. (2007). Integrating Technology into K-12 Teaching and Learning: Current Knowledge Gaps and Recommendations for Future Research. *Educational Technology Research and Development*, vol. 55, pp. 223-253.
- Hill, C. et al. (2008). Unpacking Pedagogical Content Knowledge: Conceptualizing and Measuring Teachers' Topic-specific Knowledge of Students. *Journal for Research in Mathematics Education*, 39, 372-400.
- Jammal, G. J., Jemmima, R. S & Said, P. M. (2012). *Teachers' Use of Educational Technology in U.S. Public Schools: 2009* (NCES 2010-040). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.
- Kaffash, H., Kargiban, Z., Kargiban, S and Ramezani M. (2010). A Close Look into the Role of ICT in Education. " *International Journal of Instruction*", July 2010. Vol.3, No.2

- Kafyulilo, A., Fisser, P. & Voogt, J. (2014). Determinants of the Sustainability of Teacher Design Teams as a Professional Development Arrangement for Developing Technology Integration Knowledge and Skills. In M. Searson & M. Ochoa (Eds.). *Proceedings of Society for Information Technology & Teacher Education International Conference 2014* (pp. 2130-2136). Chesapeake, VA: AACE.
- Kamau, L., M. (2014). “ Technology Adoption in Secondary Mathematics Teaching in Kenya” . An Explanatory Mixed Methods Study. Dissertations – all.paper122
- Kenya Institute of Education (2005). ICT Adoption in Secondary Schools. Nairobi: KIE.
- Kafyulilo A., (2011) Practical Use of ICT in Science and Mathematics Teachers’ Training at DUCE. Unpublished Thesis in Masters of Science in Education and Technology University of Twente.
- Kay, R. (2006). Addressing Gender Differences in Computer Ability, Attitudes and Use: The Laptop Effect. *Journal of Educational Computing Research*, vol. 34, no. 2, pp. 187-211.
- Kitzinger, J (1995). Qualitative Research: Introducing Focus Groups. *British Medical Journal* 311, 299-302.
- Kizilkaya, G. & Askar, P. (2008). “ The Effect of an Embedded Pedagogical Agent on the Students’ Science Achievement” ; *Interactive Technology and Smart Education* Vol. 5 No. 4, 2008 pp. 208-216.
- Khokhar, A. & Javaid, S. (2016). *Students’ and Teachers’ Perceptions of ICT Use in Classroom: Pakistani Classrooms: The International Academic Forum*, ER
- KNEC (2020). The year 2019 KCSE Examination Report. Nairobi: Kenya National Examinations Council.
- Koehler, J. & Mishra, P. (2009). What is Technological Pedagogical Content Knowledge? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60-70.
- Kothari C. R. (2004). *Research Methodology: Methods and Techniques*. India: New Age International publishers.
- Kothari, C. R. (2013). *Research Methodology: Methods and Techniques* (2nd Ed). New Age International (P) Ltd. Publishers. India

- Krejcie and Morgan (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 30(3), 607-610
- Krueger R. A (1994). *Focus Groups: A Practical Guide for Applied Research*. Thousand Oaks, CA: Sage Publications.
- Lee, M. H., & Tsai, C. C. (2010). Exploring Teachers' Perceived Self-efficacy and Technological Pedagogical Content Knowledge with Respect to Educational Use of the World Wide Web. *Instructional Science*, 38, 1-21.
- Li, Q., & Ma, X., (2011). A Meta-analysis of the Effects of Computer Technology on School Students' Mathematics Learning. *Educ. Psychol. Rev.* 22, 215– 243.
- Lynn, M. R. (1986). Determination and Quantification of Content Validity. *Nursing Research*, 35, 382– 385.
- Mahdum, M., Hadriana, H. & Maria, S. (2019). Exploring Teacher Perceptions and Motivations to ICT Use in Learning Activities in Indonesia: *Journal of Information Technology Research*, 18 (1)293-317.
- Malakia, J. & Cloneria, N. (2018). Teachers' Perceptions on the Use of ICT in Teaching and Learning: A Case of Namibian Primary Education: Master' s Thesis Philosophical Faculty School of Applied Educational Science and Teacher Education, University of Finland.
- Manduku, J. G., Kosgey, A. K., & Sang, H. (2006). *Adoption and Use of ICT in Enhancing Management of Public Secondary Schools: A Survey of Kesses Zone Secondary Schools in Wareng District of Uasin Gishu County, Kenya*: Kabianga University College.
- Melisa, S. (2018). Perceptions of Mathematics Teachers about ICT Integration in Teaching Mathematics in Selected Secondary Schools in IfakoIjaye Local Government Area of Lagos State, Nigeria.
- Mbugua, Z., Kibet, K., Muthaa, G. and Nkonke, G. (2012). “ Factors Contributing to Students' Poor Performance in Mathematics at Kenya Certificate of Secondary Education in Kenya: A Case of Baringo County” , *Kenya American International Journal of Contemporary Research*. Vol. 2 No. 6; June 2012 87
- Melike, O. & Fatma, O. (2019). Technological Pedagogical Content Knowledge of Mathematics Teachers and the Effect of Demographic Variables: *Contemporary Educational Technology*, 2019, 10(1), 1-24

