Mathematics Mobile Learning Using Google Classroom: Perceptions and Effects on Performance of Grade 10 Learners

By

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Declaration

I hereby affirm that the dissertation titled "**Mathematics Mobile Learning Using Google Classroom: Perceptions and Effects on the Performance of Grade 10 Learners"** is entirely my own work. All sources utilised in this dissertation are appropriately cited and acknowledged through complete references. This dissertation has not been previously submitted, either in part or in its entirety, for assessment towards any degree at any educational institution.

Signed: DATE: July 2023

Motebang Abraham Likotsi

Statement by supervisor:

This dissertation is submitted with/without the supervisor's approval.

Signed: ______________________________DATE:_____________________

Supervisor: Dr. Maboi Zacharia Mphunyane

Dedications

To my wife: ‘Manaleli Likotsi

My daughters: Naleli Paris Likotsi and Thatohatsi Olivia Likotsi

My mother: ‘Mapholo Likotsi

My sister: ‘Mampolokeng Mokhethi

For their continuous support and words of encouragement throughout my academic journey.

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Abstract

For many years, the academic performance of learners in Mathematics has raised concerns in Lesotho. Several factors have contributed to this subpar performance, including the absence of school libraries and insufficient teaching and learning resources, notably textbooks. The demand for rented textbooks through the school supply unit has consistently exceeded availability. This research study aimed to achieve two primary objectives: (a) to investigate the impact of mobile learning on learners' performance in Mathematics, and (b) to examine learners' perceptions of Mathematics mobile learning.

Utilising a quasi-experimental design, the study employed purposive sampling to select 70 learners. Two secondary schools were randomly assigned as control and experimental groups. A pre-test was administered to both groups as an initial assessment. Subsequently, the experimental group's teachers and learners received training on how to utilise Google Classroom for the distribution and receipt of various learning resources, including Mathematics tutorial videos, online quizzes, practice questions with solutions, and the facilitation of discussions, all accessible via mobile devices. Following four weeks of intervention, a post-test was administered to both the experimental and control groups. Additionally, the experimental group completed a questionnaire. The analysis employed SPSS version 20 for assessing learners' perceptions, while both independent samples t-tests and paired samples t-tests were employed to analyse the test scores.

The study revealed a statistically significant improvement in learners' performance within the experimental group (p-value = 0.000038 at a 0.05 significance level) as a result of mobile learning. Furthermore, the research established that learners held positive perceptions and attitudes towards mobile learning, expressing an intention to continue using Mathematics mobile learning in the future. These findings underscore the importance of stakeholders in exploring the potential of mobile learning to enhance the teaching of secondary Mathematics.

Keywords

Mobile learning

Mathematics mobile learning

Secondary school mathematics

Learner performance

Perceptions

Unified theory of acceptance and use of technology

List of Tables

List of Figures

List of Acronyms and Abbreviations

CIE	: Cambridge International Examinations
COSC	: Cambridge Overseas School Certificate
DIMaC	: Digital Interactive Mathematics Comic
ECoL	: Examinations Council of Lesotho
INSET	: In-service Training
JC	: Junior Certificate
HMII	: Hierarchical model for instructional interaction
LGCSE	: Lesotho General Certificate in Secondary Education
LNAEP	: Lesotho National Assessment of Educational Progress
LPP	: Legitimate Peripheral Participation
LS	: Lesson Study
MoET	: Ministry of Education and Training
UNESCO	: United Nations Educational Scientific and Cultural Organisation
UNESCO-SMEF	: United Nations Educational Scientific and Cultural Organisation-Science and Mathematics Educators Federation
NCTM	: National Council of Teachers of Mathematics

PCK	: Pedagogical Content Knowledge
PLC	: Professional Learning Communities
PSLE	: Primary School Leaving Examination
RSA	: Republic of South Africa
SACMEQ	: Southern and Eastern Africa Consortium for Monitoring Educational Quality
SPSS	: Statistical Package for the Social Sciences

Table of Contents

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

This research investigation is centred on assessing the impact of mobile learning on students' academic performance in Mathematics and examining their perceptions of mobile learning within the context of a secondary school in Maseru, Lesotho.

The chapter explores the emergence and evolution of mobile learning, positioning it as a significant component of contemporary education. It is also crucial to note that the chapter addresses the persistent issue of inadequate performance in Mathematics within the educational landscape of Lesotho.

Following this historical context, the problem statement is presented. This segment delineates the specific issue that has prompted the initiation of this study, outlining the core problem to be addressed. The problem statement serves as the foundation for the research endeavour.

Subsequently, the purpose of the study is expounded upon. This section elucidates the researcher's objectives and clarifies what is sought to be achieved by the conclusion of the study, directly addressing the research problem previously outlined. The purpose of the study guides the research process and sets the direction for the investigation.

The research questions that guide the study are articulated in the next segment. These questions serve as the investigative framework, guiding the research process and providing specific points of inquiry to be explored during the study.

Furthermore, the chapter outlines the significance of the study within the broader academic and research context. It highlights how the research contributes to the existing body of knowledge in the field of mobile learning, emphasising its potential impact on educational practices. Additionally, the section underscores the various stakeholders and groups that stand to benefit from the study's findings.

In conclusion, this chapter offers a succinct summary of its key points and provides definitions of key terms relevant to the study. It sets the stage for the subsequent chapters, framing the research context and objectives.

1.2 Background

1.2.1 Learners' performance in Mathematics

The issue of subpar performance in Mathematics in Lesotho's secondary schools has deep historical roots dating back to the early 1980s. Nenty (2010) conducted research that highlighted this historical trend. The 1982 education survey revealed a continuous decline in learners' performance across all educational levels, particularly in secondary education. Notably, the pass rate in the Cambridge Overseas School Certificate (C.O.S.C.) examination plummeted from 61% to a mere 21% in 1981. From 1981 to 1997, this pass rate fluctuated around 30%, with only an average of about 10% of students achieving division 1 or division 2 grades, which are necessary for acceptance into higher education institutions. This problem became even more pronounced in Mathematics, a core subject for admission to higher learning institutions, with only 9% of candidates obtaining a grade of C or better (Nenty, 2010, p.93).

Makara (2016) further affirms the issue of poor performance, particularly in Mathematics, at the Junior Certificate level, equivalent to grade 10. The performance in the Junior Certificate Mathematics examination from 2007 to 2012 exhibited consistently low figures, fluctuating between 7.11% and 11.58% of candidates achieving a grade of C or higher. The root of this poor performance in secondary school Mathematics can be traced back to primary school Mathematics, as evidenced by findings from the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) regarding Lesotho's grade 6 learners' performance in Mathematics. These findings indicated that Lesotho's learners performed below average (with a mean score of 447.2 in SACMEQ II, 2005, and 476.9 in SACMEQ III, 2011) when compared to international learners in Southern and Eastern Africa. However, there was a relative improvement in the performance of Lesotho learners, particularly in Mathematics, in SACMEQ IV (2017), with a mean score of 558.7. Nevertheless, there were areas that experienced a decline in competency levels compared to previous years (Maema & Mohale, 2017).

This persistently unsatisfactory performance at the primary level has far-reaching implications for secondary school Mathematics. It underscores the importance of addressing the foundational issues contributing to poor performance. Consequently, learners' performance in the Lesotho General Certificate of Secondary Education (LGCSE) and International General Certificate of Secondary Education (IGCSE) examinations remains unsatisfactory (ECoL, 2022). Table 1.2 (b), sourced from the Education Commission of Lesotho (ECoL) through its research and statistics unit in 2022, provides statistical data illustrating the gravity of the situation

Table 1.2

LGCSE Mathematics performance in 2022

Symbol in Mathematics	A*	A	B	C	D	E	F	G
Percentage of learners	0.1	0.5	1.8	8.5	11.3	17.9	25.8	19.9

Note. Adapted from *the 2019 LGCSE statistical bulletin*, by ECoL research and statistic unit, 2022.

Table 1.2 presents data revealing the stark challenges faced in Mathematics education. Approximately 0.6% of candidates achieved grades A or A* in Mathematics, signifying exceptionally high levels of underperformance. Moreover, only 10.9% of learners managed to attain a grade of C or higher in Mathematics. Disturbingly, nearly 45% of candidates received grades F or G, underlining the widespread difficulties encountered in the subject.
The recent report from the Examinations Council of Lesotho (ECoL) and the Research and Statistics Unit (2022), indicating that only 10.9% of candidates achieved a grade of C or better in Mathematics, aligns with previous research findings by Nenty (2010) and Makara (2016). This body of evidence underscores a longstanding challenge in Lesotho's education system, characterised by persistent low performance in Mathematics.

Multiple factors have contributed to this issue of academic underachievement, as noted by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) (Mothibeli & Maema, 2005) and the Lesotho National Assessment of Educational Progress (LNAEP) (2016). Among these factors is the availability of essential learning resources, such as pens, pencils, rulers, erasers, and textbooks, all of which influence the instructional approach employed during lessons. Additionally, high absenteeism among students has been a contributing factor. Furthermore, the absence of school libraries and class libraries exacerbates the problem. It is noteworthy that most schools in Lesotho rely on renting textbooks from the school supply unit, which often struggles to meet the demand for books. Additionally, some of these books are returned in poor condition, having become worn out and torn over time. These challenges collectively hinder effective teaching and learning in Mathematics, perpetuating the problem of low performance.

1.2.2 Mobile learning in the context of Lesotho

Throughout history, communication through telephones revolutionised long-distance conversations, a ground-breaking invention attributed to Alexander Graham Bell in 1876 (History.com Editors, 2022). However, the capabilities of telephones have since expanded significantly. Presently, conventional telephones are considered out-dated due to their fixed location, lack of features such as texting, limited storage capacity, and absence of internet connectivity. In contrast, modern mobile devices, specifically smartphones, encompass the traditional telephone functions, in addition to text messaging, built-in cameras, extensive storage capacity, and wireless internet connectivity (Delaporte & Bahia, 2022). Smartphones have introduced a range of academically valuable features that surpass the capabilities of classic mobile phones, including email access, chat functionalities, downloads, video calling, and increased storage space. Despite their diminutive size, smartphones have evolved to offer some of the most ubiquitous, dynamic, and sophisticated means of communication.

The prevalent use of mobile devices by young people has piqued researchers' interest in their applicability in both formal and informal education settings (Iqbal et al., 2017, p.2). Notably, in Lesotho, a developing country, mobile devices are more widespread among youth than connected computers (Makafane & Chere, 2021). This trend may be attributed to the affordability of mobile devices compared to desktop computers, as well as their portability, flexibility, and handheld nature. The necessity for mobile devices for educational purposes was underscored when schools were forced to close due to the COVID-19 pandemic, prompting nearly every student, especially high school learners, to acquire mobile devices for remote learning (Makafane & Chere, 2021).

In response to the pandemic, many schools, including private institutions, had to transition from traditional in-person teaching to online learning to ensure continuity. However, the readiness for online instruction varied, and not all students had access to computers or smartphones, particularly in rural areas. Even before the pandemic, online lessons were rarely conducted and lacked proper structure and preparation (Makafane & Chere, 2021).

In Lesotho, schools adopted a blended approach, combining traditional physical classes with mobile learning, to make up for the time lost during the pandemic. Mobile learning, defined as "the use of mobile or wireless devices for the purpose of learning while on the move" (Vyas & Nirban, 2014; Iqbal, Khan & Malik, 2017), played a crucial role in ensuring continuity in education. Mobile devices encompass a range of tools, including smartphones, laptops, tablets, smartwatches, MP3 players, and iPods (Iqbal, Khan & Malik, 2017).

Liu and Hwang (2010) distinguish between e-learning (electronic learning), m-learning (mobile learning), and u-learning (ubiquitous learning). Electronic learning primarily involves computer and internet-based learning, while mobile learning is characterised by context-aware ubiquitous learning. Ubiquitous learning represents the latest phase, where learning can occur anywhere, anytime, thanks to mobile technologies. This transition from traditional classroom learning to stationary electronic learning, and finally to ubiquitous mobile learning, is driven by advancements in wireless and mobile technologies, allowing education to transcend geographical boundaries and enabling learner-centered cooperative learning environments.

In Lesotho, students utilize their mobile phones for voice calls, accessing teaching and learning resources, time management, and connecting to web 2.0 applications such as YouTube, Facebook, Twitter, Instagram, Telegram, and WhatsApp. Additionally, educational institutions have their own academic networking sites, such as the National University of Lesotho's Thuto platform (https://thuto.nul.ls), powered by the Sakai learning management system, facilitating distance learning (Sepiriti, 2021). Secondary schools in Lesotho utilise Thusanang (https://thusanang.online/), a platform designed to enable learners to share study materials, post questions, and provide answers. Notably, Thusanang Educational Social Network was developed by Thomello Mats'asa, a 20-year-old student at the National University of Lesotho (The Reporter, 2020). Moreover, some schools in Maseru, such as one utilising jkspace, use digital platforms to send learners homework, videos, and study materials. These platforms represent the evolving landscape of education, with technology enabling enhanced communication and learning opportunities.

1.2.3 Ministry of education and training and other private sectors Interventions

The Ministry of Education and Training (MoET) in Lesotho made concerted efforts to address the longstanding issue of poor academic performance, particularly in Mathematics. This endeavour was undertaken in collaboration with the British Overseas Development Agency, commencing in 1986. During the initial phase of this project, expatriate experts were dispatched from Britain to Lesotho to provide support to local teachers in effectively teaching challenging Mathematics topics. These experts conducted workshops, visited schools across the country to demonstrate effective teaching methods for specific topics, and occasionally observed teachers, engaging in post-observation discussions. This collaborative project spanned seven years, during which significant progress was made. However, when the responsibility transitioned to Basotho educators, the frequency of school visits gradually declined from weekly to monthly and, subsequently, to biannual visits. Eventually, the support for teachers dwindled, with only education inspectors remaining, who did not provide training on Mathematics pedagogy. Unfortunately, these efforts did not yield significant improvements in Mathematics performance (Makara, 2016, p. 3).

Local Mathematics and Science teachers also attempted to tackle the issue through their association, known as the Lesotho Science and Mathematics Teachers Association (LSMTA). The LSMTA employed various strategies, including competitions involving problem-solving, projects, and quizzes, aimed at motivating and nurturing an interest in STEM (science, technology, engineering, and mathematics) subjects. Despite these efforts, the problem of poor Mathematics performance persisted, as evidenced by the Examinations Council of Lesotho's (ECOL) reports showing a serious decline in Mathematics performance at the secondary level.

In the global shift from didactic teaching methods to learner-centered approaches, mobile learning emerged as a highly effective instructional tool (Mafa and Govender, 2018). Mobile learning transcends geographical boundaries and fosters collaborative learning environments. In 2009, UNESCO and the SMEF Thakakhoali initiative sought to address the issue of underperformance by introducing mobile learning in Lesotho. However, the implementation of mobile learning faced challenges, as many schools did not permit the use of mobile devices (UNESCO, 2017). Consequently, the problem of poor Mathematics performance persisted, as indicated in the ECOL's 2022 research and statistics bulletin (Table 1.2).

Numerous researchers, such as Mafa and Govender (2018), Fabian, Topping, & Barron (2018), Hashin, Choo, and Song (2009), and Talan (2020), have emphasised that mobile learning enhances the quality of learning to some extent. A recent study in Botswana recommended that "learners should be allowed to use mobile technology in the classroom and that the use of mobile devices should be incorporated into the school curriculum" (Mafa & Govender, 2018, p. 212). Mobile learning offers new dimensions to education, providing flexibility, ubiquity, and access to learning anytime, anywhere (Hashin, Choo, & Song, 2009). El-Hussein and Cronje (2010) add that mobile learning is characterised by the mobility of both devices that use wireless internet connections and learners themselves.

In 2020, the world faced the global COVID-19 pandemic, which prompted the closure of schools and necessitated a shift to online learning, particularly through mobile learning platforms such as the Thusanang Educational Social Network in Lesotho. UNESCO, ThakaKhoali, LSMTA, and other key stakeholders in Lesotho's education system convened in 2020 to launch the Thusanang Educational Social Network. This platform allowed students to interact with peers from different schools using their mobile phones. Students could access past question papers, respond to questions, and access resources from the comfort of their homes. However, the effectiveness of this initiative was compromised as neither students nor teachers received proper training on how to use the application effectively. Teachers in public schools did not encourage learners to utilise the Thusanang Education Social Network App, leading to further declines in performance. The Lesotho General Certificate of Secondary Education (L.G.C.S.E) results for 2020 indicated that only 9% of the 17,413 learners who sat for the examination obtained a grade C or better in Mathematics (Lesotho National Broadcasting Services, 2021).

Nevertheless, the Ministry of Education and Training persisted in its pursuit of mobile learning and introduced a more user-friendly learning application. In September 2020, the ministry unveiled the Lesotho Learning Passport, a website (https://moetls.learningpassport.unicef.org) and a corresponding application available on Google Play Store. This platform catered to learners across all levels, from primary school grades 1 to 7 to high school grades 8 to 11. To access and log in to the application, learners and teachers were required to use their school registration numbers. The website guided learners in registering for their subjects, facilitating easy access to relevant instructional videos. The platform organised subjects into various topics, each accompanied by instructional videos. Downloading these videos was straightforward, reducing data costs for students. This initiative aimed to support learners, especially on days when they did not attend physical school due to rotational schedules necessitated by social distancing measures within classrooms.

1.3 Statement of the problem.

In order for a country to achieve development, it is imperative to cultivate a citizenry possessing diverse qualifications across various professions that contribute to the nation's advancement. For instance, a country equipped with an adequate number of doctors and nurses will be better equipped to provide quality healthcare services. Conversely, a nation lacking sufficient medical professionals may find itself incurring substantial expenditures on foreign healthcare personnel. Therefore, fostering excellence in science, technology, engineering, and mathematics (STEM) subjects, particularly at the high school level, is crucial to encouraging greater enrollment in these fields. This endeavour is pivotal as it can potentially address the shortage of professionals in vital sectors such as healthcare. Chaka and Govender (2017) underscore this point, asserting that education in mathematics, science, and technology is foundational to a country's development and modernization.

Extensive literature affirms that for decades, there has been a consistent problem of unsatisfactory performance in mathematics. Various factors contributing to this issue have been explored in prior research, including studies conducted by SACMEQ (Mothibeli & Maema, 2005) and the Lesotho National Assessment of Educational Progress (LNAEP, 2016). These factors encompass the availability of essential learning resources such as pens, pencils, rulers, erasers, and textbooks, all of which significantly influence the instructional approach employed. Textbooks are typically leased to schools by the school supply unit, although parents bear the cost. Regrettably, the supply of textbooks often falls short of meeting the needs of all learners each year. On that account, learners require adequate resources, tools, and materials to support their mathematics education, as practicing mathematics without textbooks proves to be exceedingly challenging.

Failure to address this problem may lead to reduced enrollment in science and technology, health sciences, and agricultural programmes, ultimately resulting in a shortage of experts in these fields over the long term. Therefore, it is imperative to investigate whether the integration of mobile learning in mathematics classrooms can yield improved mathematics performance.