- Ministry of Information Communications and Technology (2016). National Information & Communications Technology (ICT) Policy: Government Press
- Mishra, P. & Koehler. (2006). *What Is Technological Pedagogical Content Knowledge (TPACK)?* The Journal of Education, Vol. 193, No. 3, Pedagogical Content Knowledge; pp. 13-19
- MOE, (2006). *National ICT Strategy for Education and Training*, Nairobi: Government Press.
- Monica, D. & Horacio, S. (2017). ICT Integration in Mathematics Initial Teacher Training and its Impact on Visualization: The Case of Geo Gebra: *International Journal of Mathematical Education in Science and Technology*
- Mugenda, O. M., & Mugenda, A. G. (1999). *Research Methods, Qualitative and Quantitative Approach* Nairobi: Acts Press.
- Mugenda, O. & Mugenda, A. (2003). *Research Methods. Qualitative and Quantitative Approaches*. Nairobi: ACTS.
- National Research Council. (2000). *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Academic Press.
- Neyland, E. (2011). Integrating Online Learning in NSW Secondary Schools: Three Schools Perspectives on ICT Adoption. *Australia Journal of Educational Technology*, vol. 27, no. 1, pp. 152-173
- Niess, M. L. (2005). *Guiding Learning with Technology*. Hoboken, NJ: Wiley & Sons.
- Nihuka, K. A. & Voogt, J. (2011). Instructors' and Students' Competencies, Perceptions and Access to E-learning Technologies: Implications for E-learning at the Open University of Tanzania. *International Journal on E-Learning*, 10(1), 63-85.
- Nuruland, A. & Zaleha I. (2008). "Pengetahuan Teknologi Pedagogi Kandungan Guru Pelatih Matematik Sekolah Menengah", in Proceeding of *Seminar Kebangsaan Pendidikan Sains dan Matematik, Skudai, Fakulti Pendidikan Universiti Teknologi Malaysia*, pp. 1-14.
- Ogachi, N. M. (2015). *Factors Influencing Teachers' Integration of ICT in Public Secondary Schools in Isinya Sub-county, Kenya*. Master's Thesis, Unpublished: University of Nairobi.

- Ogwel, A. (2008). “ Integrating ICT in Mathematics Education: Curricula Challenges in the Kenyan System of Education” . A Paper Presented in the 1<sup>st</sup> Regional Conference on E-Learning: Increased Access to Education, Diversity in Applications and Management Strategies, Kenyatta University, November 18– 20, 2008.
- Oyelekan O. S and Aderogba A. A (2011). The place of ICT in Science, Technology, Engineering and Mathematics Education Reforms. Journal of Science Teachers Association of Nigeria, STAN, HEBN Publishers 16-22
- Orodho, J. A. (2004). *Techniques of Writing Research Proposal and Reports in Education and Social Sciences*, 5th Edition. Nairobi: Mosola Publishers.
- Orodho J. A., (2016). *Quantitative and Qualitative research methods in Education and Social Sciences*. Nairobi: Kanezja Publishers & Enterprises
- Patton, M. Q. (2015). *Qualitative Research and Evaluation Methods: Integrating Theory and Practice* (4th Ed.). Thousand Oaks, CA: Sage.
- Peralta, M. D. & Costa, M. A. (2007). *Integrating Educational Technology into Teaching* (4<sup>th</sup>Ed.), Upper saddle River, NJ: Prentice Hall.
- Plair, S. (2008). Revamping Professional Development for Technology Integration and Fluency. *The Clearing House*, vol. 82, no .2, pp. 70-74
- Plomp, T., Anderson, R. E., Law, N., & Quale, A. (Eds.). (2009). *Cross-national Information and Communication Technology: Policies and Practices in Education*. Charlotte, N.C.: Information Age Publishing.
- Polly, M., McGee, F., & Martin, S. (2010). Using Information and Communications Technology as a Pedagogical Tool: Who Educates the Educators? *Journal of Education for Teaching: International Research and Pedagogy*, 25,247-262(16)
- Republic of Kenya (2005). Sessional Paper No. 1 of 2005. A Policy Framework for Education, Training and Research, Nairobi: Government Press
- Republic of Kenya (2012). Taskforce on the Re-alignment of the Education Sector to the Constitution of Kenya 2010, Nairobi: Government Press.
- Republic of Kenya (2012). Sessional Paper No. 14 (2012). *Reforming Education and Training in Kenya*, Nairobi: Government Press.