A substantial body of literature has been dedicated to examining the effects of mobile learning on learners' perceptions, attitudes, and engagement. However, the majority of these studies have primarily focused on surveys, interviews, and observations, with limited attention given to the impact of mobile learning on mathematics performance. Furthermore, studies that do investigate the effects of mobile learning on mathematics often concentrate on the primary level, leaving a notable gap in research pertaining to higher educational levels (Fabian & Topping, 2019; Fabian, Topping & Barron, 2018; Fabian, Topping & Barron, 2016). To date, consensus on the effects of mobile learning on mathematics performance remains elusive, with contradictory findings emerging. Some studies report no significant effect (Fabian and Topping, 2019), while others reveal positive outcomes (Panteli and Panaoura, 2020; Fabian, Topping & Barron, 2018). Conversely, certain studies indicate a decline in post-test performance following mobile learning interventions, as demonstrated by Perry and Steck (2015), who observed a decrease in post-test scores in the treatment group utilising mobile devices as virtual manipulatives in a quasi-experiment. Mafa and Govender (2018) corroborate these complexities, underscoring that although mobile devices offer diverse educational utilities, their specific impact on education remains underexplored.

Given these factors, the researcher finds it imperative to undertake this study, which investigates the effects of mobile learning on learners' mathematics performance, particularly in light of the scarcity of such studies within the context of Lesotho. The closest analogous study conducted in a developing country is the one undertaken in Botswana. Furthermore, researchers acknowledge the necessity of examining learners' perceptions of mobile learning technology for its effective implementation (Rifai and Sugiman, 2018). However, in the context of Lesotho—a country with a modest economy and an evolving education system, particularly in terms of technology adoption—studies investigating learners' perceptions of learning mathematics through mobile technologies are conspicuously scarce.

1.4 Research objectives

The objectives of this study were to:

1. Investigate effects of mobile learning using Google Classroom on grade 10 learners' algebra mathematics performance.
2. Explore learners' perceptions of Mathematics mobile learning in a senior secondary school in Maseru urban.

1.5 Research questions

In an attempt to establish the extent to which mobile learning can improve learners' performance in Mathematics, the following are the research questions:

1. To what extent can mobile learning improve learners' performance in algebra mathematics?
2. How do learners in a secondary school in Maseru urban perceive the use of mobile devices in the learning of Mathematics?

1.6 Research hypotheses

A hypothesis is a statement representing the researcher's anticipated outcome (Anupama, 2018). Ary, Jacobs, and Sorensen (2010) elucidated the significance of hypotheses in quantitative research, emphasising their role in guiding data collection and interpretation, as well as providing a structural framework for reporting findings and conclusions derived from the study. Additionally, Ary, Jacobs, and Sorensen (2010) affirmed that hypotheses offer researchers a "relational statement that is directly testable in a study" (p. 83). Typically, three types of hypotheses exist: research hypotheses, null hypotheses, and alternate hypotheses. Whereas a research hypothesis articulates the expected findings of the research, the null hypothesis posits the absence of any relationship between the dependent and independent variables, and the alternate hypothesis posits a specific relationship between these variables. Ary, Jacobs, and Sorensen (2010) further clarified that the null hypothesis can either be rejected or retained based on inferential statistics, which indicate whether the observed relationship between variables is statistically significant or simply a result of chance.

To address the first research question, the following hypotheses will be tested at a significance level of 5%

The null hypotheses H_0

H_0: Mobile learning as an instructional tool has no significant effect on learners' performance in algebra topic in Mathematics.

H_0: The traditional method approach of instruction has no effect on learners' performance in algebra topic in Mathematics.

H_0: There is no statistically significant difference in the performance of grade 10 learners in algebra topic in mathematics between those taught using mobile learning via Google Classroom and those taught solely using traditional methods.

The primary research objective seeks to examine the impact of mobile learning, specifically through Google Classroom, on the mathematics performance of grade 10 learners. Its corresponding null hypothesis posits that there is no statistically significant difference in the algebra mathematics performance of learners exposed to mobile learning when compared to those taught solely through traditional methods. This null hypothesis stands in direct contrast to the research objective, thereby establishing the conditions for either accepting or rejecting the research hypothesis. The null hypothesis addresses the research question concerning the extent to which mobile learning can enhance learners' performance in algebra mathematics. It is rejected when statistical analysis reveals a significant difference in performance scores between the control group (traditional teaching) and the experimental group (mobile learning).

Additionally, another research objective in this study involves investigating the perceptions of learners regarding mobile learning in the context of mathematics education within a senior secondary school in Maseru urban. This objective gives rise to the research question: "How do learners in a secondary school in Maseru urban perceive the use of mobile devices in the learning of mathematics?" While the research objective is broad and overarching, the research question is specific and focuses on soliciting specific insights regarding learners' perceptions.

1.7 Purpose of the study

More recently, the academic literature has presented conflicting findings concerning the impact of mobile learning on mathematics education. While some researchers have reported no statistically significant difference in performance between their experimental groups and control groups (Fabian, Kristin, Topping & Keith, 2019), others have documented positive effects (Panteli and Panaoura, 2020; Fabian, Topping & Barron, 2018). Contrarily, there are studies that have shown a decline in post-test performance following the intervention, as evidenced by Perry and Steck (2015), who observed a drop in the post-test scores among the treatment group utilizing mobile devices as virtual manipulative in a quasi-experimental setting.

Moreover, the effective implementation of mobile learning in mathematics education hinges on students' perceptions of such technologies, given that they are the primary users of these tools and the primary beneficiaries of education. Therefore, this study is designed to accomplish the following objectives:

1. Investigate the impact of mobile learning on learners' performance in mathematics.
2. Explore the perceptions of mathematics mobile learning among learners in a senior secondary school in Maseru urban.

1.8 Significance of the study

This study will make a valuable contribution to the on-going research concerning mobile learning. These findings can serve as essential inputs for policy makers, aiding them in their decision-making process regarding the potential inclusion or utilisation of mobile learning in schools. Additionally, the outcomes of this study will provide valuable insights to teachers and school administrators, shedding light on learners' perceptions of mobile learning and its impact on their academic performance in mathematics. These results can also serve as a catalyst for teacher training institutions to recognise the importance of offering training programmes on the effective utilisation of mobile technologies, as well as the integration of blended learning approaches. This aligns with the findings of Makafane and Chere (2021), which underscored the necessity for institutional support and training in leveraging mobile technologies for educational purposes.

Moreover, the outcomes of this study will make a significant contribution to the existing body of literature and the on-going discourse regarding the influence of mobile technology on learners' mathematics performance. Furthermore, it has the potential to inform the possible acceptance and integration of mobile technologies into secondary education, as perceived by the learners themselves.

1.9 Summary of chapter 1

This chapter serves as an introductory overview of the research study, presenting its fundamental objectives, delineating the research problem, and tracing the historical evolution of efforts to address the issue of underperformance in mathematics. The historical narrative begins with the involvement of expatriate experts from Britain in 1986, who provided assistance to teachers, including mathematics instruction (Makara, 2016), and culminates in the contemporary digital era marked by mobile learning. Additionally, this chapter elucidates the study's overarching goals and outlines the various stakeholders who stand to benefit from its outcomes, encompassing policymakers, educators, parents, and students.

The subsequent chapter will delve into a comprehensive literature review, encompassing prior research related to mobile learning, the quality of academic performance, learners' perceptions of mobile learning, and the theoretical framework that underpins the study.

1.10 Definition of key terms

1. Mobile learning is defined as learning through wireless mobile devices (Farooq et al, 2002)
2. Perception is defined as process whereby the brain generates a representation of the external world that is coherent, meaningful and actionable (Gazzaniga, 2020).
3. Mobile devices are hand held devices that can be connected to the internet through wireless connection (Delaporte & Bahia, 2022).
4. Smart phone is defined according to (techtarget.com) as cellar telephone that is joined with computer features such as operating system (Kirvan, 2022).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 2 commences with an extensive review of the existing literature pertaining to several key aspects, including secondary school mathematics, the process of learning mathematics at the secondary level, and mathematics mobile learning within secondary education. This section carefully establishes connections and alignment between the definitions of secondary school mathematics, the process of learning mathematics, and mathematics mobile learning as delineated in prior literature, and the specific aims, objectives, and research questions of the present study.

Furthermore, this chapter provides a comprehensive examination of the impact of mobile learning on learners' performance in secondary school mathematics and offers a rationale for the selection of Google Classroom as the designated mode of learning. Additionally, it offers a precise definition of perceptions, with a particular focus on learners' perceptions concerning mathematics mobile learning, and elucidates the interconnectedness of these perceptions with the broader concept of mathematics mobile learning.

The chapter also introduces a theoretical framework that has been adopted for this study, detailing how this framework guided the development of the research questionnaire, influenced the presentation of results, and aided the researcher in addressing the central research question concerning how learners perceive mathematics mobile learning

2.2 Philosophy of mathematics

Ernest (2018) has highlighted the enduring debate within the realm of the philosophy of mathematics, which primarily revolves around the conflicting perspectives of traditionalist mathematicians and social constructivist philosophers of mathematics. Traditionalist mathematicians contend that mathematics is characterised by its "certainty, cumulative nature, and immunity to social influences," while social constructivist mathematicians perceive mathematics as a construct shaped by societal and cultural factors. This study aligns itself with the social constructivist philosophical stance on mathematics.

According to Paul Ernest (1998), Mathematics is conceived as a "human creation influenced by historical contexts and the consensus of thinkers who cannot fully eliminate the inherent ambiguities in language and the interpretation of meaning." This social constructivist conceptualisation of mathematics is closely intertwined with the Connectivism theory in the context of mobile learning. Connectivism theory posits that internet technologies have given rise to novel platforms for individuals to learn and share information across the digital landscape. In this study, the process of social interaction and the construction of mathematical knowledge among learners occur through the utilisation of mobile devices within the framework of Google Classroom.

Furthermore, Siemens (2005) suggests that learners expand their knowledge through online networks and underscores the significance of these connections, which are deemed more crucial than the current state of one's knowledge. The evolution of mathematics throughout history has encompassed abstraction and logical reasoning, stemming from fundamental concepts like counting, calculation, measurement, and the methodical examination of the shapes and motions of physical objects. Mathematics, as a discipline, inherently leverages scientific and technological progress to inspire new mathematical discoveries. Hence, from the social constructivist perspective, there arises a compelling rationale for the integration of technological and scientific advancements into the mathematics classroom, enabling mathematics to continually inform development and discovery.

2.3 Mathematics in secondary schools

According to the IGCSE syllabus, secondary school Mathematics is designed for students aged 14 to 16. In a broader context, encompassing both the 2023 IGCSE and 2023 LGCSE syllabi, secondary mathematics comprises a range of intricate problem-solving topics, including algebra, number theory, mensuration, trigonometry, vectors and transformations, geometry, probability, and statistics. For the purposes of this study, the focus was on algebra, specifically aligned with the year planner and scheme of work for both the experimental and control schools. The aim was to maintain consistency with the schools' pre-established curricular plans, avoiding any disruptions, given that the intervention for this study spanned a lengthy period of 5 weeks.

This study was conducted among grade 10 learners in secondary school. The assessment used to investigate the impact of mathematics mobile learning on learners' performance in Mathematics centred on algebra. More specifically, the evaluation encompassed tasks related to substituting values into formulae, simplifying algebraic expressions, factorising algebraic expressions, creating equations, solving linear equations, tackling linear simultaneous equations, and solving quadratic equations through factorization. These assessment components align with the study's objectives.

Secondary schools, serving as a preparatory stage for university education, introduce students to more intricate and diversified mathematical concepts, in accordance with the IGCSE curriculum. The syllabus expects learners to employ advanced problem-solving techniques and apply mathematical principles within real-world contexts. Consequently, students are anticipated to demonstrate a deeper comprehension of these concepts during examinations and assessments (Gienibook, 2023).

2.4 Mobile learning in secondary school mathematics

Researchers have defined mobile learning in various ways. Some define it as "the use of mobile or wireless devices for the purpose of learning while on the move" (Vyas & Nirban, 2014; Iqbal, Khan & Malik, 2017). Others describe it as the use of mobile technologies to facilitate learning (Hwang and Tsai, 2011). Mobile learning has also been defined as the deployment of mobile devices in the teaching and learning process (Farooq et al., 2002; Vyas & Nirban, 2014; Iqbal, Khan & Malik, 2017). Some researchers emphasise its flexibility and ubiquity, allowing learning to take place anywhere, anytime (Hashin, Choo & Song, 2009). Others define mobile learning based on the mobility of both the device using wireless internet connection and the learner, who is not confined to one location, thus emphasising the mobility of learning itself (El-Hussein & Cronje, 2010).

In this study, mobile learning refers to the use of portable devices such as tablets and smartphones in the process of teaching and learning. This definition aligns with the definitions provided by Vyas and Nirban (2014) and Iqbal, Khan, and Malik (2017). The study required learners to use tablets and smartphones to access mathematics learning materials, complete mathematics assignments, and participate in online mathematics quizzes. These devices were chosen for their portability, allowing learners to carry them anywhere.

Successful integration of mobile learning in schools can lead to cost savings on physical learning materials. With the on-going advancements in technology, mobile technology is likely to continue playing an increasingly important role in education. Learners' growing affinity for mobile devices, as suggested by studies like Massero (2023), indicates a positive reception of these advancements.

While mobile learning has gained significance in the classroom, its use and effectiveness in a mathematics classroom are still being established. Ackay (2017) emphasises the need for appropriate technology integration into teaching and learning to enhance the understanding of mathematics and its applications. Saritas (2022) highlights the demand for adequate and rapid feedback in solving mathematical problems, which mobile learning can provide by extending the traditional classroom to virtual spaces where students can practice problem-solving and access solutions. Students' natural inclination toward technology has made it an attractive instructional method for educators to consider, potentially leading to a more engaging and effective learning experience.

Various learning theories have been applied in mathematics education, including behaviourism, constructivism, and cognitivism. Behaviourism focuses on teacher-centred instruction, while cognitivism emphasises how learners mentally process encountered stimuli (Lessani et al., 2016). Constructivism, on the other hand, involves linking mathematics to learners' daily experiences and using creative problem-solving approaches instead of abstract formulas (Vintere, 2018). These theories underscore the importance of devising effective teaching and learning approaches that resonate with learners, ultimately improving performance and retention of subject matter. Mobile learning, in the context of this study, offers a new mode of delivering subject content, potentially enhancing learners' understanding and problem-solving skills.

In secondary school mathematics, specific learning tools such as calculators and mathematical instruments play a crucial role. Ackay (2017) found that technology integration in high school mathematics classrooms was lower than in middle school, emphasising the need to align technological advancements with specific teaching approaches to positively impact learners' interaction with mathematics content.

2.5 Effects of mobile learning on learners’ mathematics performances

The primary objective of the present study is to examine the impact of mobile learning through Google Classroom on the Mathematics performance of grade 10 learners. The central research question aims to assess the extent to which mobile learning can enhance learners' performance in Mathematics. This inquiry is complemented by a corresponding null hypothesis, which posits that there is no significant difference in the performance of learners in algebra mathematics when taught through mobile learning compared to those taught using traditional methods alone.

The underlying premise of this study is rooted in the belief that mobile learning has the potential to enhance learners' engagement, motivation, and overall attitudes toward the subject. It is hypothesised that the utilisation of mobile devices for learning mathematics will likely result in improved performance, as evaluated through standardised tests or assessments.

2.5.1 Effects of mobile learning on learners’ engagement

Student engagement is a multifaceted concept recognised as a predictor of learning performance (Maamin, Maat, & Iksan, 2022). Prior research has affirmed that mobile learning serves to enhance learner engagement, a pivotal factor known to have a positive impact on performance in Mathematics (Tay, Lee, & Ramachandran, 2021; Fabian, Topping, & Barron, 2016). For this reason, it is reasonable to postulate that the implementation of mobile learning can lead to improved mathematics performance among learners through the enhancement of their engagement.

2.5.2 Effects of mobile learning on learners’ motivation

Learners' motivation also plays a significant role in predicting their performance in Mathematics. El-Adl and Alkharusi (2020) discovered a positive correlation between learners' motivation (intrinsic or extrinsic) and their performance in Mathematics. Aligning with this discovery, Bamidele (2021) also observed that mobile learning enhances learners' motivation. Resultantly, it can be inferred that mobile learning boosts learners' motivation, and consequently, motivated learners are more likely to achieve positive results in Mathematics.

Murtiyasa, Jannah, and Rejeki (2020) developed mobile learning media for Mathematics, specifically focused on the topic of Matrices. Their study revealed that this mobile learning media empowered 10th-grade learners to engage in independent mathematics learning beyond the classroom, while also fostering heightened interest and motivation among students in learning mathematics through technology. This study contends that this increased motivation resulting from the use of mobile learning media is likely to lead to improved academic performance in Mathematics.

2.5.3 Effects of mobile learning on learners' attitudes

Similarly, Fabian, Topping, and Barron (2018) conducted a quasi-experimental study employing a mixed methods approach to investigate the effects of mobile technology on students' attitudes and performance in Mathematics. The study involved a sample of 52 primary school learners in grades 6 and 7, aged between 9 and 11 years, who were divided into two groups: the treatment group and the control group.

The experimental group underwent a pre-test on geometry (a Mathematics assessment) and completed a Mathematics attitude inventory questionnaire. Following their participation in an 8-hour mobile-supported collaborative learning program spanning three months, the experimental group completed an end-of-activity evaluation questionnaire. The results of this study indicated that the experimental group exhibited a positive perception towards the use of mobile devices in Mathematics, as supported by student interviews and the end-of-activity evaluation.

Both the control group and the treatment group were administered the same Mathematics test and the mathematics attitude inventory, similar to those given prior to the program. The findings revealed that mobile learning had a positive impact on the learners' performance. However, in terms of attitudes towards Mathematics, as assessed by the mathematics attitude inventory, no significant change was observed in either group, except for a notable decrease in enjoyment reported by the control group.

The authors noted, "These results indicate that the use of mobile technology elicits a positive response from students in terms of their perceptions of the mobile activities and improvements in their performance. However, further investigation is required to understand the effects of using mobile technology on students' attitudes towards mathematics" (Fabian et al., 2018, p. 1119).

2.6 Learners' perceptions of mathematics mobile learning

Qiong (2017) provides a general definition of perception as the process of acquiring awareness or recognition of sensory information. However, within the context of this study, perception is specifically defined as an individual's mind-set regarding a particular subject, encompassing their beliefs related to performance expectations, the effort required for utilisation, social influence, facilitating support, attitudes, and intentions for future use.

Another research objective of this study is to permeate into the perceptions of learners concerning Mathematics mobile learning in a senior secondary school located in Maseru urban. This objective gives rise to the research question: "How do learners in a secondary school in Maseru urban perceive the use of mobile devices in the learning of Mathematics?" While the research objective is broad and generalised, the research question is focused and pertains to the objective by soliciting specific insights into learners' perceptions.

Examining learners' expectations, whether prior to the implementation of mobile learning or following its introduction, is considered essential. This is crucial because these expectations can significantly impact the success of the intervention, particularly Mathematics mobile learning, as learners may either embrace or reject the technology. On the other hand, learners' perceptions can exert an influence on their Mathematics performance.

In a separate study conducted by Ozdamli and Uzunboylu (2015), a survey involving 467 teachers and 1556 learners across 32 different schools in Northern Cyprus aimed to ascertain the positive or negative perceptions of both students and educators regarding mobile learning. The research also assessed the readiness of students and teachers for mobile learning implementation. The findings indicated that secondary school learners exhibited a positive outlook toward mobile learning. However, when it came to adequacy, the results indicated a perceived insufficiency. It's important to note that this study did not specifically focus on Mathematics but instead explored the general application of mobile learning.

In contrast, a study by Baya'a and Daher (2009) centred on 32 eighth-grade learners, aged between 12 and 14 years, in an Arab middle school in Israel, employing grounded theory methodology and discourse analysis to examine learners' perceptions of mathematics mobile learning. Notably, this study had Mathematics as its subject matter, with lessons linked to real-life applications of Mathematics. The research revealed that the students were favourably impressed by the potential and capabilities of mobile phones in Mathematics education. Again, it suggested that mathematics education could gain substantial benefits from the integration of mobile devices into the learning process.