- Robová, J. (2013). Specific skills necessary to work with some ICT tools in Mathematics Effectively. *Acta Didactica Mathematicae*, 35, 71– 104.
- Said, B. (2014). Ability to Deliver and Advancement of Women in Academic and Administrative Positions in Public Universities in Central Uganda. *Educational Research International Journal*, 3(2), 36-44
- Schiler, J. (2003). Working with ICT: Perceptions of Australian Principals, *Journal of Educational Administration*, vol. 41, no. 3, pp. 171-185.
- Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological Pedagogical Content Knowledge (TPCK): The Development and Validation of an Assessment Instrument for Pre-service Teachers. *Journal of Research on Technology in Education*, 42(2), 123-149.
- Shikuku, B. (2012). “ Effect of Syllabus Coverage on Secondary School Students’ Performance in Mathematics in Kenya” . *International Journal on Education and Science*, 4(1): 31-34 (2012)
- Roschelle, et al., (2010). A social Perspective on Technology Enhanced Mathematical Learning from Collaboration to Performance. *ZDM*, 42(1), 91– 104.
- Stefan, A. et al., (2006). *Teachers’ Attitudes towards Information and Communication Technologies: The Case of Syrian EFL Teachers: Computers & Education* (47) 373-398
- Stols, G., & Kriek, J. (2011). Why Don’ t All Mathematics Teachers Use Dynamic Geometry Software in their Classrooms? *Australasian Journal of Educational Technology*, 27, 137-151.
- Sulungai, R., Toili, M & Amadalo, S. (2014). Effects of Teachers’ Experience and Training on Implementation of Information Communications Technology in Public Secondary Schools in Kakamega, South District, Kenya. *Journal of Humanities and Social Science*, 20(3), 26-38.
- Swarts, C. & Wachira, R. (2010). Educators and Technology Standards: Influencing the Digital Divide. *Journal of Research on Technology in Education*. 34 (3):326-335.

- Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., Schmid, R.F., (2011). What Forty Years of Research Says about the Impact of Technology on Learning: A Second Order Meta-analysis and Validation Study. *Rev. Educ. Res.* 81 (1), 4– 28.
- Teddlie, C., and A. Tashakkori. (2003). Major Issues and Controversies in the Use of Mixed Methods in the Social and Behavioral Sciences. In *Handbook on Mixed Methods in the Behavioral and Social Sciences*, pp. 3– 50. Thousand Oaks, CA: Sage.
- Teo, T. (2008). Pre-service Teachers' Attitudes towards Computer Use: A Singapore Survey. *Australasian Journal of Educational Technology*, vol. 24, no.4, pp. 413-424.
- Thomas L, MacMillan J, McColl E, Hale C & Bond S (1995). Comparison of Focus Group and Individual Interview Methodology in Examining Patient Satisfaction with Nursing Care. *Social Sciences in Health* 1, 206-219
- Thompson, A. & Mishra, P. (2009). *Breaking News: TPACK becomes TPACK!* *Journal of Computing in Teacher Education*. 24(2), 38-39.
- Tsai, B. (2012). Pedagogy, Information and Communication Technology and Teachers' Professional Knowledge. *The curriculum Journal*. 15(2), 153-159
- Ungerleider, Charles S. & Tracey C. Burns (2002). Information and Communication Technologies in Elementary and Secondary Education: A State of the Art Review. *Information Technology and Learning* 2-28.
- U.S. Department of Education. National Center for Education Statistics (2000). Teachers' Tools for the 21st Century: *A Report on Teachers' Use of Technology*.
- Usluel, Y. K., Askar, P., & Bas, T. (2008). A Structural Equation Model for ICT Usage in Higher Education. *Educational Technology & Society*, vol. 11, no. 2, pp. 262-273.
- Volman M. and Van Eck, E. (2001). Gender Equity and Information Technology in Education: The Second Decade. *Review of Educational Research*, vol. 71, no. 4, pp. 613-634.
- Willermark, S. (2017). *Technological Pedagogical and Content Knowledge: A Review of Empirical Studies Published from 2011 to 2016*: *Journal of Educational Computing Research*, Vol. 56(3) 315– 343