The literature review exposed a predominance of studies that primarily focused on the perceptions of tertiary-level students regarding mobile learning. These studies, including Odede (2021), which investigated undergraduate students' perception of mobile learning and mobile self-efficacy, consistently reported a positive perception of mobile learning among university students. However, this created a gap in research concerning secondary school learners. The current study aims to address this gap by concentrating on secondary school students.

Furthermore, Talan (2020) discovered that the academic level and duration of mobile learning had no discernible effect on learners' performance. Instead, it was the subject being taught that significantly influenced learners' performance. This suggests that the impact of mobile learning on performance varies according to the subject or course. Yet, there is a dearth of studies exploring learners' perceptions of mobile learning, particularly in the context of Mathematics. Moreover, there is a notable absence of research on learners' perceptions of mobile learning in Lesotho, despite the prevalent emphasis among researchers on the potential of mobile learning to enhance learners' performance. This is particularly pertinent as many developed countries have embraced mobile learning while Lesotho grapples with the issue of poor Mathematics performance, as indicated by data from the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ). Additionally, Makafane and Chere (2021) characterised online learning in Lesotho as irregular and not officially endorsed as a mode of education. Oppositely, this underscores the urgency of exploring mobile learning research to address the challenge of underperformance in Mathematics.

Hence, it is imperative to gain insights into students' perceptions of learning Mathematics through mobile devices, as students are central to the teaching and learning process. Furthermore, most of the studies reviewed here did not specifically focus on Mathematics as a subject. There exists a pressing need for research that centres on Mathematics and caters to the unique context of Lesotho's population.

2.7 Theoretical framework

2.7.1 Theoretical framework for learners' perceptions on Mathematics mobile learning.

The educational landscape is currently transitioning from traditional classroom learning to digital and mobile learning, marking a shift from conventional electronic learning methods. Past experiences have underscored the significance of gauging individuals' willingness to embrace technology before its introduction into educational settings. Throughout the years, researchers have employed various models to understand technology acceptance, including the Technology Acceptance Model (TAM), the Theory of Reasoned Action (TRA), and the Unified Theory of Acceptance and Use of Technology (UTAUT). These models have evolved and adapted to the specific context of the technologies being researched, aiding researchers in selecting appropriate data collection methods, data analysis techniques, and result interpretation strategies for assessing learners' perceptions.

Venkatesh et al. (2003) developed the Unified Theory of Acceptance and Use of Technology (UTAUT) by amalgamating components from seven prominent models in technology acceptance research. Wang, Wu, and Wang (2009) identified these foundational models as the Theory of Reasoned Action (TRA), proposed by Fishbein & Ajzen in 1975; the Technology Acceptance Model (TAM) by Davis in 1989; the Motivational Model (MM), a collaborative effort by Davis, Bagozzi, and Warshaw in 1992; the Theory of Planned Behaviour (TPB) by Ajzen in 1991; the Social Cognitive Theory (SCT) by Bandura in 1986; the model of PC utilization (MPCU) by Triandis in 1977; and Thompson, Higgins, & Howell's work in 1991.

The UTAUT serves as a comprehensive theory that examines and elucidates behavioural intentions to utilise specific types of technology, particularly information technology. This theory comprises four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions, which together determine individuals' intentions to use technology and their actual usage behaviour (Venkatesh et al., 2003). Venkatesh et al. (2003) further proposed that factors such as gender, age, experience, and the voluntariness of use mediate the impact of these constructs on usage intentions and behaviour.

Within the UTAUT framework, the dependent constructs encompass behavioural intention and usage behaviour, while the independent constructs comprise performance expectancy, effort expectancy, social influence, facilitating conditions, gender, age, experience, and voluntariness of use (Venkatesh et al., 2003). Figure 2.7.1 illustrates the UTAUT model, depicting the relationships between these constructs.

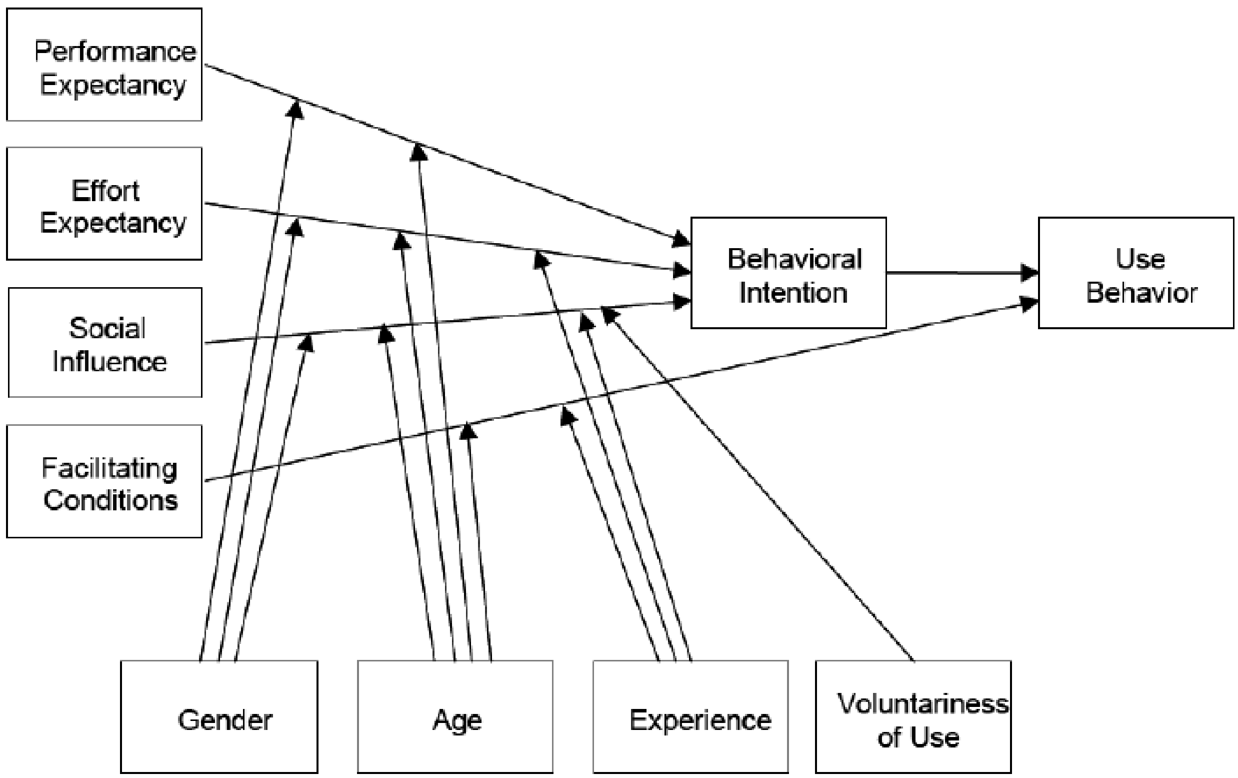
To gain a deeper comprehension of the UTAUT model, it is crucial to define the four determinant factors contributing to usage intention and behaviour concerning technology:
Performance expectancy, as defined by Venkatesh et al. (2003), pertains to the extent to which an individual believes that using an information system or technology will enhance their job performance. In the context of mobile learning, performance expectancy relates to a learner's perception of how mobile learning can be beneficial by providing quick access to information with minimal effort, anytime and anywhere. Nevertheless, Donaldson (2011) noted the scarcity of research in this area, particularly for high school students, emphasizing the need to investigate the effects of performance expectancy on mobile learning.

Effort expectancy refers to the degree of ease an individual associate with utilising technology, as explained by Venkatesh et al. (2003). In the context of mobile learning, effort expectancy reflects a user's perception of how user-friendly mobile learning is. For example, if the system employs web 2.0 features, effort expectancy concerns the ease of navigation without causing frustration.
Social influence, according to Venkatesh et al. (2003), refers to the extent to which a person perceives that influential individuals believe they should use a new information system. In the context of mobile learning, social influence encompasses how teachers, parents, guardians,

classmates, and peers' opinions regarding mobile learning can influence a learner's intention to embrace and use this mode of learning.

Figure 2.7.1

Unified Theory of Acceptance and use of Technology model (UTAUT)



Note. Adapted from *User acceptance of information technology: Toward a unified view* Venkatesh et al, 2003.

This essentially implies that students who are newcomers to mobile learning are more likely to embrace it if they receive encouragement and support from teachers, parents, and peers who endorse its use. Then again, when influential figures within the academic and social sphere do not advocate for the adoption of mobile learning, students are more inclined to reject it.

Facilitating conditions, as defined by Venkatesh et al. (2003), refer to the extent to which an individual believes that the organisational and technical infrastructure is in place to support the use of a specific system. In the context of mobile learning, this implies that the availability of training, support, and the necessary mobile devices for mobile learning is crucial. The absence of these resources, or a lack of skills and mobile devices for using mobile technology, can pose significant barriers. Successful studies on the effectiveness of mobile learning often commence with providing training to teachers and students, underscoring the role of facilitating conditions in influencing technology acceptance.

One of the key advantages of the UTAUT model is its superior explanatory power. It can account for up to 70% of the variance in usage intention (Venkatesh et al., 2003). This sets it apart from other models such as the Technology Acceptance Model (TAM), which only explains around 40% of the variance in intention (Moran, 2006; Venkatesh et al., 2003). Seyal and Rahman (2009) conducted comparative tests of UTAUT against eight competing individual models using the same dataset and found that UTAUT outperformed these models, explaining 69% of the total variance.

Given these advantages of the UTAUT theoretical framework over other models, it will serve as the guiding framework for the present study. The UTAUT framework will inform the development of the measurement instrument used to assess learners' perceptions of mobile learning in mathematics. Furthermore, it will aid in the analysis and presentation of the study's data.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The primary objective of this research endeavour is to explore the impact of mobile learning in the field of Mathematics among tenth-grade students utilising Google Classroom. Furthermore, it aims to ascertain the perspectives and perceptions of these learners regarding mobile learning in mathematics. This chapter serves the purpose of delineating the methodological framework adopted for this study. Additionally, it elucidates the epistemological and ontological assumptions underpinning the research. The chapter also expounds upon the research design, wherein the rationale for employing a quasi-experimental design is justified.

Subsequently, the section examine into detailing the study's target population, providing insights into the geographic distribution and demographic characteristics of the participants. Furthermore, the researcher offers a rationale for the chosen sampling procedure. Following the discussion on sampling, the chapter proceeds to elucidate the research instruments employed for both the quasi-experiment and survey components. This elucidation is complemented by a thorough assessment of the reliability and validity of the survey instrument.

Within the subsequent section, attention is turned to the procedures and conditions governing the data collection phase, including measures taken to mitigate potential errors during this process. Ethical considerations are then addressed, delineating the steps undertaken to safeguard the human rights and privacy of the study's participants throughout the data collection phase.

Subsequent to the discussion on ethical considerations, the chapter elaborates on the data analysis procedure. The final two sections of this chapter are devoted to a comprehensive examination of the study's limitations and delimitations. Here, the researcher candidly outlines both the inherent constraints that are impossible to circumvent and the self-imposed limitations that have been imposed upon the study's scope.

3.2 Research paradigm

A research paradigm serves as foundational perspective from which we conceptualise various research theories and methodologies, as noted by Cohen, Manion, and Morrison (2007). Such paradigms play a pivotal role in guiding the research process, as they dictate the formulation of research objectives and questions, the selection of data types, and the methods of data analysis. There are several distinct paradigms that inform research approaches, including the normative/positivist paradigm, interpretive/anti-positivist paradigm, and critical paradigm, as outlined by Ary, Jacobs, and Sorensen (2010).

Positivism, a well-defined research paradigm, serves as the philosophical underpinning of quantitative methodologies, as highlighted by Machisi (2020). According to August Comte, this paradigm posits that knowledge can be acquired through systematic observation and experimentation, a perspective elucidated by Cohen, Manion, and Morrison (2007).
In the context of the present study, one of its primary objectives is to examine the impact of mobile learning, facilitated through Google Classroom, on the mathematical performance of tenth-grade students. The quantitative approach, characterised by its emphasis on objective measurement and empirical data, aligns harmoniously with the assessment of performance and perceptions. Utilizing quantitative data in the form of performance scores enables the numerical quantification of the effects of mobile learning on mathematical performance.

Positivism underscores the significance of identifying causal relationships, a principle that resonates with the study's aim of exploring the connection between mobile learning and mathematics outcomes. Moreover, the positivist approach places a strong emphasis on the concepts of reliability and validity, thereby bolstering the credibility of the study's findings. By facilitating statistical analysis, it enables the uncovering of patterns and relationships within the collected data. Consequently, the current study has adopted a positivist paradigm approach, given its alignment with the aforementioned research objectives and methodological considerations.

3.3 Design of study

Research design refers to the systematic blueprint and organisational framework of an inquiry, meticulously devised to procure responses to specific research inquiries, as articulated by Ary, Jacobs, and Sorensen (2010). The formulation of a robust research design is essential as it serves as a strategic guide for researchers in the execution of diverse research activities. This, in turn, enhances the efficiency of the research process, facilitating the acquisition of comprehensive information while optimizing resource utilization by minimising efforts, costs, time, and financial expenditures, as emphasized by Kothari (2019).

3.3.1 Quasi-experimental design

The primary objective of this study is to examine the impact of mobile learning on the academic performance of students in the field of Mathematics. Additionally, the study seeks to discern the perspectives and perceptions of students regarding mobile learning in Mathematics. Consequently, this study adopts a quantitative research approach, defined by Kothari (2019) as a method rooted in the measurement of quantitative data. As illuminated by Gay, Mills, and Airasian (2012), quantitative research serves the purpose of describing current conditions, investigating relationships, and exploring cause-and-effect phenomena.

Research design choices can encompass experimental, non-experimental, or mixed methods. In the context of investigating the effects of mobile learning in Mathematics, this study employs an experimental research design. An experimental design, as explained by Ary, Jacobs, and Sorensen (2010), is a systematic plan that involves the manipulation of an independent variable to observe its impact.

To elaborate on the terminology, variables are key components of experimental research. These variables can be categorized as dependent (those influenced by another variable) or independent (those manipulated by the researcher). In this study, the dependent variable is the performance of learners, while the independent variable is Mathematics mobile learning.

There exist various types of experimental research designs, including true experiments, quasi-experiments, and pre-experimental designs. Given the practical constraints associated with randomly assigning students to experimental and control groups, especially when students utilize their own mobile devices, this study opts for a quasi-experimental design. The prefix "quasi" signifies a partial or pseudo resemblance to true experimental research, albeit with distinctions. In quasi-experimental design, participants are not randomly assigned, unlike true experimental design, where random assignment is mandatory. Nevertheless, both designs involve the manipulation of the independent variable.

The specific quasi-experimental design utilized in this study is the nonrandomized control group pre-test–post-test design, also known as the non-equivalent control group design. This choice aligns with the recommendations of Ary, Jacobs, and Sorensen (2010), who consider it a suitable alternative when random assignment is impractical. In the absence of random assignment, the researcher employed a coin toss to designate the experimental and control groups.
The study involved selecting these two groups from different schools. To ensure uniformity, the researcher conducted workshops with experienced grade 10 teachers from both schools, instructing them on lesson planning and conducting traditional lessons using a standardized approach. Subsequently, a pre-test was administered to both groups to establish their equivalence at the outset of the study.

The teacher assigned to the experimental group received training on the utilization of Google Classroom as a learning platform from the researcher, who had prior experience with the platform. This training spanned one week, during which time learners familiarized themselves with Google Classroom. Additionally, the teacher established a WhatsApp group to facilitate communication between learners and their teacher.

Within the experimental group, learners engaged in mobile learning activities, accessing educational resources through Google Classroom. This aligns with the operational interaction level as defined by Wang, Chen, and Anderson (2014), wherein learners interact with technology to connect with educational networks for knowledge acquisition. The teacher played a guiding role, directing learners to appropriate resources.
The pre-test was followed by the introduction of the treatment, which, in this case, entailed Mathematics mobile learning via Google Classroom for the experimental group. The control group, on the other hand, continued with traditional lessons covering the same topics. Efforts were made to maintain uniformity between the two groups, encompassing lesson planning,

classroom activities, and assignments. The sole divergence was the incorporation of mobile learning for the experimental group through Google Classroom, a freely available digital learning platform. The aim was to discern whether any significant differences observed between the two groups could be attributed to the treatment.

The study's design ensured that both groups had similar mean scores or approximately equal means at the commencement of the experiment, thereby safeguarding the internal validity of the results by mitigating potential confounding factors such as selection–maturation and selection–regression interactions. Moreover, the nonrandomized control group pre-test–post-test design proved to be a time-efficient choice compared to other quasi-experimental designs.

Upon the conclusion of the four-week treatment period, a questionnaire was administered to the experimental group to gauge their perceptions of mobile learning in Mathematics. The study employed a cross-sectional design for this purpose, utilizing a questionnaire survey. Respondents were allocated 45 minutes to complete the self-administered questionnaire, which was subsequently collected and reviewed by the researcher. The response rate among learners in the experimental group was 100%, ensuring comprehensive data for analysis. The collected questionnaires were then subjected to analysis

3.4 Population of the study

Researchers recommend selecting a subset of a larger population to participate in a study. This larger group, from which the study's findings can be generalised, is referred to as the "population," while the smaller group participating in the study is known as the "sample."
In the context of this study, the target population consisted of grade 10 learners attending private secondary schools in Maseru urban, Lesotho. This population was chosen for practical reasons, as it was more feasible to adjust the year planners or scheme of work for internal classes. Initially, the two schools had different terms planned for teaching the selected topic. Maseru urban was selected for its convenience to the researcher's location.

Based on geographical data from the Research and Statistics Unit of ECoL in 2020, the 2019 LGCSE examination showed that urban schools had slightly higher proportions of candidates achieving Grades B to E. Specifically, 2.0% of urban candidates obtained Grade B compared to

1.7% of rural candidates. In the case of Grade C, urban candidates constituted 9.6% of the total, while rural candidates accounted for 7.6%.

3.5 Study Sample

The study involved 70 grade 10 students from two distinct schools located in Maseru urban, Lesotho. Specifically, there were 35 learners assigned to the experimental group and 35 learners to the control group. Lesotho comprises 10 districts, with Maseru being the capital. This study was conducted in the urban region of Maseru, approximately 10 kilometres away from the Central Business District of the city.

The participants consisted of both male and female students aged between 15 and 17 years, all sharing a similar socio-economic background. They were in their senior year, following the International General Certificate of Secondary Education (IGCSE) curriculum. It was assumed that neither group of students had prior exposure to mobile learning through Google Classroom. Therefore, a week-long training session was conducted for the experimental group to familiarise them with the use of Google Classroom.

All learners in the experimental group were expected to have access to either a smartphone, a tablet, or a laptop computer with wireless internet connectivity, as these mobile devices were prevalent among the youth population. Iqbal et al. (2017) also emphasised the widespread use of mobile devices among young people, contributing to the growing interest in integrating mobile technology into the education sector. Additionally, Gillwald and Mothobi (2017) identified mobile phones as the primary devices for internet access in Lesotho and noted a correlation between the number of mobile phones owned by individuals and their level of education. Their study found that 54% of individuals with a secondary education possessed a mobile device.