- Williams, M. D. (2003). *Technology Integration in Education: An Asia-pacific Perspective*, Singapore: Prentice Hall, 17-31.
- Wozney, L., Venkatesh, V., & Abrami, P. C. (2006). Implementing Computer Technologies: Teachers' Perceptions and Practices. *Journal of Technology and Teacher Education*, vol. 14, No.1, pp. 173-207.
- Yildirim, S. (2007). “ Current Utilization of ICT in Turkish Basic Education Schools: A Review of Teacher's ICT Use and Barriers to Integration” . *International Journal of Instructional Media*, Vol. 34, no.2, pp. 171-86.
- Young, S. C. (2003). Integrating ICT into Second Language Education in a Vocational High School. *Journal of Computers Assisted Learning*, 19, 447-461.
- Yusoff, M. S. B. ABC of Content Validation and Content Validity Index Calculation. *Medicine Journal*. 2019; 11(2):49– 54. <https://doi.org/10.21315/eimj2019.11.2.6>

**APPENDICES**

**Appendix I: University Introduction Letter**

Date.....

Dear Respondent,

**RE: Teachers’ Use of Technology and its Correlation to Students’ Achievement on National Mathematics Exams in Makeni County, Kenya**

Am working on the aforementioned doctoral research topic from Kenyatta University, School of Education. This is a request that you assist me in gathering critical material data and figures by completing out the accompanying survey form. Please respond within two weeks.

Your identity will remain secret, and information provided will only be used for research reasons.

In case of any questions or areas that need clarification, please contact me at 0721 790 477.

Your mutual assistance is much appreciated.

Yours sincerely,

Francis Nzoka,

Signature.....

Researcher, Kenyatta University.

## Appendix II: Questionnaire for Mathematics Instructors

In order to unearth the association between instructors' use of technology and students' Mathematics achievement on national exams in Makueni County, this survey is intended to gather information. You have been identified as a respondent by the researcher. Please supply the information that was required. All information provided will be kept completely private and used for this study.

### Section I: General Information

1. What is your gender? Male  Female
  
2. Indicate your age.  
Below 25 years  26-30 years  31-40 years   
41-50 years  51-60 years
  
3. What are your credentials for the job?  
Masters in Education  Bachelors Degree in Education   
Diploma in Education   
Others (Specify).....
  
4. (a) Do you know how to use a computer? Yes  No   
  
(b) What degree of training, if any, has been received?  
Competency, such as, lecture, workshop, apprenticeship   
KNEC, ICDL or Comparable certificate   
Diploma   
Degree   
Other, please state.....

(c) Do you have any experience utilizing ICT in the classroom?

Yes [ ] No [ ]

In (c) above, if any, how long did it take?

1 day [ ] 1 week [ ] 1 month [ ]

Other, please state.....

5. Was the ICT training on Mathematics or general for all subjects?.....

.....

6. Indicate with a tick the ICTs available in your school:

Overhead projectors [ ] Whiteboards [ ]

Computers [ ] Tablets [ ]

Scientific calculators [ ] Cellular devices [ ]

Geo-boards [ ]

Others, please state.....

7. How frequently do you incorporate ICTs into your Maths lessons?

Daily [ ] Weekly [ ] Monthly [ ]

Other, please state.....

8. Is there a computer laboratory in your school? Yes [ ] No [ ]

i) Do the PCs have internet access? Yes [ ] No [ ]

ii) Are there technical assistants to fix computer-related problems?

Yes [ ] No [ ]

9. School category (tick as appropriate)

Boarding for boys [ ]

Boarding for girls [ ]

Day mixed school [ ]

Day school for boys [ ] Day school for girls [ ]

## SECTION II: Content Knowledge and Achievement in Mathematics

For the following statements, please rate the level of concurrence or dissent regarding your self-assessments on **Content Knowledge** where 1 represents ‘strongly disagree’, 2 ‘disagree’, 3 ‘neutral’, 4 ‘agree’, and 5 ‘strongly agree’. (Technologies include use of mobile phones, geo-boards, computers, projectors and scientific calculators).