3.6 Sampling procedure

The selection of schools for participation in this study employed the purposive sampling technique, primarily aimed at cost reduction due to the utilisation of expensive mobile learning devices. Purposive sampling is a non-probability sampling method that entails the deliberate

recruitment of participants meeting specific criteria. In this study, schools with similar characteristics and participants equipped with mobile devices were targeted for inclusion. Given the quasi-experimental nature of this study, it necessitated the use of non-probability samples. Non-probability sampling involves the non-random selection of participants, aligning with the prerequisites of a quasi-experimental design, which mandates non-random participant selection.
Within the context of purposive sampling, probability sampling was employed to select one school as the experimental group and another school as the control group from the previously chosen schools. This selection process was accomplished through a coin toss. Both of the selected schools are private institutions with learners sharing a common socio-economic background. Notably, these schools are affiliated with the Lesotho Private Schools Association and the Lesotho Science and Mathematics Teachers Association. This approach aligns with previous research studies that have compared separate schools as experimental and control groups (e.g., Hamid & Kamarudi, 2021; Machisi, 2020; Mafa & Govender, 2018; Acar, Tertemiz & Tasdemir, 2018; Khan, Mcgeown & Bell, 2019).

Machisi (2020), for instance, investigated the impact of Van Hiele theory-based instruction on grade 11 learners' performance, utilising four schools, with two serving as the control group and the other two as the treatment group. Hamid and Kamarudi (2021) assessed the influence of the Mathematical Creativity Approach on mathematics creativity and performance in Mathematics using a quasi-experimental design, employing 32 form four students from each school as either the experimental or control group. Mafa and Govender (2018) conducted a study involving two schools in Botswana, designating one as the experimental group and the other as the control group to explore the effects of mobile learning on learners' performance.

The equivalence of the experimental group and control group at the outset or after administering the pre-test is crucial for bolstering the credibility of results in non-randomized control group pre-test–post-test studies (Ary, Jacobs & Sorensen, 2010). This equivalence can be affirmed through the close approximation of the group means. Ary, Jacobs, and Sorensen (2010) further emphasise that if the two groups are comparable at the outset of the experiment, the design is less susceptible to internal validity threats like selection–maturation since the experiment commences and concludes at the same time. To ensure equivalent groups in this study, the purposive sampling technique, also known as judgment sampling, was employed to select participants for the control group. The group mean of the intervention group was then compared to three other grade 10 classes to identify the class with a closely matching mean.

3.7 Research Instrument

In this research study, the primary objective was to assess the impact of mobile learning through Google Classroom on the mathematical performance of grade 10 learners. To accomplish this, both pre-test and post-test assessments were conducted. These tests were designed based on a specific topic within the mathematics curriculum. Each test was presented to the learners in a structured format, featuring information about the grade level, subject, topic, test duration, total score, and instructions. Responding to the test questions took place directly on the provided space within the question paper. A total of 35 learners from both the experimental and control groups participated in both the pre-test and post-test assessments. It's worth noting that the questions in the pre-test and post-test were deliberately constructed to be analogous. Each question in the pre-test had a corresponding question in the post-test, with identical point allocations for both sets of questions.

To ensure the reliability and validity of the assessments, both the pre-test and post-test were subjected to a thorough review by the research supervisor and the subject teachers. Additionally, the tests were administered and supervised by the respective subject teachers within each group, maintaining consistency in the evaluation process.

One of the study's objectives was to gauge the learners' perceptions and experiences concerning the use of mobile learning in mathematics education. Upon the conclusion of the experiment, learners in the experimental group were required to complete a survey questionnaire. This questionnaire comprised two main sections: demographic data and items derived from the Unified Theory of Acceptance and Use of Technology (UTAUT). The demographic section encompassed five items, including the respondents' age, gender, class level, ownership of a mobile device, and the frequency of engaging in mathematics mobile learning.

The second section of the questionnaire focused on learners' perceptions of mathematics mobile learning and featured items adapted from the UTAUT framework. Respondents were prompted to rate their agreement with each item on a five-point Likert scale, with response options ranging from "strongly agree" (5) to "strongly disagree" (1). This Likert scale format allows for nuanced responses and facilitates numerical analysis, enabling the examination of frequencies, correlations, and other quantitative data. As Cohen, Manion, and Morrison (2007) highlight, Likert scales provide a means of collecting data that offers both sensitivity and differentiation of responses while generating quantifiable values.

For the purpose of this study, an established measurement instrument originally developed by Thomas, Singh, and Gaffar (2013) was adapted. This instrument was derived from the UTAUT model but had initially focused on mobile learning in general subjects. To align with the specific context of this study, the questionnaire was tailored to emphasise mathematics mobile learning. A total of twenty-one items were formulated, drawing from the six key constructs of the UTAUT model. The first four items pertained to performance expectancy, the subsequent three items related to effort expectancy, and three items were linked to social factors. The final six items at the conclusion of the questionnaire assessed attitude and behavioural intentions regarding mathematics mobile learning.

3.8 Validity and reliability

3.8.1 Quasi-experiment validity and reliability

Bryman (2008) underscored the importance of reliability, validity, and replication as essential criteria for assessing and evaluating the quality of research (p. 44). He further expounded that reliability concerns the repeatability of study results, emphasizing the consistency of test outcomes, particularly in quantitative research. Ary, Jacobs, Sorensen, and Razavieh (2010) provided a definition of validity, describing it as the degree to which an instrument measures what it is intended to measure. Furthermore, validity extends to the interpretation and meaningfulness of results derived from the instrument (p. 225).

The instrument employed to gather data for both the pre-test and post-test consisted of questions sourced from recent International General Certificate of Secondary Education (IGCSE) 0580 Mathematics past question papers. Careful consideration was given to the inclusion of questions spanning all levels of Bloom's taxonomy to accommodate learners of varying abilities. Each question featured in the pre-test had an equivalent question in the post-test, carrying the same weight in terms of marks and corresponding content. This design aimed to mitigate any disparities in question difficulty between the pre-test and post-test. The assessments underwent a thorough review and moderation process involving two teachers from each of the participating schools. Additionally, the tests received scrutiny and moderation from a research supervisor. Feedback and insights provided by these three experts informed revisions to the draft tests. A final version was further reviewed for relevance and clarity by four experts in the field of Mathematics education before the tests were printed.

Various factors that could potentially compromise the internal validity of the tests were considered and vigilantly monitored during the data collection phase of this study. These factors encompassed maturation, including selection–maturation, which was addressed by synchronising the commencement and conclusion of the experiment for both groups. Selection bias was mitigated by ensuring that the two groups exhibited no significant differences in mean pre-test scores, and the selection of the experimental and control groups was determined through a random process involving the spinning of a coin. Additionally, the threat of instrumentation was minimised by constructing similar questions with equal mark weights in both the pre-test and post-test. To reduce the influence of social interaction and social desirability, two distinct schools were utilized as the control and experimental groups. However, the selection of these schools took into account their shared characteristics to avoid potential selection bias.

3.8.2 Survey validity and reliability

Ary, Jacobs, Sorensen, and Razavieh (2010) advised that when employing a research instrument previously developed by other researchers, the research proposal should include both the instrument's name and documented evidence of its reliability and validity (p. 579). In accordance with this guidance, this study incorporates evidence of reliability and validity sourced from Singh and Gaffar's (2013) research titled "The Utility of the UTAUT Model in Explaining Mobile Learning Adoption in Higher Education in Guyana."

To ensure the reliability of the questionnaire, Thomas, Singh, and Gaffar (2013) conducted a pilot study prior to utilising their questionnaire for the main research. Internal reliability was assessed using Cronbach's alpha, while convergent validity was evaluated through the calculation of the Average Variance Extracted (AVE). These assessments aimed to determine the accuracy and precision of each item in the questionnaire, as per the criteria outlined by Hair, Black, Basin, Anderson, and Tatham (2006).

The findings indicated that the reliability scores for each statement, as determined by Cronbach's alpha scores, fell within the range of 0.797 to 0.911. These scores exceeded the established threshold of 0.7, leading Thomas, Singh, and Gaffar (2013) to describe the questionnaire as possessing adequate internal reliability, in accordance with the criteria set forth by Hair, Black, Basin, Anderson, and Tatham (2006).

Convergent validity was assessed by computing the Average Variance Extracted (AVE), and the results revealed that all items scored above 0.5, with the exception of facilitating conditions. This outcome aligns with the criteria established by Hair et al. (2010) for demonstrating convergent validity. These results are summarized in Table 3.7.

Table 3.7

Items loading on the UTAUT constructs

Item of questionnaire	Performance expectancy PE	Effort expectancy EE	Social Factors SF	Facilitating Conditions FC	Behavioural Intentions BI
PE 1	.744				
PE 2	.8o9				
PE 3	.773				
PE 4	.762				
EE 1		.86o			
EE 2		.9o5			
EE 3		.878			
SF 1			.888		

SF 2			.935		
SF 3			.452		
FC 1				.374	
FC 2				.5o3	
FC 3				.779	
FC 4				.745	
FC 5				.741	
BI 1					.927
B1 2					.91o
BI 3					.769
average variance extracted AVE	.597	.777	.622	.421	76o
Cronbach alpha	.875	.911	.789	.797	.899

Note. Adapted from *the utility of the UTAUT model in explaining mobile learning adoption in higher education in Guyana* by Thomas, Singh and Gaffar, 2013.

The discriminant validity of the constructs was assessed by following the method proposed by Fornell and Larcker (1981), which involves comparing the square root of the average variance extracted with the correlations among the factors. Table 3.7 presents the results, demonstrating that discriminant validity has been successfully established.

In Table 3.1, the correlations among factors or constructs are displayed off the diagonal, while the square root of the average variance extracted values are presented on the diagonal in bold. This table clearly illustrates that the square root of the average variance extracted for each factor exceeds the correlation values of that factor with all other factors within the model. This outcome confirms the presence of discriminant validity among the constructs.

3.9 Data collection

Nenty (2009) emphasised the importance of clearly articulating the conditions under which data collection occurred to facilitate the replication of the study. Therefore, this section elucidates the methodology employed for data collection in this research.

The research design adopted for this study was experimental, necessitating the use of pre-test and post-test data collection methods. Additionally, a questionnaire was administered to gather data pertaining to learners' perceptions of mathematics mobile learning. Following the obtainment of permissions from the Ministry of Education and Training, as well as the consent of the principals and relevant subject teachers in both participating schools, the researcher prepared the pre-test and post-test assessments. These assessments underwent a comprehensive review and moderation process, involving both the teachers and the research supervisor.

The primary objective of the pre-test and post-test assessments was to gauge the impact of the intervention, specifically mobile learning, on learners' mathematics performance. This was achieved by comparing test scores before the intervention (i.e., the pre-test) and after the intervention (i.e., the post-test) for each group. Notably, both groups completed the pre-test on the same day.

Given the use of purposive sampling in this study, aimed at selecting groups with similar characteristics by the end of the study, the pre-test mean score of a class within the experimental group was compared to the means of three other classes in the control school. The goal was to identify a class with an approximately equal pre-test mean, which was subsequently designated as the control group. This meticulous process was instrumental in ensuring the credibility of the study results, guarding against potential internal validity threats such as selection–maturation and selection–regression interactions.

To further control for potential confounding variables, workshops were conducted on a weekly basis by the researcher and the two subject teachers. These workshops focused on harmonising lesson planning to ensure that both groups received instruction in a similar manner. This approach aimed to isolate the effects of the mobile learning treatment on post-test outcomes. Over the course of the subsequent four weeks, mobile learning activities were integrated into the curriculum, with both groups concurrently participating in their regular physical classroom lessons. These mobile learning activities were designed to correspond with traditional classroom lessons, thereby ensuring a coherent instructional experience for all participants.

3.9.1 Week 1 of experimental group mobile learning activities.

In the experimental group, the teacher established a Whatsapp group to facilitate seamless communication with the learners and created a Google Classroom platform where assignments, instructional videos, and practice exercises were regularly disseminated. On occasions, WhatsApp groups were utilised to distribute these educational resources. During the initial week, the experimental group received an individual practice document via Google Classroom, which included questions and answers for self-assessment. This task was designed as an independent assignment for learners to complete at their convenience, utilising their mobile devices. This approach aligns with the definition of mobile learning as outlined by Farooq et al. (2002), which characterises mobile learning as a mode of learning facilitated through wireless mobile devices.
The initial-week assignment necessitated learners to consolidate like terms and simplify algebraic expressions. Subsequently, learners were encouraged to compare their own solutions and answers with the provided worked solutions at the end of the document. Because these activities were conducted beyond the confines of the classroom, permitting learners to engage from the comfort of their homes or any location at any time within the stipulated deadline, they align with the concept of mobile learning, as articulated by Hashin, Choo, and Song (2009). This perspective defines mobile learning by its inherent flexibility, enabling learning to occur at any location, at any time.

In a similar vein to assignments, the experimental group of learners was also directed to access an online quiz hosted on quiz-maker.com. This quiz focused on activities that required learners to perform substitutions into given formulae or expressions. The online quiz adopted a multiple-choice format, presenting four answer options for each question. It consisted of ten multiple-choice questions, and upon completion, learners were able to view their total score and review correct answers. This exercise enabled learners to hone their skills in responding to questions that involved substitutions into formulae, as they assessed their own performance through the quiz.

3.9.2 Week 2 of experimental group mobile learning activities.

During the second week of the research study, the researcher created tutorial videos covering various methods for solving linear equations. These instructional videos encompassed the resolution of linear equations, equations with variables on both sides, and linear simultaneous equations. The distribution of these videos was carried out through the WhatsApp platform and within the Google Classroom. Learners were expected to download the videos, share them with peers who may have faced difficulties due to limited mobile data access, and independently watch the tutorials. These videos were accessible for viewing either directly from the storage of their mobile devices or via the Google Classroom platform. It was during this process that the learners engaged in learning the techniques for solving linear simultaneous equations, as they watched the teacher demonstrate these skills in the video format. Importantly, learners had the flexibility to rewind and fast-forward the videos as many times as needed. This mode of learning aligns with the concept of mobile learning, as it occurs through the use of mobile devices.

Additionally, within the same week, learners were presented with worked examples related to the process of factoring expressions by extracting common factors from brackets. Subsequently, learners were encouraged to participate in discussions and offer comments within the Google Classroom environment. The interaction among learners through their mobile devices within the Google Classroom, where they shared their perspectives, posed questions, and responded to inquiries, epitomised yet another dimension of mobile learning. This mode of engagement facilitated interactivity and active participation among the learners.

3.9.3 Week 3 of experimental group mobile learning activities.

At the outset of the third week, the learners proceeded with their study of factorisation, with a specific focus on quadratic expressions in the form of x^2 + ax + b and ax^2 + bx + c. The instructional emphasis during this phase centered on equipping the learners with the ability to solve quadratic equations utilising factorisation techniques. To support this learning process, video tutorials were disseminated to the learners via the Google Classroom platform. These tutorials provided step-by-step demonstrations of how to factorise quadratic expressions and employ factorisation as a method for solving quadratic equations. This mode of instruction, delivered through digital means on their mobile devices, exemplified the concept of mobile learning.

3.9.4 Week 4 of experimental group mobile learning activities.

The learners engaged in activities centred on the addition and subtraction of numeric fractions, which were presented in document format. The objective of these activities was to help learners establish a connection between numeric fraction operations and the representation of algebraic fractions as a unified fraction. As part of the learning process, learners were provided with a link to a YouTube video that explained the concept of expressing algebraic fractions as a single fraction. Learners were required to download and view this video. These activities spanned a duration of four weeks. Subsequently, a post-test was administered to both the experimental and control groups on the same date.

In addition to the assessments, the experimental group was tasked with completing 35 questionnaires, one for each participant. These questionnaires were designed to elicit the learners' perceptions of mobile learning in mathematics. All 35 questionnaires were duly completed by the participants. Both the test scores and questionnaire responses were collected and subjected to further analysis.

3.10 Data analysis procedure

3.10.1 Data analysis procedure on learners' performance in Mathematics

This study primarily focused on the collection and analysis of quantitative data. In accordance with the recommendation of Nenty (2009), the research hypothesis was rearticulated within this section. The null hypothesis posited that there exists no statistically significant difference in the performance of learners in algebra mathematics when instructed using mobile learning compared to those instructed solely through traditional methods. To assess this null hypothesis, an independent sample t-test was employed with a significance level set at 5%, as prescribed by Ary, Jacobs, and Sorensen (2010).

Following the administration of both the pre-test and post-test assessments and the subsequent scoring of these mathematics tests, the obtained test scores were entered into the SPSS 20 software for rigorous analysis. Consistent with the guidance of Ary, Jacobs, and Sorensen (2010), the independent sample t-test was deemed appropriate for determining whether a significant difference existed between the performance outcomes of the experimental group and the control group in the post-tests. The outcome of this analysis was presented through the generation of a table containing relevant sample statistics for each group.

3.10.2 Data analysis procedure on learners' perceptions of Mathematics mobile learning

This study also aimed to explore learners' perceptions regarding mobile learning in mathematics. To assess these perceptions, quantitative data was gathered through a survey instrument and subsequently analysed using SPSS 20 software. In the analysis process, variables were carefully defined and input into SPSS. The data pertaining to learners' perceptions was then subjected to analysis, resulting in the generation of frequency tables that depicted the extent of agreement among learners with respect to the Unified Theory of Acceptance and Use of Technology (UTAUT) constructs.

To enhance the presentation of this data, frequency tables were transferred to Microsoft Excel 2010. Within Excel, the data was utilized to create bar charts, providing a visual representation of the frequency distribution for each response category in terms of percentages.

3.11 Ethical Considerations

Four ethical principles serve as safeguards to protect research participants: harm to participants, lack of informed consent, deception, and invasion of privacy (Bryman, 2012). This study was meticulously conducted and data collection adhered to these ethical principles.

Concerning informed consent, invasion of privacy, and deception, formal permission was sought and obtained from the Maseru Regional Inspectorate office within the Ministry of Education and Training of the Government of the Kingdom of Lesotho to gather data for this research study. Hence, the researcher visited the respective schools with the official letter of permission from the Ministry of Education and Training, whereupon they articulated their intention to collect data within these educational institutions.

The school principals were duly informed about the researcher's visit and their expressed interest in conducting this research. Consequently, the school principals involved the relevant grade 10 mathematics teacher and the head of the Mathematics and Science department, who were already briefed on the researcher's objectives. Permission to proceed with data collection was granted, and a formal letter of consent was presented to and signed by the grade 10 mathematics teacher.

These consent letters explicitly stipulated that the data collected would exclusively be used for research purposes and guaranteed the protection of participants' identities. Furthermore, the letters affirmed that should the teacher or the school choose to withdraw their participation from the study at any point, they would be free to do so without any constraints.

3.12 Summary and conclusion

This chapter elucidated the research methodology employed in the present study. It commenced with a disclosure of the study's epistemological and ontological assumptions. Therefore, the chapter provided an in-depth explanation and rationale for the adoption of the quasi-experimental and descriptive research designs. Additionally, the chapter encompassed a comprehensive description of both the study's population and sample, accompanied by an outline of the sampling procedure employed.

Furthermore, the chapter offered an insight into the research instrument, including discussions related to the validity and reliability of the survey questionnaire, as well as the pre-test and post-test assessments. Detailed procedures for data collection and subsequent analysis were also expounded upon.

Concluding this chapter, there was an explication of the ethical principles governing the researcher's conduct throughout the study.