Proposition		1	2	3	4	5
1	I am capable of teaching lessons that effectively blend mathematical concepts, technologies, and instructional methods.					
2	I have the ability to choose technologies that blend arithmetic culture, technology and educational methods					
3	I can select pedagogical tools for my class that will enhance what I teach, how I teach, and the learning outcomes of pupils.					
4	I have the capacity to effectively transmit pertinent information to students and colleagues using technology					
5	To assist pupils in accomplishing their own objectives, I have access to a wide range of resources.					
6	In a Mathematics class, I can employ diverse strategies to make students active contributors.					
7	I am capable of ensuring that every learner has equitable access to virtual arithmetic learning materials and equipment.					
8	I can assist children understand various cultures by engaging them with technology.					
9	I have the ability to join online learning forums to learn about new ways of using technology to help students learn Mathematics more effectively					

## SECTION II: Pedagogical Knowledge and Achievement in Mathematics

For the following statements, please rate the concurrence or dissent level regarding your self-assessments on **Pedagogical Knowledge** where 1 represents ‘strongly object’, 2 ‘object’, 3 ‘neutral’, 4 ‘concur’, 5 ‘strongly concur’.

Statement		1	2	3	4	5
1	Using technology, I have the capacity to assess my own teaching in terms of theoretical principles.					
2	With the right amount of difficulty, am able to provide digital target mathematical input.					
3	I can choose authentic mathematics digital resources to meet the needs of my students					
4	I can choose digital learning activities that help learners gain a better understanding of their cultures					
5	I am capable of selecting the best digital methods for teaching Mathematics to students					
6	I am able to digitally schedule when and how I will employ target language to teach Mathematics					
7	I am able to employ technology to recognize arithmetic difficulties that students have					
8	I can create Mathematics courses that are tailored to meet digital curriculum needs					
9	I am aware of the contextual elements that impede or enhance digital mathematics learning.					
10	Am conversant with research being done in the field of Mathematics instruction using contemporary technology.					
11	I can try out different digital teaching approaches for Mathematics					

**SECTION III: Technological Knowledge and Achievement in Mathematics**

For the following statements, please rate the concurrence or dissent level regarding your self-assessments on **Technological Knowledge** where 1 represents ‘strongly object’, 2 ‘object’, 3 ‘neutral’, 4 ‘concur’ and 5 ‘strongly concur’.

(Technologies refer to the usage of electronic devices such as mobile phones, use of whiteboards, geo-boards, projectors, soft wares, computers and scientific calculators)

<b>Proposition</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1	Am conscious of classroom technologies that I can use to teach Mathematics.					
2	Am aware of technologies that I can utilize to better comprehend and do Mathematics					
3	I have the capacity of resolving personal technological issues					
4	I quickly can pick up technology and use it to teach Mathematics					
5	I stay abreast of new technology as they emerge					
6	While teaching Mathematics, I constantly experiment with technology					
7	I am well-versed in the many technologies used in teaching Mathematics					
8	I have the necessary technical skills for utilizing technology.					
9	I've had the opportunity to interact with a range of technology.					

#### SECTION IV: Teachers' Perception of ICT Use in Teaching Mathematics

The following assertions are listed in the following order; 1 for 'strongly dissent,' 2 for 'dissent,' 3 for 'neutral,' 4 for 'concur,' and 5 for 'strongly concur'. Please, tick as appropriate.

Proposition		1	2	3	4	5
1	Academically, use of ICT can help students develop a passion for Mathematics					
2	ICT use is beneficial in creating appropriate learning settings that appeal to diversity of student learning modalities/styles					
3	Use of ICT is beneficial in encouraging students to collaborate					
4	The use of ICT can help learners' focus spans to be extended.					
5	Use of ICT is beneficial in assisting teachers in covering content in a timely manner					

#### SECTION VI: Academic Achievement

1. Are you satisfied with the current academic achievement in Mathematics for your class? Yes [ ] No [ ]

2. Fill in the mean scores obtained your students in Mathematics;

First Term Mean Score: \_\_\_\_\_ Mean Grade \_\_\_\_\_

Second Term Mean Score: \_\_\_\_\_ Mean Grade \_\_\_\_\_

### **Appendix III: Focus Group Discussion Guide for Students**

As a participant in this investigation, your identity has been verified. Please, send along the needed information. Any data supplied will solely be utilized for this research and be maintained in absolute confidence.

1. What are your thoughts concerning use of ICT in instruction of Mathematics?
2. Is your school's ICT infrastructure adequate to support Math learning?
3. Do you believe that the school administration encourages Mathematics instructors to use ICT?
4. Do you believe that schools' reluctance to incorporate ICT into their Math curricula is a result of a shortage of knowledgeable and assured instructors?
5. What was your math performance percentage last term?
6. What obstacles do you see in the way of your schools use of ICT for Maths instruction?
7. How can these challenges be addressed?

**THANK YOU**

#### **Appendix IV: Interview Schedule for the Principals**

As a participant in this investigation, your identity has been verified. Please, send along the needed information. Any data supplied will solely be utilized for this research and be maintained in absolute confidence.

1. What is the level of competency of your instructors in using ICT to teach Mathematics?
2. Do your school's Mathematics instructors, in your opinion as principal, have ICT skills and knowledge?
3. Do you believe there is a link between instructors' technical content understanding and students' Math achievement in Makueni County secondary schools?
4. Do teachers achieve high scores on the TPACK subscales in mathematics education as a result of ICT use?
5. Does teachers' trust in the classrooms usage of ICT improve students' Math achievement?
6. Are you able to analyze the amount to which teachers have developed TPACK and its effectiveness for technology-enhanced instruction, particularly in Mathematics, in your administrative position?
7. What connection, in your opinion, exists between secondary school Mathematics achievement in Makueni County and instructors' assessments of ICT use?

**THANK YOU**

## Appendix V: Questionnaire Validation Tool

**Dear Experts,**

This tool's goal is to kindly request that you verify the questions that will be utilized to collect information on the association between instructors' use of technology and students' KCSE Mathematics exam by indicating whether or not each item is pertinent.

Use the scale of ratings below, checking each option as necessary:

### Level of Significance

1= the item is not relevant to the measured domain

2= the item is somewhat relevant to the measured domain

3= the item is quite relevant to the measured domain

4= the item is highly relevant to the measured domain

### Objective 1: Teachers' Content Knowledge in ICT Use and Achievement in Mathematics

The understanding of how technology and content interact and impact one another will serve as the foundation for teachers' expertise of ICT subject matter.

	Statement	Highly Relevant	Quite Relevant	Somewhat Relevant	Not Relevant
1	I am capable of teaching lessons that effectively blend mathematical concepts, technologies, and instructional methods.				
2	I have the ability to choose technologies that blend arithmetic culture, technology and educational methods				
3	I have the ability to implement technology in my classroom that will improve the lessons I deliver, the way I affect student learning and my own				

	understanding of the subject.				
4	I have the capacity to effectively transmit pertinent information to students and colleagues using technology				
5	To assist pupils in achieving their own objectives, I may employ a range of strategies.				
6	In a Mathematics class, I can employ multiple strategies to make pupils active contributors.				
7	I am capable of ensuring that all pupils have equitable access to virtual arithmetic learning materials and equipment.				
8	I can assist children understand various cultures by engaging them with technology.				
9	I have the ability to join online learning forums to learn about new ways of using technology to help students learn Mathematics more effectively				

**Objective 2: ICT Pedagogical Expertise and Mathematics Achievement**

Teachers' awareness of the impact of particular technologies on Mathematics teaching and learning will serve as the foundation for their expertise of ICT pedagogy.

	<b>Statement</b>	<b>Highly Relevant</b>	<b>Quite Relevant</b>	<b>Somewhat Relevant</b>	<b>Not Relevant</b>
1	In terms of theoretical				

	principles, and using digital tools, I can evaluate my own instruction.				
2	I can use technology to deliver targeted mathematical input at a suitable level of complexity.				
3	I can choose authentic mathematics resources to digitally meet the needs of my students				
4	I can choose learning digital activities that help learners gain a better understanding of their cultures				
5	I am capable of selecting the best digital methods for teaching Mathematics to students				
6	I can use technology to plan when and how I will use target language to teach mathematics.				
7	I am able to recognize arithmetic difficulties that students experience				
8	I can create Mathematics courses that are tailored to meet digital curriculum				

	needs				
9	I am cognizant of the environmental factors that hinder or facilitate digital learning of Mathematics				
10	I am conscious of present-day digital studies in mathematics education.				
11	I can try out different digital teaching approaches for Mathematics				

### **Objective 3: Mathematical Proficiency and Technological ICT Expertise**

According to this investigation, teachers' technological proficiency in ICT use involves their capacity to employ technology in Mathematics instruction, as well as their capacity to overcome technological obstacles.

<b>Statement</b>		<b>Highly Relevant</b>	<b>Quite Relevant</b>	<b>Somewhat Relevant</b>	<b>Not Relevant</b>
1	I am aware of technologies I can employ in the classroom to teach Mathematics				
2	Am aware of technologies that I can utilize to better comprehend and do Mathematics				
3	I can fix technological issues without assistance.				
4	I have the capacity to quickly pick up technology and use it to teach Mathematics				
5	I stay abreast of new technology as				

	they emerge				
6	While teaching Mathematics, I constantly experiment with technology				
7	I am well-versed in the many technologies used in teaching Mathematics				
8	I have the technical abilities that are required to use technology.				
9	I've had the opportunity to interact with a range of technology.				