CHAPTER 4

PRESENTATION OF DATA

4.1. Introduction

This chapter serves as an exposition of the research findings derived from the collected data. Both the pre-tests and post-tests underwent rigorous analysis through the utilisation of an independent sample t-test, executed using IBM Statistical Package for the Social Sciences (SPSS) 20. The primary aim of this analysis was to determine whether a significant difference existed between the experimental group and the control group.

The initial section of this chapter is dedicated to the presentation and analysis of learners' performance in Mathematics. It includes an examination of the pre-test scores of both groups through an independent sample t-test. To gauge the extent of improvement within each group, a paired samples t-test was conducted by comparing pre-test and post-test scores for each respective group. The final subsection under the "Learners' Performance in Mathematics" category encompasses an independent samples t-test analysis of the post-tests administered to both the control and experimental groups.

In addition to the performance data, this chapter offers demographic insights, presented in tabular form, which includes the frequencies and percentages related to respondents' ages, as well as the number of mobile devices owned by the learners, presented as a frequency table. These tables are accompanied by comprehensive interpretations.

The last section of this chapter focuses on the presentation of results regarding learners' perceptions, which were assessed utilizing the Unified Theory of Acceptance and Use of Technology (UTAUT) constructs. Each construct, comprising three to five items, is consolidated into a single bar chart. The height of the bars in these charts signifies the frequency of each Likert-scale response. Consequently, this chapter features a total of six bar charts pertaining to learners' perceptions of mathematics mobile learning, with each chart followed by an in-depth interpretation of its findings.

4.2 Presentation of demographic information

4.2.1 Age respondents

Each of the 35 learners within the experimental group provided their age information on the questionnaire. A summary of these responses is presented in Table 4.2.1. The table delineates that the participants' ages ranged between 15 and 16 years. Predominantly, the majority of respondents were 15 years old, constituting approximately 69% of the total respondents.

Table 4.2.1

Frequency of learners' age

Age of learners					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15	24	68.6	68.6	68.6
	16	11	31.4	31.4	100.0
	Total	35	100.0	100.0	

4.2.2 Number of mobile devices respondents own

Every participant in this study possesses at least one mobile device, and the specific number of mobile devices owned by each participant is detailed in Table 4.2.2. The outcomes of this examination reveal that 86% of the participants possess a single mobile device, while 11% of participants own two mobile devices. Additionally, 3% of students reported having three mobile devices.

Table 2.2.2

Number of mobile devices each learner has

No. of mobile devices					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	30	85.7	85.7	85.7
	2	4	11.4	11.4	97.1
	3	1	2.9	2.9	100.0
	Total	35	100.0	100.0	

4.2.3 Number of times respondents use Mathematics mobile learning per week

Table 4.2.3 presents a frequency table detailing the frequency with which each learner utilises a mobile device for learning mathematics within a one-week timeframe. The data within the frequency table underscores that a majority of learners make frequent use of their mobile devices, with 65% of respondents indicating that they employ their mobile devices for mathematics learning purposes between 4 to 5 times per week.

Table 4.2.3

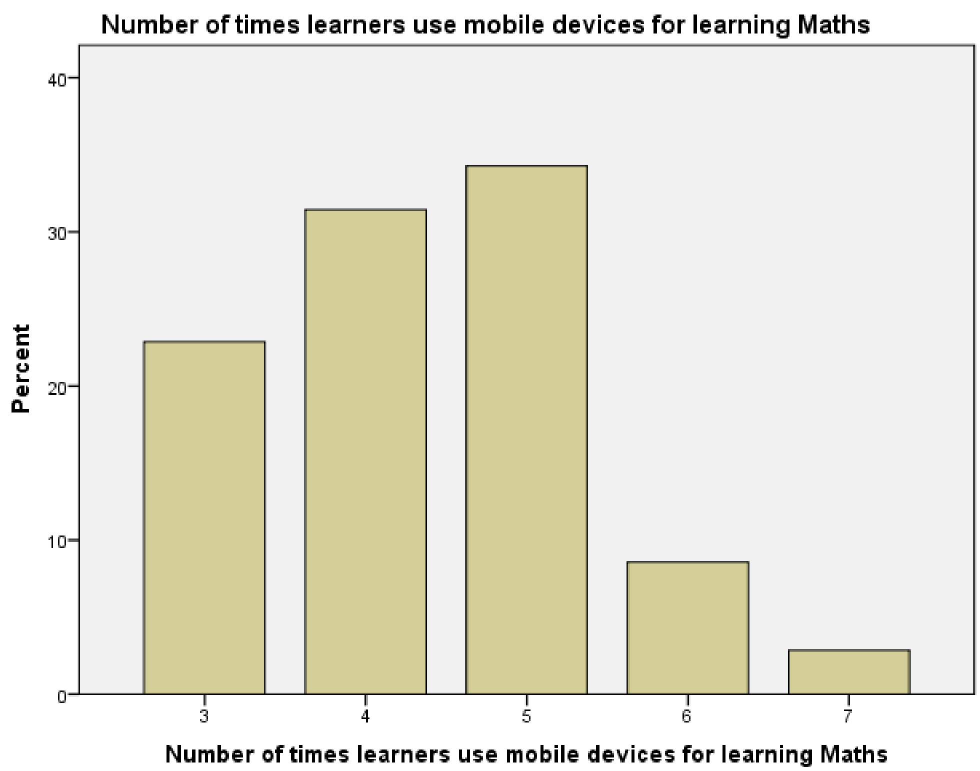
Number of times learners use mobile devices for learning Mathematics

No. of times	Frequency	Percent	Valid Percent	Cumulative Percent
3	8	22.9	22.9	22.9
4	11	31.4	31.4	54.3
5	12	34.3	34.3	88.6
6	3	8.6	8.6	97.1
7	1	2.9	2.9	100.0
Total	35	100.0	100.0	

Figure 4.2.3 illustrates a bar chart representing the frequency of learners' mobile device usage for mathematics learning. The chart unmistakably portrays that the majority of learners, accounting for over 65% of respondents, employ their mobile devices for mathematics learning purposes between 4 to 5 times per week. Inversely, a notably smaller fraction of learners utilize their mobile devices for mathematics learning on a more frequent basis, specifically 6 to 7 times per week.

Figure 4.2.3

Number of times learners use their mobile devices for learning Mathematics



4.3 Presentation of learners' performance in Mathematics

4.3.1 Assumptions of statistical tool

To avoid violation of assumptions of underlying the independent samples t-test namely:

1. Assumption of independence

2. Assumption of normality
3. Assumption homogeneity of variance

4.3.1.1 Assumption of independence

The validity of this condition cannot be ascertained through the samples themselves. Nevertheless, during the study's design phase, two distinct schools were deliberately chosen to serve as the control and experimental groups. Additionally, the assessments were closely monitored by subject teachers to guarantee the independence of participants' scores, ensuring that they were not systematically interconnected.

4.3.1.2 Test for assumption of normality

The normality test was conducted utilizing the Shapiro-Wilk test, with a predetermined alpha level (α) of 0.05, signifying the level of significance for the statistical analysis. The null hypothesis posited that there is no substantial deviation from normality. As indicated in Table 4.3.1.2(a), the p-values or significance values for the pre-test scores and post-test scores were found to be 0.582 and 0.337, respectively. In light of these results, it is appropriate to retain the null hypotheses. Consequently, it can be concluded that the levels of the independent variable exhibit a normal distribution.

Table 4.3.1.2(a)

Normality test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test Scores	.075	70	.200*	.985	70	.582

Post-test Scores	.092	70	.200*	.980	70	.337

Figure 4.3.1.2 (a) shows the pre-test scores Box and Whisker plots of pre-test scores showing no outliners. Revealing the maximum score of 27, minimum score of 4, median of 15 and interquartile range of about 6.

Figure 4.3.1.2 (a)

Pre-test scores on box and whisker plots

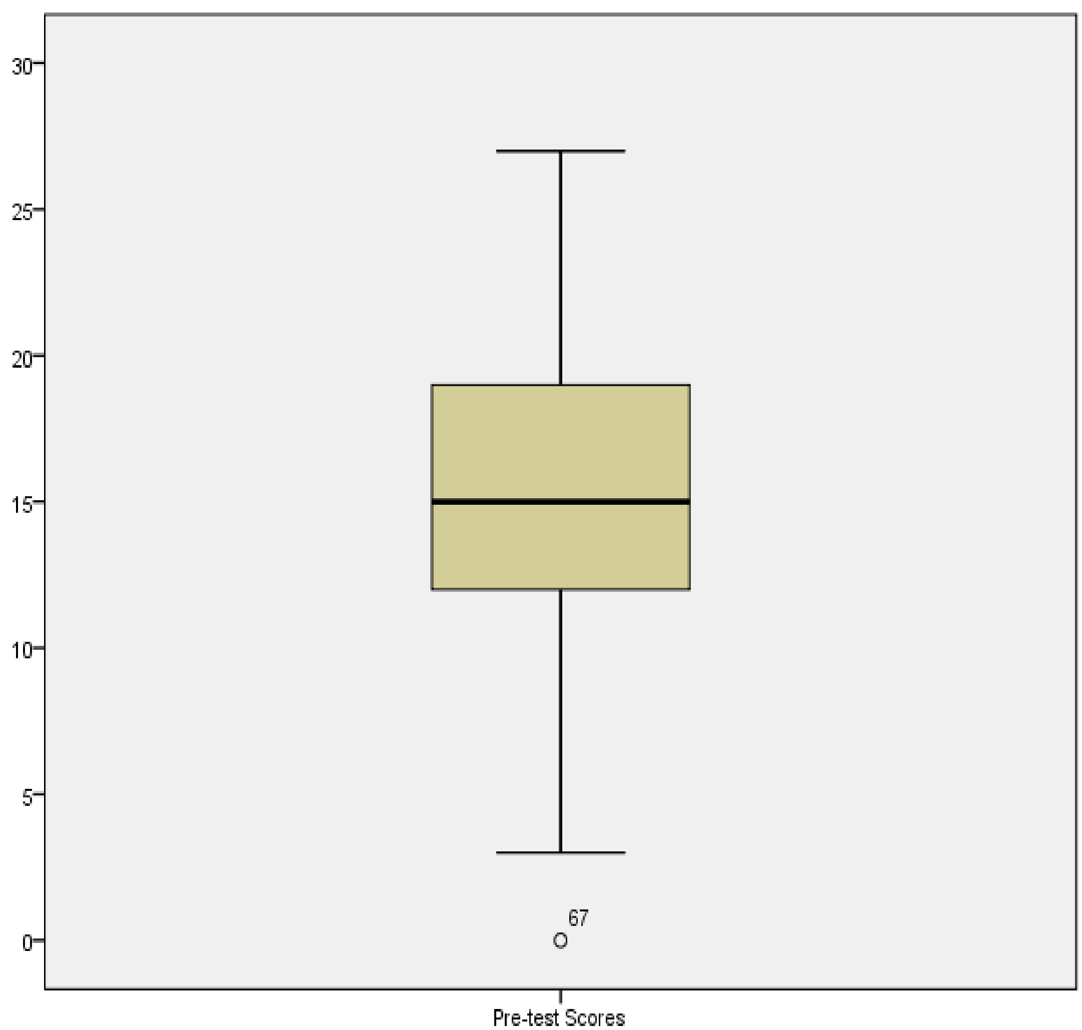


Figure 4.3.2.1(b) shows normal the Q-Q plots of pre-test scores

Figure 4.3.1.2(b)

Normal Q-Q plots of pre-test scores

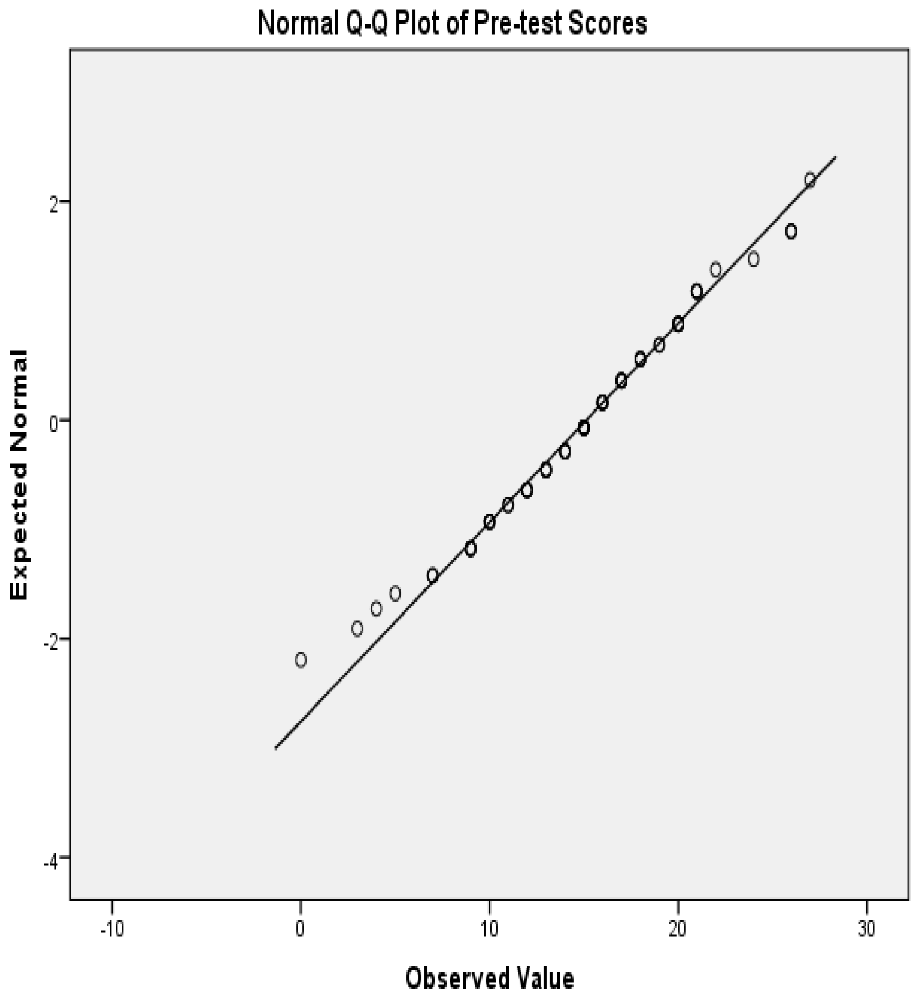


Figure 4.3.1.2 (c) shows the post-test scores Box and Whisker plots with no outliers. The box and whisker plot shows maximum score of 30, minimum score of 13. The median score of 18, upper quartile score and lower quartile score of 25 and 19 respectively.

Figure 4.3.1.2 (c)

The box and whisker plots for post-test scores

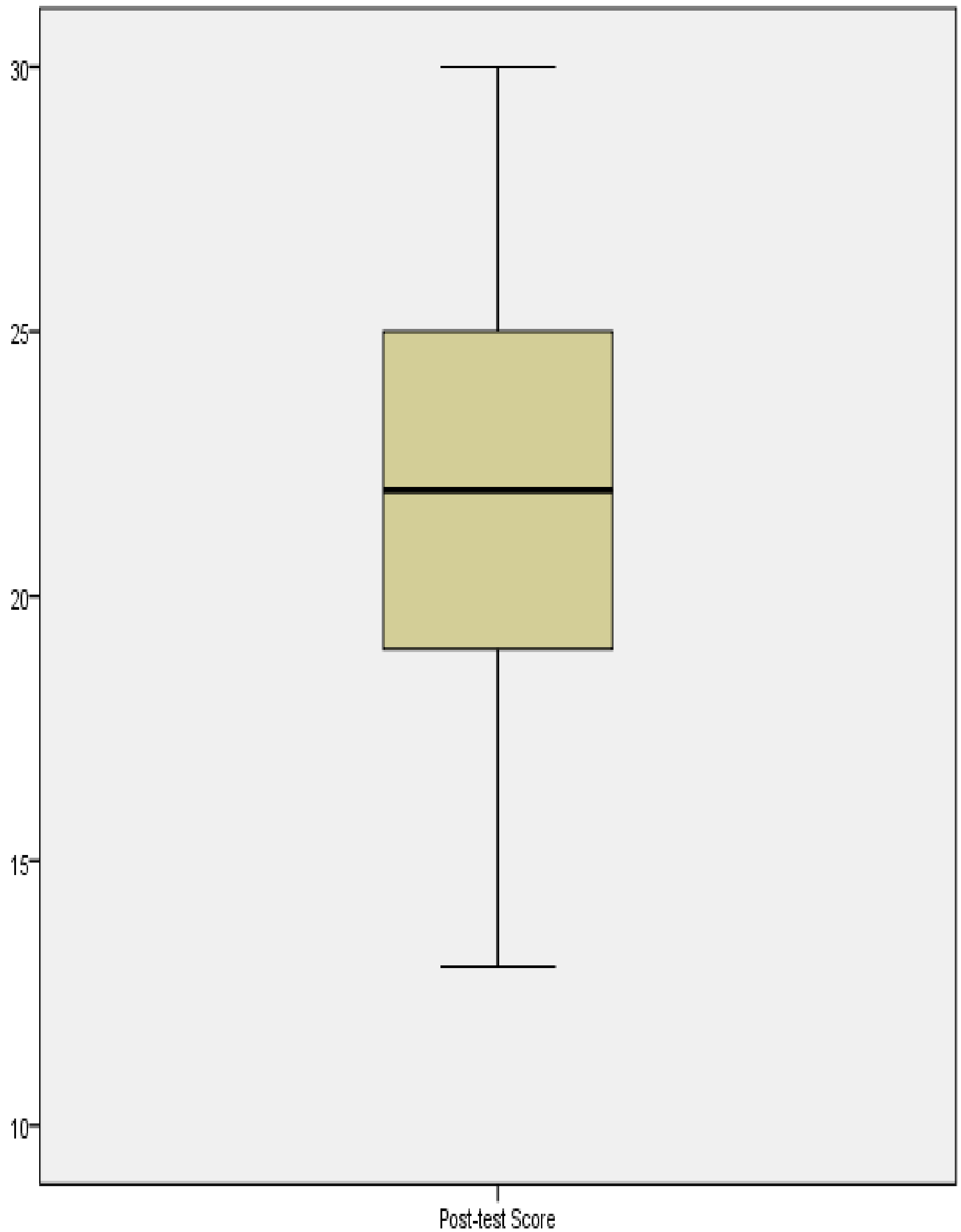


Figure 4.3.1.2(d) shows normal the Q-Q plots of post-test scores

Figure 4.3.1.2(d)

The normal Q-Q plots of the post-test scores

4.3.1.3. Test for homogeneity of variance

Table 4.3.1.3(a) displays the results of Levene's test, which assesses the equality of variances for pre-test scores. The null hypothesis posited that there was no significant difference in variance between the two groups. As per Almquist, Kvart, and Brännström (2019), when the p-value in the "sig." column exceeds 5%, the focus shifts to the row indicating equal variances assumed, while if the p-value falls below 5%, the focus shifts to equal variances not assumed.

In the context of Table 4.3.1.3(a), the focus is directed towards the row signifying equal variances assumed, as the significance value is 0.348, which is less than the 0.05 threshold.

Accordingly, the null hypothesis is upheld, indicating that the assumption of homogeneity in variances has been satisfied.

Table 4.3.1.3(a)

Levene's F test for pre-test scores

Independent samples test			
		Levene’s test for equality of variance	
		F	Sig.
Pre-test scores	Equal variances assumed	0.894	0.348
	Equal variances not assumed		

Table 4.3.1.3(b) displays the outcomes of Levene's F test, which evaluates the equality of variances for post-test scores. The results indicate a p-value of 0.810, which is not statistically significant at the 0.05 significance level. As a result, the null hypothesis, asserting that there is no noteworthy difference in variance between the two groups, is upheld. This implies that equal variance can be assumed, signifying that the assumption of homogeneity of variance has been satisfied.