**Objective 4: ICT Use in Mathematics Instruction as Perceived by Instructors**

The benefits of ICT usage in the classroom, as well as its correlation to learners' achievement in Mathematics, will be used to evaluate instructors' perspectives.

	<b>Statement</b>	<b>Highly Relevant</b>	<b>Quite Relevant</b>	<b>Somewhat Relevant</b>	<b>Not Relevant</b>
1	Academically, use of ICT can help students develop a passion for Mathematics				
2	ICT use is beneficial in creating appropriate learning settings that appeal to diversity of student learning modalities/styles				
3	Use of ICT is beneficial in encouraging students to collaborate				
4	The use of ICT can help learners' focus spans to be extended.				
5	Use of ICT is beneficial in assisting teachers in covering content in a timely manner				

**Appendix VI: Krejcie and Morgan (1970) Guide for Sample Sizes**

<b>N</b>	<b>S</b>	<b>N</b>	<b>S</b>	<b>N</b>	<b>S</b>	<b>N</b>	<b>S</b>	<b>N</b>	<b>S</b>
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	100000	384

N = Population Size

S = Sample Size

**Appendix VII: Consent Letter for Interview**

My name is Francis Katumo Nzoka, and at Kenyatta University, am pursuing a PhD. Respectfully, I request for your participation in a research study titled "Correlation between Teachers' Use of ICT and Students' Success in Mathematics in Makueni County, Kenya". At a time that is convenient for you, your institution will host this 45-60 minutes interview. To the best of my knowledge, there are no anticipated risks related to the interview. The researcher will take precautions to ensure your privacy and identity are safeguarded. Despite the fact that the interview will be taped for analysis purposes, the content of the recordings will be destroyed immediately it is transcribed. Your name or any other personal details will not appear in the typed interview.

You have the option to withdraw from this interview at any moment since it is discretionary. You will have access to the results after the investigation is finished. Further questions can be directed to the researcher on 0721 790 477.

I accept to take part in the study after reading the given information.

Name.....

Date.....Signature.....

**Appendix VIII: Student Consent Letter**

Dear Respondent,

At Kenyatta University, in Nairobi, Kenya, am conducting research for my PhD program focused on "Correlation between Teachers' Use of Technology and Students' Achievement in Mathematics in National Examinations in Public Secondary Schools in Makueni County, Kenya."

Your principal has given me permission to perform this research at your school. I therefore respectfully request that you participate. This study stands a good chance of helping you improve your arithmetic skills, which is why you should take part. The researcher's expectations of you as a participant are outlined in this letter. After the conclusion of the day classes, you will be expected to engage in focus group discussions led by the researcher.

You are not required to participate if you do not choose to since this is optional. You will have access to the results after the investigation is finished. Kindly sign the accompanying form if you have willingly agreed to participate.

Thanking you in advance.

Sincerely yours,

Francis K Nzoka,

Signature.....

(Researcher)

**STUDENT WRITTEN CONSENT**

I have read this letter in which I am asked to participate in a study at my school. I am familiar with the study's details and what is required of me. I agree to participate in this research on my own volition .

Student's name..... Students signature..... Date.....

Parent/guardian's name..... Parent/guardians signature..... Date.....

## Appendix IX: University Research Authorization



KENYATTA UNIVERSITY  
GRADUATE SCHOOL

E-mail: [dean-graduate@ku.ac.ke](mailto:dean-graduate@ku.ac.ke)

Website: [www.ku.ac.ke](http://www.ku.ac.ke)

P.O. Box 43844, 00100  
NAIROBI, KENYA  
Tel. 020-8704150

Our Ref: E83/CE/29056/2015

DATE: 11<sup>th</sup> August, 2020

Director General,  
National Commission for Science, Technology  
& Innovation  
P.O. Box 30623-00100,  
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MR. FRANCIS KATUMO NZOKA – REG. NO. E83/CE/29056/2015

I write to introduce Mr. Nzoka who is a Postgraduate Student of this University. He is registered for Ph.D Degree programme in the Department of Educational Management, Policy & Curriculum Studies, School of Education.

Mr. Nzoka intends to conduct research for Ph.D. Proposal entitled, "Effect of Teacher Integration of Information Communications Technology of Students' Performance in Mathematics in National Examinations in Makueni County, Kenya".

Any assistance given will be highly appreciated.

Yours faithfully,

  
PROF. ELISHIBA KIMANI  
FOR: DEAN, GRADUATE SCHOOL

## Appendix X: Research License from NACOSTI

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 925882	Date of Issue: 11/November/2020
<b>RESEARCH LICENSE</b>	
	
<p>This is to Certify that Mr.. Francis Katamo Nzoka of Kenyatta University, has been licensed to conduct research in Makueni on the topic: EFFECT OF TEACHER INTEGRATION OF INFORMATION COMMUNICATIONS TECHNOLOGY ON STUDENTS' PERFORMANCE IN MATHEMATICS IN NATIONAL EXAMINATIONS IN MAKUENI COUNTY, KENYA for the period ending : 11/November/2021.</p>	
License No: BAHAMAS ABS/P/20/7566	
925882 Applicant Identification Number	 Director General NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
	Verification QR Code
	
<p>NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.</p>	

## Appendix XI: Request from TSC to Collect Data

### TEACHERS SERVICE COMMISSION

Tel: 2892000/0722-208-552

Email: [info@tsc.go.ke](mailto:info@tsc.go.ke)

Web: [www.tsc.go.ke](http://www.tsc.go.ke)



TSC HOUSE  
KILIMANJARO ROAD  
UPPER HILL  
PRIVATE BAG- 00100  
NAIROBI, KENYA

When replying please quote

Ref. N<sup>o</sup>: TSC/R.A/VOL.03/52/69

27<sup>th</sup> January, 2021

<franczoka@gmail.com>

#### **RE: REQUEST TO COLLECT DATA**

Your request to collect data to inform your research on: **Effect of Teacher Integration of Information Communications Technology on Students' Performance in Mathematics in National Examinations in Makueni County, Kenya** has been granted.

You are advised to proceed to the TSC County Director (Makueni) for assistance.

On completion of the exercise, you are expected to submit **one hard copy** and **a soft copy in pdf** of the research report to our Office.

  
**FATUMA M. ABDI**  
**FOR: SECRETARY**  
**TEACHERS SERVICE COMMISSION**

Copy to: County Director -Garissa

**Appendix XII: Authorization for Research by County Director**

**TEACHERS SERVICE COMMISSION**

Telephone:  
0773499465

[cdirmakueni@tsc.go.ke](mailto:cdirmakueni@tsc.go.ke)



Makueni TSC County Office  
P.O. Box 505 -90300  
**MAKUENI**

Ref. NO: **MKN/TSC/ 483024/49**

**Date:** 4<sup>th</sup> February, 2020

✓ Nzoka Francis Katumo  
**TSC NO. 483024**

**RE: AUTHORIZATION TO COLLECT DATA FOR RESEARCH PURPOSES**

Reference is made to Commission's letter vide Ref No. TSC/R.A/VOL.03/52/69 dated 27<sup>th</sup> January, 2021 on the above subject.

Kindly note that the above teacher has been authorized to collect data on *Effect of Teacher Integration of Information Communications Technology on Students' Performance in Mathematics in National Examinations in Makueni County, Kenya* for period ending 24<sup>th</sup> November, 2021.

Please accord the teacher the necessary assistance during this period.



CATHERINE G. MWENDA (MRS)  
TSC COUNTY DIRECTOR  
**MAKUENI COUNTY**

**Cc:**  
The Secretary  
Teachers Service Commission  
**NAIROBI**

The County Director of Education  
**MAKUENI**

The Principal  
**MAKUENI GIRLS SECONDARY SCHOOL**



**Appendix XIV: Research Authorization by County Commissioner**



**OFFICE OF THE PRESIDENT  
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT**

**Telegram:**  
**Telephone: 0743-987-177**  
**Fax:**  
**Email: cc.makueni@interior.go.ke**

**COUNTY COMMISSIONER  
MAKUENI COUNTY  
P.O. Box 1-90300  
MAKUENI**

**Ref: MKN/CC/ADM.6/1 VOL.IV/33**

**16<sup>th</sup> November, 2020**

Francis Katumo Nzoka  
**KENYATTA UNIVERSITY**

**RE: RESEARCH AUTHORIZATION**

Reference is made to Director General National Commission for Science Technology and Innovation Research License **Ref. No. BAHAMAS ABS/P/20/7566** dated **11<sup>th</sup> November, 2020** on the above subject.

You are hereby authorized to undertake research on **"Effect of teacher integration of information communications technology on students' performance in mathematics in national examinations in Makueni County"** for a period ending **11<sup>th</sup> November, 2021**.

By a copy of this letter the Deputy County Commissioners are requested to give you the necessary assistance.

A handwritten signature in blue ink, appearing to be 'B. K. Nicolas', with a horizontal line extending to the right.

**B. K. NICOLAS  
FOR COUNTY COMMISSIONER  
MAKUENI**

c.c.  
County Director of Education  
**MAKUENI COUNTY**

Deputy County Commissioners  
**MAKUENI COUNTY**

### Appendix XV: Map of the Study Locale