Table 4.3.1.3(b)

Levene's F test for post-test scores

Independent samples test			
		Levene's test for equality of variance	
		F	Sig.
Pre-test scores	Equal variances assumed	0.058	0.810
	Equal variances not assumed		

4.3.2 Independent sample t-test of Pre-tests

To safeguard the credibility of the results against potential threats to internal validity, such as selection-maturation and selection-regression interactions, as highlighted by Ary, Jacobs, and Sorensen (2010), the researcher conducted a comparison of the mean score of the experimental group's pre-test with that of three other classes in the control group's pre-test. This comparison aimed to identify a suitable control group with no significant difference, ensuring that both groups commenced the study at an equivalent level. The results of this mean comparison are presented in Table 4.3.2(a).

Table 4.3.2(a)

Comparison of pre-test class means

The experimental group pre-test mean	The control group pre-test means and classes	
	mean	Class
15.43	18.96	Grade 10A
	14.86	Grade 10B
	10.29	Grade 10C

According to Table 4.3.2(a), the class that exhibited the highest similarity to the experimental group was grade 10B, with a pre-test mean score of 14.86. This finding indicates that the two groups were indeed quite similar at the outset of the study. Moreover, the similarity between the two groups at the study's commencement is further substantiated by the independent sample t-test conducted for both schools or groups.

Through purposive sampling, the choice of grade 10B as the control group was deliberate, as it possessed characteristics most akin to those of the experimental group. This selection was made with the specific intent of enhancing the credibility of the study's results and findings, as it effectively mitigated potential internal validity concerns, such as selection-maturation and selection-regression interactions.

Table 4.3.2(b) provides group statistics, presenting the pre-test mean scores of both the control and experimental groups.

Table 4.3.2(b)

Group statistics of control group and experimental group

Group Statistics					
	Groups	N	Mean	Std. Deviation	Std. Error Mean
Pre-test Scores	Experimental Group	35	15.43	5.741	.970
	Control Group	35	14.86	5.298	.896

Table 4.3.2(b) displays the pre-test mean scores for both the experimental and control groups. The mean score for the experimental group was 15.43, while the control group had a mean score of 14.86. This resulted in a difference of 0.57 points between the mean scores of the two groups. It's worth noting that one potential explanation for the slightly higher mean score in the experimental group could be attributed to the fact that more learners in this group had prior knowledge of how to factorise quadratic expressions compared to the control group. Each group comprised 35 learners. The standard deviation for the pre-test scores was 5.741 for the experimental group and 5.298 for the control group.

Table 4.3.2(c) presents the results of the independent samples t-test, specifically Levene's test for equality of variances. Following the guidance of Almquist, Kvart, and Brännström (2019), if the p-value in the "Sig." column exceeds 5%, the focus should be on the row indicating equal variances assumed. Conversely, if the p-value falls below 5%, the focus shifts to equal variances not assumed. In this instance, Table 4.3.2(c) directs our focus to the row of equal variance assumed, as the significance value is 0.348, which is less than 0.05.

With the focus established, attention turns to the "Sig. (2-tailed)" column in Table 4.3.2(c), which reveals that the difference between the two groups is not statistically significant. This conclusion is drawn from a p-value of 0.667, which is less than the 0.05 significance level.

Table 4.3.2 (c)

Independent samples t-test of pre-test scores of control group and experimental group

Independent sample test								
		Levene's test for equality of variance		t-test for equality of means				
Post-test score	Equal variances assumed	F	Sig.	t	df	Sig.(2-tailed)	Mean difference	Std. error difference
	Equal variances not assumed	0.894	0.348	4.33 4.33	68 67.566	0.667 0.667	0.571 0.571	1.320 1.320C

4.3.3 Paired t-test of pre-test and post-test of control group

To assess whether the traditional teaching method employed in the control group resulted in a significant improvement in learners' performance, the pre-test and post-test scores for the control group were subjected to paired-sample analysis using SPSS 20. The outcomes are presented in Table 4.3.3(a), revealing that the control group exhibited an increase in their mean score from

14.86 in the pre-test to 19.77 in the post-test. The sample size comprised 35 learners, and the standard deviations for the pre-test and post-test scores were 5.298 and 3.711, respectively.Table 4.3.3 (a)

Table 4.3.3(b)

Pre-test and Post-test paired samples statistics for control group

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Scores	14.86	35	5.298	.896
	Post-test Score	19.77	35	3.711	.627

Table 4.3.3(b) displays the results of a paired sample t-test conducted to analyse the pre-test and post-test scores for the control group. The table indicates a mean difference of -4.914, a t-value of -7.372, 34 degrees of freedom, and a significance value (p-value) of 0.000. Since the p-value is less than 0.05, it is reasonable to conclude that a significant difference exists between the pre-test and post-test scores at the conclusion of the experiment.

Table 4.3.3(b)

Paired sample t-test for control group pre-test and post -test scores

Paired Samples Test							
	Paired Differences				t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			

				Lower	Upper			
Pair 1 Pre-test Scores - Post-test Score	-4.914	3.944	.667	-6.269	-3.560	-7.372	34	.000

4.3.4 Paired t-test of pre-test and post-test of experimental group

The paired sample statistics reveal that in the experimental group, there was a notable improvement of 8.54 in the mean score before and after the treatment. The pre-test mean was 15.43, whereas the post-test mean was 23.97. As indicated in Table 4.3.4 (a), a sample size of 35 learners participated in both tests. The pre-test scores for the experimental group exhibited a relatively high standard deviation of 5.741, suggesting that the data was widely dispersed. In contrast, the post-test scores displayed a lower standard deviation of approximately 3.569, indicating that the test scores were more closely clustered around the mean.

Table 4.3.4 (a)

Pre-test and post-test paired sample statistics for the experimental group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Scores	15.43	35	5.741	.970
	Post-test Score	23.97	35	3.569	.603

The results of the paired t-test sample for the experimental group's pre-test and post-test scores are displayed in table 4.3.4(b). This table illustrates the paired variables, which are the experimental group's pre-test and post-test, along with their corresponding analysis. The mean difference is -8.543, the T-value is -7.474, the degrees of freedom are 34, and the significance level (P-value) is 0.000. The P-value being less than 0.05 indicates a significant change in performance attributed to the treatment.

Table 4.3.4(b)

Paired sample t-test of pre-test and post-test of the experimental group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-test Scores - Post-test Score	-8.543	6.762	1.143	-10.866	-6.220	-7.474	34	.000

4.3.5 Independent sample t-test of experimental and control group post-tests.

Both the experimental group and the control group demonstrated significant improvements in their performance. However, it is essential to determine which group exhibited a more substantial improvement in the post-test. To investigate whether there was a significant difference in performance between the two groups, we conducted an independent t-test between the control group's post-test scores and the experimental group's post-test scores.

Table 4.3.5 (a) provides group statistics for post-test scores, encompassing both the control group and the experimental group. Their respective mean scores are 19.77 and 23.97. The sample size consisted of 35 participants, which was consistent for both groups. Notably, the control group exhibited a more dispersed distribution of scores, with a standard deviation of 3.711, whereas the experimental group displayed a slightly more concentrated standard deviation of 3.569. This suggests that there may be differences in the performance between the two groups that warrant further investigation.

Table 4.3.5(a)

Group statistics of post-test for control group and experimental group

Group Statistics					
	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post-test Score	Experimental group	35	23.97	3.569	.603
	Control group	35	19.77	3.711	.627

Table 4.3.5 (b) displays the results of the independent sample t-test conducted to compare the post-test scores between the control and experimental groups. Initially, Levene's test for equality of variances was performed, yielding a non-statistically significant p-value of 0.810. For this reason, we focused on the row where equal variances were assumed.

In Table 4.3.5 (b), the significance value (Sig, 2-tailed) is reported as 0.000, with an estimated p-value of 0.000038. This p-value, which is substantially less than 0.05, indicates a significant difference in the mean scores between the control group's post-tests and the experimental group's post-tests.

Table 4.3.5 (b)

Independent sample t-test for control and experimental group

Independent sample test									
		Levene's test for equality of variance		t-test for equality of means					
Post-test score	Equal variances assumed	F	Sig.	t	df	Sig.(2-tailed)	Mean difference	Std. error difference	
	Equal variances not assumed	0.058	0.810	4.826 4.826	68 67.896	0.000 0.000	4.2 4.2	0.870 0.870	

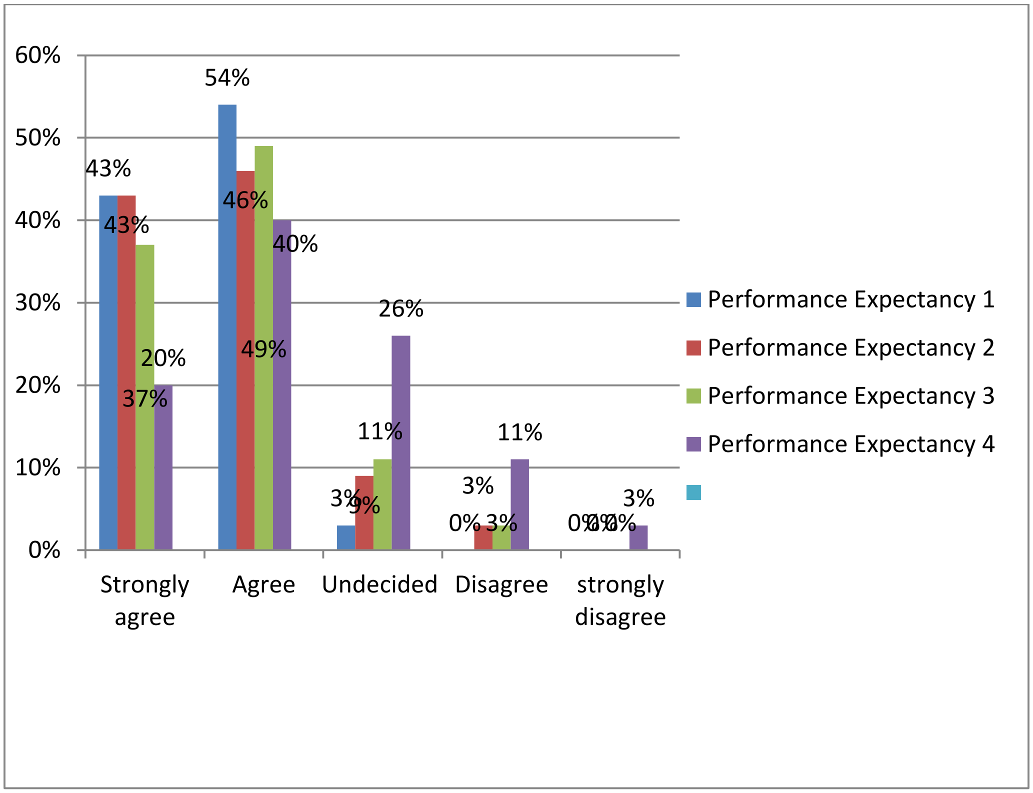
4.4 Presentation of learners' perceptions using UTAUT model

4.4.1 Performance expectancy

Figure 4.4.1(a) displays a bar chart illustrating the responses of learners, indicating their level of agreement with provided performance expectancy statements as a percentage frequency. Each statement is denoted by a specific performance expectancy number. For instance, Performance Expectancy 1 corresponds to the first statement, while Performance Expectancy 2 represents the second statement. Similarly, Performance Expectancy 3 and 4 correspond to the third and fourth statements within the Performance Expectancy category for Mathematics mobile learning.

Figure 4.4.1(a)

Performance expectancy items



Performance Expectancy 1: "Mobile Technologies are useful in Mathematics education." The results indicate that 43% of learners strongly agreed with this statement, and 54% of learners agreed with it, resulting in a total of 97% of learners providing a positive response. Only 3% of learners remained undecided, with no learners expressing a negative viewpoint.

Performance Expectancy 2: "Using mobile technologies in Mathematics enables students to accomplish their tasks more quickly." In the bar chart, it is evident that 43% of learners strongly agreed with Performance Expectancy 2, while 46% of learners agreed with it, totaling 89% of learners with a positive response. Only 3% of learners disagreed with the statement, and 9% were undecided.

Performance Expectancy 3: "Mobile learning would improve learners' performance in Mathematics." According to the findings presented in Figure 4.4.1, 37% of learners strongly agreed with Performance Expectancy 3, and 49% of learners agreed with it. This accounts for 86% of learners giving a positive response. Only 3% of learners disagreed with the statement, while the remaining 11% were undecided.

Performance Expectancy 4: "Using mobile devices in learning mathematics would improve the learners' productivity." The results indicate that 20% of learners strongly agreed with Performance Expectancy 4, and 40% agreed with the statement. This amounts to 60% of students providing a positive response. However, 11% of learners disagreed, 3% strongly disagreed, and 26% neither agreed nor disagreed with the statement, resulting in a total of 14% of learners expressing a negative viewpoint.

On average, across all four performance expectancy statements, 83% of learners expressed a positive perspective. This suggests that the majority of learners believe that mobile learning contributes to improved performance in Mathematics and enhances their productivity. In contrast, 7% of learners held a negative viewpoint, and 10% remained undecided.

4.4.2 Effort expectancy

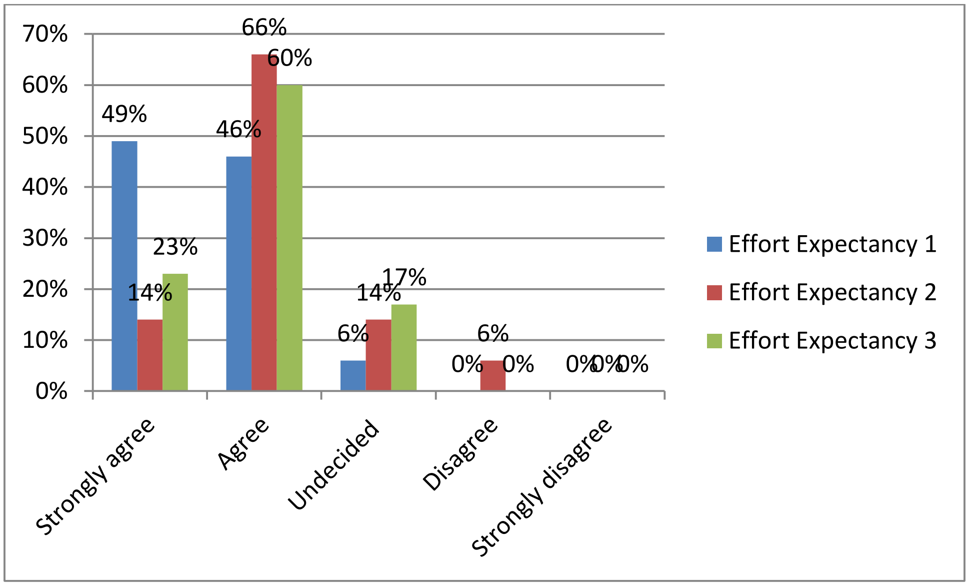
Figure 4.4.2 (a) shows response of learners rating their agreement with the given effort expectancy statements against the frequency of their response in percentage. The first statement measuring level of their agreement with effort expectancy is represent by effort expectancy 1 on the bar chart key. The second statement measuring their level of agreement with effort expectancy is represented by effort expectancy 2 on the bar chart. Lastly the third statement is represented by effort expectancy 3.

Effort Expectancy 1: "Mobile technologies are easy to use." The study's results demonstrate that 49% of learners strongly agreed with this statement, and 46% of learners agreed with it. As a result, a total of 94% of learners provided a positive response, with only approximately 6% remaining undecided.

Effort Expectancy 2: "Finding or using features in mobile technologies is easy." The findings indicate that 14% of learners strongly agreed with this statement, while 66% of learners agreed with it, totalling 80% of learners with a positive response. Only 6% of learners disagreed, and the remaining 14% were undecided.

Figure 4.4.2 (a)

Effort expectancy items



Effort Expectancy 3: "Learning to operate mobile technologies is easy." The study revealed that 23% of learners strongly agreed with this statement, and 60% agreed with it. This means that 83% of learners exhibited a positive response, while the remaining 17% were undecided.

On average, considering all three statements on effort expectancy, 86% of learners expressed a positive viewpoint, with 12% remaining undecided, and the remaining 2% providing a negative response. This indicates that the majority of learners find mobile devices easy to use, consider them user-friendly, and believe that they require minimal effort when using web 2.0 tools.

4.4.3 Social factors

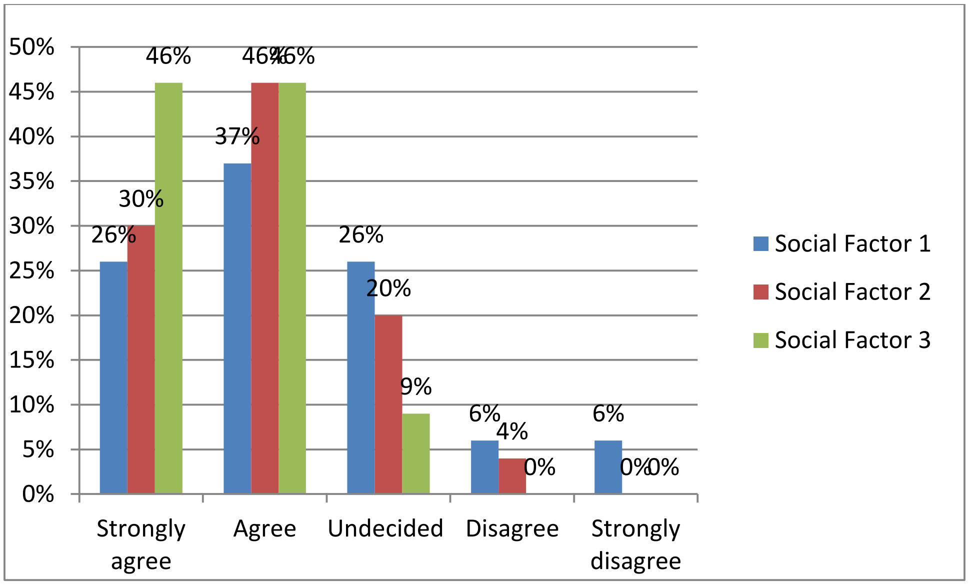
Figure 4.4.3 (a) presents a bar chart depicting the frequency of responses to each social factor statement.

Social Factor 1: *"People who influence my behaviour think that I should use mobile technologies in learning Mathematics."*

The chart reveals that 26% of learners strongly agreed with this statement, and an additional 37% agreed, resulting in a combined total of 63% of learners providing a positive response. About 26% of learners were undecided, while the remaining 12% of learners were equally split between the two negative responses, disagreeing and strongly disagreeing.

Figure 4.4.3 (a)

Social Factors items



Social Factor 2: "*People who are important to me think that I should use mobile technologies for learning Mathematics."*

The findings indicate that 33% of learners strongly agreed with this statement, and an additional 46% of learners agreed with it. However, 20% of students were undecided, while the remaining 4% disagreed. In total, 79% of learners provided a positive response to this statement.

Social Factor 3: *"Mathematics teachers are supportive of the use of mobile technologies."*

The bar chart demonstrates that 46% of learners strongly agreed with this statement, and an additional 46% of learners agreed with it, resulting in a total of 92% of learners providing a positive response. The remaining 8% of learners were indecisive. This indicates that learners believe that important individuals in their lives who influence their behaviour recommend the use of mobile devices for learning Mathematics.

On average, 3% of learners gave a negative response, while 18% of learners neither agreed nor disagreed. This results in 78% of learners who provided a positive response on average.

4.4.4 Facilitating conditions

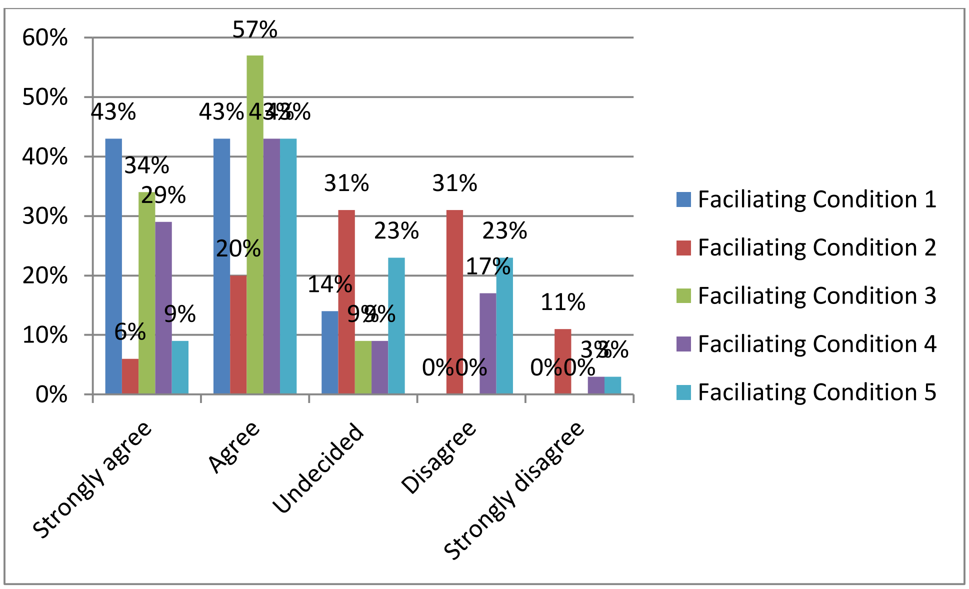
Figure 4.4.4 (a) shows the bar chart for results of facilitating conditions.

Facilitating condition 1: *In general, my school has support for mobile learning*.

Regarding the Likert scale, 43% of learners chose "Strongly Agree," and an additional 43% selected "Agree," resulting in a total of 86% providing a positive response. The remaining 14% of learners were undecided, and no learners gave a negative response to the statement.

Figure 4.4.4(a)

Facilitating conditions items



Facilitating Condition 2: Generally, the country in which my school is located has support (infrastructure, policies, etc.) for mobile learning. In Figure 4.4.4 (a), represented by the second set of bars, Facilitating Condition 2 is depicted. The bar chart illustrates that 6% of learners strongly agreed, while 20% agreed with the statement. However, a considerable 31% of learners were undecided. Contrarily, 31% disagreed, and 11% strongly disagreed, totalling 42% of learners with a negative response. Only 26% gave a positive response. A significant number of learners were uncertain about whether they believed their country supports mobile learning.

Facilitating Condition 3: They have the resources necessary to use mobile learning. For this condition, 29% of learners strongly agreed, and 57% agreed, resulting in 86% providing a positive response. Only 5% gave a negative response, while 9% were undecided.

Facilitating Condition 4: They have the knowledge necessary to use mobile learning. Similarly, under Facilitating Condition 4, 29% of learners strongly agreed, and 43% agreed that they have the necessary knowledge for mobile learning, totalling 72% with a positive response. However, 17% disagreed, and 3% strongly disagreed, making up 20% with a negative response. Another 9% could neither give a positive nor negative response.

Facilitating Condition 5: Support from an individual or service is available when problems are encountered with mobile learning technologies. This statement garnered 9% strongly agreeing and 43% agreeing, resulting in 52% with a positive response. On the contrary, 26% gave a negative response, while the remaining 23% were undecided.

On average, 64% of learners provided a positive response, while 19% gave a negative response across all Facilitating Conditions. The remaining 17% of learners were undecided. This suggests that most learners believe that both their school and government support their use of mobile devices for learning by providing technical infrastructure and policies. However, a significant number of learners disagree.

4.4.5 Attitudes

Figure 4.4.5 (a) shows a bar chart that presents the learners' response on the attitudes item. **Attitude 1**: *Using mobile learning technologies in Mathematics is a good idea.*

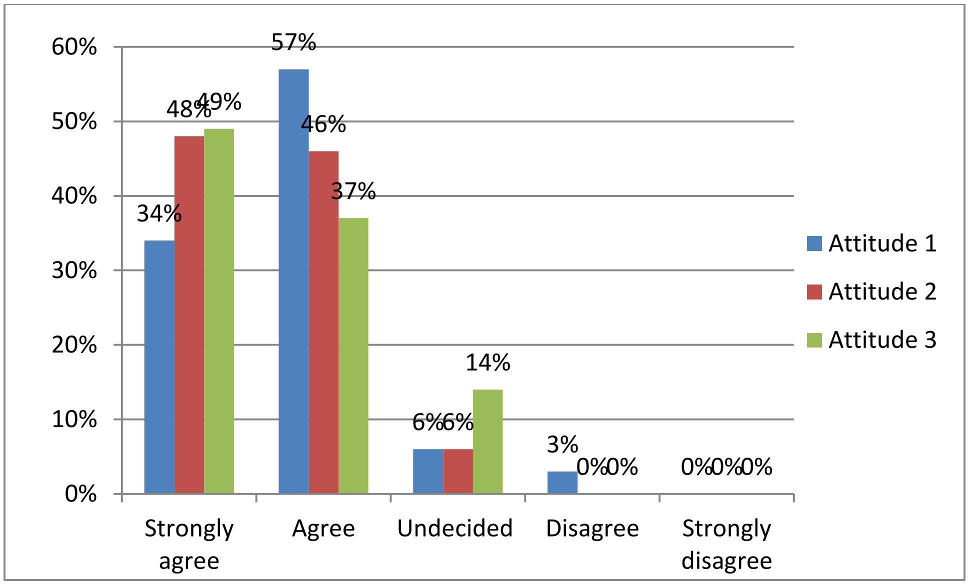
The responses from learners indicate that 34% of them strongly agreed with this statement, while an additional 57% agreed with it. Combining these two positive responses yields a total of 91% with a positive attitude. Only 6% of learners were undecided, and merely 3% disagreed.

Attitude 2: *I would like to use mobile learning technologies for learning Mathematics.*

In this case, 48% of learners strongly agreed with the statement, and 46% agreed with it, resulting in a whopping 96% of learners expressing a positive attitude. The remaining 6% were learners who were undecided.

Figure 4.4.5 (a)

Figure 0-1 Attitudes items



Attitude 3: *I believe that learning Mathematics with mobile learning technologies would be fun.*

The study uncovered that 49% of learners strongly agreed with this statement, while an additional 37% agreed with it. Together, these two positive responses accounted for 86% of learners having a positive attitude towards this statement. Conversely, 8% of learners gave a negative response, and 14% were undecided.

On average, 90% of learners exhibited a positive attitude towards the use of mobile devices for learning Mathematics, with only 9% being indecisive and a mere 1% in disagreement.

4.4.6 Behavioural intentions

Figure 4.4.6 (a) reveals that none of the learners expressed disagreement or strong disagreement with any of the behavioural intentions related to future use of mobile learning for mathematics.

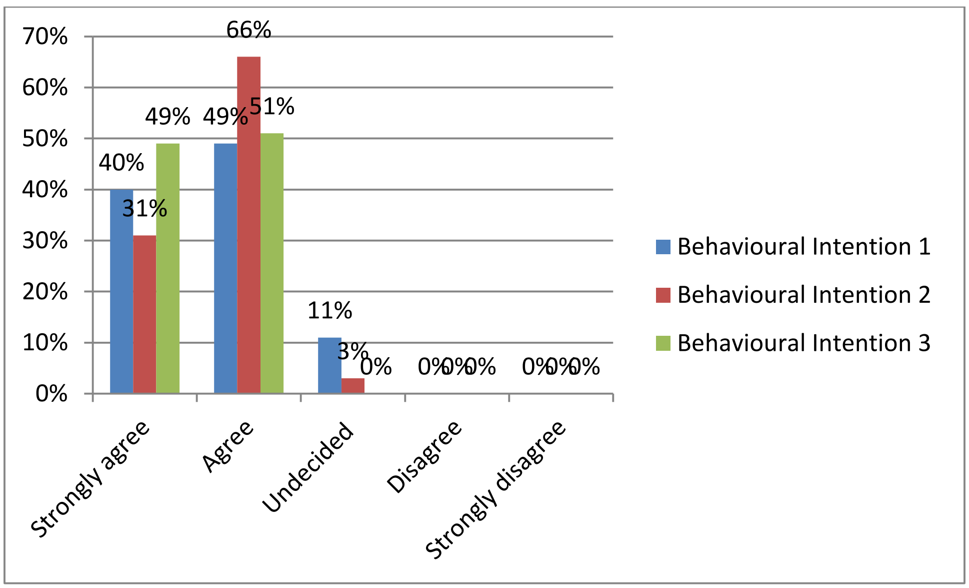
Behavioural Intention 1: I have a plan to use mobile learning technologies in Mathematics in the near future. For this statement, 11% of participants were undecided, while the remaining 89% either strongly agreed or agreed with it.

Behavioural Intention 2: I have a plan to use mobile learning technologies in the near future. Remarkably, 100% of learners provided a positive response to this statement, with 49% strongly agreeing and 51% agreeing.

On average, within the context of behavioural intentions to use mobile learning for mathematics, this study found that 96% of learners are inclined to continue using mobile devices for learning Mathematics. Notably, none of the learners expressed a negative response, and the remaining 4% remained undecided.

Figure 4.4.6 (a)

Behavioral intensions items



4.5 Summary and Conclusion

The demographic data of the participants, including their age, the number of mobile devices they possess, and the frequency of mobile device usage for learning Mathematics, were presented. The assumptions underlying the statistical analyses were addressed. The pre-tests were subjected to an independent sample t-test, revealing no statistically significant difference between the control and experimental groups, with a p-value of 0.667 at a 0.05 significance level.

Furthermore, a paired samples t-test was conducted on each group for the pre-test and post-test, demonstrating significant improvements in both groups following the intervention. To determine which group exhibited greater improvement, an additional independent sample t-test was performed on the post-test scores. The results indicated that the experimental group made a statistically significant improvement, with a group mean difference of 4.2 and a p-value of 0.0000038 at a 0.05 alpha level.

In terms of learners' perceptions, a substantial majority believed that mobile learning contributes to improved Mathematics results and helps meet their learning needs, resulting in a high performance expectancy positive response rate of 83%. Most learners also found mobile devices easy to use, viewing them as user-friendly tools that facilitate the use of web 2.0 resources with minimal effort, as evidenced by an 86% positive response rate for effort expectancy statements.
Regarding social factors, 78% of learners believed that important individuals in their lives who influence their behaviour recommended the use of mobile devices for Mathematics learning. Similarly, for facilitating conditions, 64% of learners responded positively, indicating that most learners perceived support from both schools and government entities for the use of mobile devices in learning. However, it is worth noting that 19% of learners expressed disagreement with this notion.

Notably, 42% of learners disagreed with the statement suggesting that the country in which their school is located provides support (infrastructure, policies, etc.) for mobile learning. Learners exhibited a positive attitude towards the use of mobile devices for learning Mathematics, with 90% having a positive attitude towards Mathematics mobile learning. Additionally, 96% of learners expressed intentions to continue using Mathematics mobile learning in the future.

CHAPTER 5

DISCUSSION OF FINDINGS

5.1 Introduction

This chapter engages in a comprehensive discussion of the study's findings, systematically examining the convergence and divergence between the current study's results and those of related studies, such as Nenty (2009). It critically analyses any disparities observed when comparing the current study's findings with previous research. The discussion commences with an exploration of the quasi-experimental results, beginning with an in-depth analysis of the pre-test outcomes following the application of an independent samples t-test.

Subsequently, the chapter delves into the examination of the pre-test and post-test results for each of the experimental and control groups. The focus is on elucidating the patterns and trends observed in these test results. Additionally, the discussion addresses the post-test results for both the intervention group and the control group, offering insights into any significant variations in performance.

The concluding section of this chapter encompasses a detailed discussion of the survey conducted to gauge learners' perceptions, employing the Unified Theory of Acceptance and Use of Technology (UTAUT) as the theoretical framework. Each construct within the UTAUT model, namely performance expectancy, effort expectancy, social factors, facilitating conditions, attitudes, and behavioural intentions, is scrutinised comprehensively. The discussion is enriched by relevant literature that aligns with and contextualises the findings related to these constructs.

5.2 Discussion of findings on effects of mobile learning on learners’ performance in Mathematics

To ensure the comparability of the two groups, the experimental and control groups, an effort was made to align them as closely as possible. This involved comparing the group mean of the experimental group with that of three other classes within the same grade (grade 10) of the control group (school). The class with a similar mean was identified for further analysis. This step was taken in line with the recommendation of Ary, Jacobs, and Sorensen (2010), who argue that when the two groups are equivalent at the outset of an experiment, it mitigates internal validity threats, such as selection-maturation issues, as both groups commence and conclude the experiment simultaneously.

Upon conducting an independent sample t-test analysis of the pre-tests for both the experimental and control groups using SPSS 20, it was revealed that there was no statistically significant difference between these two groups at the beginning of the experiment. The significance value (p-value) obtained, which was 0.667 and exceeded the threshold of 0.05, as per Ary, Jacobs, and Sorensen (2010), led to the conclusion that there was no significant distinction between the two groups at the outset. This finding aligns with similar studies, such as the one conducted by Hamid and Kamarudid (2021), who also performed a t-test on their experimental and control group pre-tests and reported no substantial differences at the outset of their experiment.

Both the experimental and control groups exhibited significant improvements from their respective pre-test scores, as evidenced by the results of paired sample t-tests conducted on the pre-test and post-test scores. These outcomes were consistent with the researcher's expectations and corroborated existing knowledge suggesting the effectiveness of the traditional teaching method. Nevertheless, it was imperative to evaluate the impact of the intervention on learners' mathematics performance, in line with one of the study's objectives.

The null hypothesis posited that mobile learning would not significantly affect learners' performance in mathematics. However, this hypothesis was rejected based on the results of an independent sample t-test, which indicated a significant difference of 0.000038 between the post-test scores of the experimental group and the control group, in favour of the experimental group. This finding resonates with those of Hamid and Kamarudid (2021), who conducted a similar t-test on their experimental and control group post-tests, yielding a p-value of 0.004 and a t-value of 2.979. Likewise, a study by Mafa and Govender (2018), involving two different schools in Botswana, found significant differences in post-test scores between an experimental group using WhatsApp groups for educational purposes and a control group. The p-value obtained was 0.000000005125, well below the 0.05 threshold. In another test conducted by Mafa and Govender (2018), the experimental group again exhibited significant improvement, with a p-value of 0.0000000004706. These findings align with those of the current study, supporting the notion that mobile learning can positively impact learners' performance in mathematics.

5.4 Discussion of findings on learners’ perceptions using UTAUT model

The second objective of this study aimed to delve into the perceptions of learners regarding Mathematics mobile learning in a senior secondary school. To address the corresponding research question, which inquired about how learners perceive Mathematics mobile learning, a questionnaire was administered to the experimental group upon the conclusion of the intervention program. The findings revealed that learners held high performance expectancy, indicating their belief that mobile devices facilitated their mathematics learning tasks, leading to improved academic performance and quick access to information with minimal effort, regardless of time or location. This aligns with the concepts of flexibility and ubiquitous access associated with mobile learning (Donaldson, 2011; Venkatesh et al., 2003). Among the respondents, 83% were those who effectively utilised mobile devices for various mathematics learning activities, including accessing tutorials on Google Classroom and YouTube, engaging in discussions on WhatsApp and Google Classroom, attempting online quizzes, and employing mathematics applications such as Photomath, Quizlet, and Guathmath to aid their understanding of mathematical concepts. These learners were well-versed in the potential that mobile devices offered within the mathematics learning environment and exhibited a strong affinity for the mobile learning program.

In exploring the perception of learners regarding the effort expectancy associated with mathematics mobile learning, results indicated that 86% of learners had a positive view, finding mobile learning to be a user-friendly approach. This finding resonates with the flexibility and ubiquity inherent in mobile learning, allowing learners to engage in learning activities effortlessly, anytime and anywhere (Hashin, Choo & Song, 2009). Learners who had received training on Google Classroom found it easier to navigate the internet for mathematics tutorials, access study materials, and complete online quizzes. This learning process aligns with the concept of connectivism, where teachers assist learners in making appropriate connections within their learning networks (Kizito, 2016). Learners effectively navigated their learning networks, using social media and web 2.0 technologies to interact with peers and locate learning resources.

Social factors were another critical aspect of learners' perceptions, particularly the extent to which learners believed important figures in their lives encouraged the use of mathematics mobile learning. One notable result pertained to social factor 3, which focused on the supportive role of mathematics teachers in the use of mobile technologies. An impressive 92% of learners agreed with this statement, with only 8% being undecided. This finding underscored the significant influence teachers wielded in motivating learners to engage in mathematics mobile learning activities, indicating that learners perceived considerable support throughout the program.

The concept of facilitating conditions, which pertained to the belief that schools and the Ministry of Education and Training supported mathematics mobile learning through policies and infrastructure, was also examined. A substantial number of learners believed there was inadequate governmental support in terms of infrastructure and policies for mobile learning in schools. Furthermore, a significant portion of learners felt there was insufficient support available when encountering challenges during mobile learning. This perception was attributed to the limited resources available to support technology-based learning in Lesotho, as well as learners using their personal devices throughout the program. Lesotho's educational policies and strategies have recognized the importance of ICT in education, but implementation challenges have persisted (Gillwald et al., 2017). Therefore, 42% of learners disagreed that the government provided adequate support for mobile learning in terms of infrastructure and policies.

Regarding attitudes toward mobile learning, 90% of learners expressed positive attitudes, indicating their favourable disposition toward mathematics mobile learning. This finding echoes the outcomes of prior studies focusing on undergraduate and postgraduate students. However, recent research on high school mathematics learners has revealed similarly positive attitudes toward mathematics mobile learning (Sincuba and John, 2017; Mamolo, 2022; Yosiana, Djuandi, and Hasanah, 2021). These findings collectively emphasise the widespread positive attitude that learners hold toward mobile learning.

Similarly, with regard to behavioural intentions to use mathematics mobile learning, 96% of learners expressed a willingness to continue using mobile devices for learning mathematics in the future. While learners were aware of potential distractions associated with mobile devices, they recognised that the benefits of mobile learning outweighed the challenges. These findings reinforce the idea that the learners involved in this study are inclined to persist in using mobile learning for mathematics in the future. Previous research also supports these intentions to use mobile learning (Ennouamani, Mahani, and Akharraz, 2020).

In summary, learners' positive perceptions of mathematics mobile learning translate into increased engagement in mobile learning activities, which previous research has linked to improved academic performance. Thus, the positive attitudes and behavioural intentions exhibited by learners in this study suggest that their enhanced performance in mathematics is a result of their favourable perception of the intervention.

5.5 Discussion of findings on effects of mobile learning on learners’ mathematics performance and perceptions of mathematics mobile learning.

The findings of this study have uncovered a potential association between the positive impact of mobile learning on learners' mathematics performance and their favourable perceptions of mathematics mobile learning. As discussed in the previous sections of this chapter, the study observed an enhancement in mathematics performance when comparing the test scores of the control group with those of the experimental group after the latter received the mobile learning intervention through Google Classroom. Additionally, the study revealed that learners hold positive perceptions of mathematics mobile learning.

Fabian, Topping, and Barron (2016) conducted a study to investigate changes in attitudes toward mobile technology, specifically tablets, when used for learning mathematics. They employed surveys at the conclusion of each mobile learning activity, followed by focus group discussions to gain deeper insights into students' feedback and experiences. Parallel to the present study, Fabian, Topping, and Barron (2016) found that a majority of students held positive perceptions of utilising mobile technology for learning mathematics. In particular, one participant who performed well in the mathematics test reported a better understanding of mathematics lessons when using mobile devices compared to traditional approaches. Furthermore, Fabian, Topping, and Barron (2016) noted a significant improvement in learners' mathematics performance. Interviews conducted with learners from the treatment group who outperformed their peers in the control group in the post-test revealed their positive perceptions and attitudes toward using mobile technology for mathematics learning. These learners found mobile learning activities engaging and enjoyable.

In a similar vein, the present study found that 9 out of 10 learners expressed a desire to continue using mobile learning for mathematics instruction. Based on these findings, it can be inferred that learners who excelled in the mathematics performance test also held positive perceptions of mathematics mobile learning.

CHAPTER 6

IMPLICATIONS, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter encompasses several key components, including implications, conclusions, limitations, recommendations, and suggestions for further studies. As per Nenty's (2009) guidelines, this section aims to reiterate the problem addressed in the research and elucidate the implications of the findings for resolving the identified problem. The current study probe into how these findings can offer insights and guidance to pertinent stakeholders in their efforts to tackle the stated problem. Following this, the chapter presents a conclusion drawn from the study's outcomes.

Subsequently, the chapter outlines the limitations encountered during the research process and provides recommendations that are formulated with the objective of contributing to the resolution of the identified problem. These recommendations delineate the specific roles and actions that various stakeholders should undertake to address the problem effectively.
The chapter concludes with suggestions for further studies, which are intended to guide future researchers in the same domain. These suggestions aim to encourage the continuous pursuit of knowledge and exploration within this field of study.

6.2 Implications of findings

6.2.1 Implication of effects of mobile learning on learners' Performance.

The Ministry of Science and Technology, along with the Lesotho Science and Mathematics Teachers Association, and scholars in STEM disciplines have consistently emphasised the critical importance of achieving strong performance in Mathematics and science. This viewpoint is supported by Balogum (2008), who asserts that education in Mathematics, science, and technology serves as the foundation for development and modernisation. Nevertheless, both recent and older literature has highlighted the persistent issue of low performance in Mathematics, attributed to various factors, including the availability of learning resources, particularly mathematics textbooks that are rented from the school supply unit. Although parents can manage to pay for these rented textbooks, they often do not suffice to cater to all the students' needs. The researcher posits that this challenge could potentially be addressed through the integration of mobile devices into teaching and learning processes, especially since many students informally utilize mobile technology at tertiary institutions, as indicated in a recent study conducted by Makafane and Chere (2021) at a higher education institution in Lesotho.

The findings of this study revealed a significant difference, with a p-value of 0.000038, between the treatment group and the control group at a significance level of 0.05. This difference can be attributed solely to the utilisation of mobile technology. These results suggest that policy-makers should consider the implementation of mobile technology in schools. Significantly, the secondary education curriculum in Lesotho already encourages the use of technology in teaching and learning; however, there is a lack of substantial support from policy-makers to implement various forms of technology. Furthermore, mobile devices are personal gadgets already owned by learners. For the Ministry of Education and Training, the enhanced performance observed in the treatment group indicates the necessity of creating a reliable website that can support learners with study materials. Such materials could include easily accessible past questions, their corresponding marking schemes, topic-related questions with solutions, and user-friendly tutorials. It is noteworthy that learners in the experimental group displayed a positive response to these interventions.

These findings imply that school principals, school boards, and proprietors of private educational institutions should consider incorporating mobile learning interventions, especially in cases where there is a shortage of rented textbooks. Additionally, teachers play a crucial role, as improved learner performance in the experimental group suggests that educators should encourage the use of mobile technology outside of the classroom. Learners should be empowered to seek information independently with minimal assistance from teachers. The connectivism theory underscores the notion that knowledge exists beyond the confines of the classroom, and teachers can guide learners on how to access and navigate this wealth of knowledge effectively.

6.2.2 Implications of learners' perceptions on mobile learning

Additional factors contributing to the issue of underperformance include teacher motivation, learner self-motivation, and learners' attitudes toward mathematics. Research conducted in various countries has consistently indicated that learners generally hold positive perceptions of mobile learning (Rifai and Sugiman, 2018; Safie, Wahid, and Idris, 2017; Ozdamli and Uzunboylu, 2015; Bay and Daher, 2009; Hashin, Choo, and Song, 2009). The successful implementation of mobile learning in mathematics education is contingent on students' perceptions of such technologies, given that they are the primary users and beneficiaries of educational tools. While researchers acknowledge the importance of investigating learners' perceptions of mobile learning technology for its effective implementation, there is a dearth of studies in Lesotho that have explored this aspect.

This study investigated into learners' perceptions of Mathematics mobile learning, revealing that learners believe mobile learning reduces the effort required to learn mathematics and enhances their academic performance. These findings suggest that learners recognise the potential benefits of mobile learning and are likely to embrace and utilize it for their educational advancement. Moreover, the study findings indicated that a significant number of learners perceive mobile learning to have ample support from the government. An interesting observation emerged from the statement, *"In general, the country in which my school is located has support (infrastructure, policies, etc.) for mobile learning,"* as a considerable number of learners strongly disagreed with this assertion. This suggests that learners are acutely aware of the need for more substantial support for mobile learning initiatives. Additionally, learners demonstrated positive attitudes and intentions to use mobile learning in the future, implying that they would readily accept mobile learning if introduced by their teachers. Given their positive attitudes, the implementation of mobile learning is less likely to encounter resistance from students in this context.

6.3 Conclusion

The results of this study demonstrate that mobile learning has a positive impact on learners' performance in Mathematics. Additionally, the study reveals that the studied population holds favourable perceptions of Mathematics mobile learning and expresses intentions to utilise mobile devices for future Mathematics learning endeavours.

6.4 Limitations of the study

To provide a comprehensive understanding of the study's context and assist in its interpretation, it is essential to outline the study's limitations (Machisi, 2020). The independent variable in this quasi-experiment is mobile learning, which necessitates participants to possess a smartphone or tablet and access to mobile data or wireless internet connectivity. However, due to financial constraints, participants were required to use their own mobile devices. As a result, the study was confined to individuals who already owned such devices. Additionally, the sample size was restricted to 35 participants. This limitation arose because only one class of 35 learners in the experimental group was permitted to utilise mobile devices. Both the school principal and the researcher concurred that it would pose a significant inconvenience to parents if learners were subsequently asked to acquire mobile devices after the school had initially informed them that mobile devices were mandatory solely for IGCSE class students. Thereupon, the participant count was capped at 70.

Another constraint of the study pertains to the non-random allocation of participants into the experimental and control groups. Although the assignment of the two groups (schools) was randomized, the selection of individual participants was not. That being the case, the study's findings cannot be generalised beyond the confines of the Maseru urban area.

6.5 Delimitations of the study

The researcher implemented specific limitations to refine the scope of this study, deliberately excluding schools where students lacked access to mobile devices, personal mobile data, or wireless internet connections.Conceptually, this study was delimited to concentrate on evaluating the impact of mobile learning through Google Classroom on students' mathematics performance and their perceptions of mathematics mobile learning. Geographically, the study was confined to two schools within the urban area of Maseru. Methodologically, the study adopted a pre-post control design, with one group undergoing the mobile learning treatment via Google Classroom, while the other did not. Importantly, participant allocation was nonrandom. Additionally, the study employed a survey instrument to gauge students' perceptions of mathematics mobile learning and utilized standardised tests, such as the independent sample t-test, to assess mathematics performance.

6.6 Recommendations

Based on the findings and limitations of this study, the researcher offers the following recommendations:

1. Encouraging and formalizing the adoption of mathematics mobile learning in Lesotho's secondary education system is strongly advised.
2. Consider conducting a replication of this study on a larger and more diverse population, potentially encompassing all ten districts of Lesotho, to obtain a broader perspective.
3. For future research, it is recommended to replicate this study using a true experimental design. This approach would involve random assignment of participants and potentially require a more substantial financial budget. True experiments offer the advantage of minimizing threats to the internal validity of a study through random subject assignment.

6.7 Suggestions for further studies

Before the implementation of mobile learning can proceed, it is imperative to explore the perspectives of teachers regarding its utilisation. This necessity arises from the current findings, which indicate that certain participants perceive a lack of support or encouragement from their social environment regarding the use of mobile devices for Mathematics learning.

References

Acar, D., Tertemiz, N., & Tasdemir, A. (2018). The effects of STEM training on the academic achievement of 4th graders in science and mathematics and their views on STEM training teachers. *International electronic journal of elementary education*, 10(4), 505–513. https://doi.org/10.26822/iejee. 2018438141.

Ackay, A. (2017). Instructional technologies and pre-service mathematics teachers' selection of technology. *Journal of Education and Practice*. www.iiste.org ISSN 2222-288X

Agarwal, R., & Prasad, J. (1999). Are individual differences germane to the acceptance of new information technologies? *Decision sciences, 30,* 361-391.

Almquist, Y. B., Kvart, S., & Brännström L. (2019). *A practical guide to quantitative methods with SPSS*. Research Reports, Stockholm University.

Anupama, K. (2008). Hypothesis types and research. *International journal of nursing science and practice and* research, 4(2), 78-80.

Ary, D., Jacobs, L.C., Sorensen, C., & Razavieh, A. (2010). *Introduction to research in education* (8th ed.). Nelson Education Ltd.

Balogun, O. A. (2008). The idea of an 'educated person' in contemporary African thought. *The journal of pan African studies*, 2(3), 117-128.

Bamidele, A. (2021). The use of mobile learning to improve students' motivation and the achievement of learning outcomes. 6. 175-183.

Baya'a, N.F., & Daher,W.M. (2009). Learning Mathematics in an authentic mobile environment: the perceptions of students. *International journal of interactive mobile technologies(ijim).* 3, 6-14.

Brotherton, B. (2008). *Researching Hospitality and Tourism: A Student Guide*. SAGE Publications Ltd. https://dx.doi.org/10.4135/9781446280362

Chaka, J.G., & Govender, I. (2017). Students' perception and readiness towards mobile learning in college of education: a Nigerian perspective. *South African journal of education*,37(1).

Chen, L. (2004). A hierarchical model for student and teacher interaction in distance learning. *Distance education in China*, 2(05), 24-28.

Chung, H., Chen S., & Kuo, M. (2015). A study of EFL college students' acceptance of mobile learning. *Social and behavioural science*,176, 333-339.

Cohen, L. Manion, L., & Morrison, K. (2007). *Research Methods in Education* (6th ed.). London.

Davis, F. D. (1986). *A technology acceptance model for empirically testing new end-userinformation systems:Theory and results.* Unpublished Doctoral dissertation,Massachusetts Institute of Technology.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterl*, 13(3), 319-340.

Davis, F.D., Bogozzi, R. P., & Warshaw, P.R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management science*,35, 982-1003.

Delaporte, A., & Bahia, K. (2022). *The state of mobile connectivity 2022*. GSMA head office.

Donaldson, L. R. (2011). *Student acceptance of mobile learning.* (unpublished doctoral thesis). Florida state university.

Downes, S. (2007). *What connectivism is*. http://halfanhour.blogspot.com/2007/02/what-connectivism-is.html.

Downes, S. (2012). Connectivism and connective knowledge. Essays on meaning and learning networks. *My eBooks*. http://www.downes.ca/me/mybooks.htm.

El-Adl, A. & Alkharusi, H. (2020). Relationships between self-regulated learning strategies, learning motivation and mathematics achievement. *Cypriot Journal of Educational Science.* 15(1), 104–111. https://doi.org/10.18844/cjes.v15i1.4461

El-Hussein, M.O.M., & Cronje, J.C. 2010. Defining mobile learning in the higher education landscape. *Educational technology & society*, 13(3), 12-21.

Ennouamani, S., Mahani, Z., & Akharraz, L.A. (2020). Context-aware mobile learning system for adapting learning contentand format of presentation: design, validation, and evaluation. *Educ unf technol* 25, 3919-3955. http://doi.org/10.1007/s10639-0202-101490-9

Ernest, P. (2018). The Philosophy of Mathematics Education: An Overview. *The Philosophy of Mathematics Education Today*, 13-37. https://link.springer.com/book/10.1007/978-3-319-77760-3

Ernest, P. (1998). *Social Constructivism as a Philosophy of Mathematics*. Albany, NY: State University of New York Press.

Examination Council of Lesotho Research and Statistics Unit. (2022). *The 2019 LGCSE statistical bulletin.*

Fabian, K., & Topping, K. J. (2019). Putting "mobile" into mathematics: results of randomised controlled trial. *Contemporary education psychology*.

Fabian, K., Topping, K., & Ian, G. (2018). Using mobile technology for mathematics: effects on students' attitudes and achievement. *Education research and development*, 66, 1119-1139. https://doi.org/10.1007/s11423-018-9580-3.

Fabian, K., Topping, K.J., & Barron, I.G. (2016). Mobile technology and Mathematics: effects on attitudes, engagement and achievement. *Journal of computers in education*. 3(1), 77-104.

Farooq, U., Schafer, W., Rosson, M. B., & Carroll, J. M. (2002) *M-education: bridging the gap of mobile and desktop computing*. Centre for human computer interaction and department of computer science. Virginia Polytechnic Institute and State University.

Gardiner, T. (2016). Teaching mathematics at secondary level. https://library.oapen.org/bitstream/id/cc45409d-e30f-4489-9510-0793249cf72a/646659.pdf

Gay, L.R., Mills, G.E., & Airasian, P. (2012) *Educational research: competencies for analysis and application* (10th ed.). Upper Saddle River.

Gazzaniga, M.S. (2020). Perceptions as a brain-based representation of the world. *Nature reviews neuroscience*. 21(11), 174-682.

Gillwald, A. & Mothobi,O. (2017). *Low internet penetration despite 90% 3G coverage in Lesotho.* Woodstock, Cape Town: Research ICT Africa.net.

Ginns, P., & Ellis, R. (2007) Quality on blended learning exploring the relationship between on-line and face-to-face teaching and learning. *Internet and higher education,*10, 53-64 doi: 10.1016/j.iheduc.2006.10.003.

Hair Jr., J.F., Black, W.C., Babin, B.J., Anderson, R.E., & Tatham, R.L. (2006). *Multivariate data analysis* (6th ed.). Prentice-Hall International, New Jersey.

Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2010). *Multivariate Data Analysis* (7th ed.). Pearson, New York.

Hair, J.F., Black, W.C., Babin , B.J., Anderson, R.E., & Tatham, R.L. (2006). *Multivariate Data Analysis* (6th ed.). Pearson Prentice Hall, Upper Saddle River.

Hamid, N.H.A., & Kamarudi, N. (2021). Assessing students' Mathematics Achievements and Mathematics creativity using Mathematics creativity approach: a quasi-experimental research. *Asian journal of university education*, 17(2), 100-112.

Hashin, H., Choo, K. A., & Song, H. (2009). *Exploring learner's perceptions of mobile learning*. International conference on e-learning.

Hwang, G.J., & Tsai, C.C. (2011). Research trends in mobile and ubiquitous learning: A review of publication in selected journals from 2001 to 2010. *British journal of educational technology*, 42(4), 65-70. http://doi.org.10.1111/j.1467-8535.2011.01183.x.

Isaacs, S. (2007), ICT education in Lesotho. *Survey of ICT and education in Africa: Lesotho country report*, 2(1), 1-10.

Jopo H., Maema M., & Ramokoena M. (2011) SACMEQ III reports, Policy Brief, Lesotho. http://www.sacmeq.org/sites/default/files/sacmeq/reports/sacmeq-iii/policy-brief/les_school_inputs_17nov2011_final_map.pdf

Kerlinger, F.N., & Lee, H.N. (1968). *Foundation of behavioural research* (4th ed.). Rinehart and Winston.

Khan, M., Mcgeown, S., & Bell, S., (2020). Can outdoor learning environment improve children's academic attainment? A quasi-experimental mixed method study in Bangladesh.

Kizito, R. N. (2016). Connectivism in learning activity design: Implications for pedagogically-based technology adoption in African higher education contexts. *The international review of research in open and distributed learning*, 17(2).

Kothari, C.R. (2019). *Research Methodology: methods and techniques*. (4th ed.). New age international publishers.

Gill, A., Deen-Swarray, M., & Mothobi, O. (2017). *State of ICT in Lesotho*. Lesotho communication authority. Maseru.

Lessani, A., Aida S., &Yunus, K. (2016). The comparison of learning theories in mathematics Teaching Methods. *Institute for Mathematical Research.*

Liu, G. Z., & Hwang, G. J. (2010). A key step to understanding paradigm shifts in e-learning:

Towards content-aware ubiquitous learning. *British journal of education technology*, 41(2), 1-9.

Maamin, M., Maat, S.M. H., & Iksan, Z., (2022).The influence of student engagement on mathematical achievement among secondary school students. *Mathematics* 10(41). https://doi.org/10.3390/ math10010041

Machasi, E. (2020). *Van Hiele theory-based instruction ,Geometric proof competence and grade 11 students reflections*.[Doctoral dissertation, University of South Africa].

Mafa, K. R. & Govender, I. (2018). The use of mobile technology devices in Botswana secondary schools to enhance teaching and learning. *International journal of science and research*,74(8). http://doi:10.21506j.ponte.2018.8.15

Makafane, T. D. & Chere-Masopha, J. (2021). Covid-19 crisis: challenges of online learning in one university in Lesotho. *African perspective of research in teaching & learning*, 5(1), 126-138.

Makara, M. C. (2016). *Improving teachers' pedagogical practices through lesson study in secondary schools in Maseru Lesotho*.[Doctoral dissertation Central university of technology].

Mamolo, L.A. (2022). Students' evaluation and learning experience on utilization of digital interactive Math Comics (DIMaC) mobile app. *Adv Mobile learn educ res*, 2(2), 375-388. https://doi.org/10.25082/AMLER.2022.02.006

Maema, M.,& Mohale, M. (2017). SACMEQ IV reports, National Reports, Lesotho. http://www.sacmeq.org/sites/default/files/sacmeq/reports/sacmeq-iv/national-reports/sacmeq_iv_report_les_0.pdf

Marshman, M., & Goos, M. (2018). The Beliefs about mathematics, its teaching and learning of those involved in secondary mathematics pre-service teacher education. *University of the Sunshine Coast*. https://files.eric.ed.gov/fulltext/ED592540.pdf

Mensah, R.O., Agyemang, F., Acquah, A., Babah, P.A., & Dontoh, J. (2020). Discourses on conceptual and theoretical frameworks in research: Meaning and implications for researchers. *Journal of african interdisciplinary Studies*, 4(5), 53 – 64.

Miller, H., & Cuevas, J. (2017). Mobile learning and its effects on academic achievement and student motivation in middle grades students. *International journal for scholarship of technology enhanced learning*, 1(2), 91-110.

Mothibeli, A., & Maema, M. (2005). *The SACMEQ II project in Lesotho: A study of the conditions of schooling and quality of education.* SACMEQ education policy research series. Harare. International institute for education planning.

Murtiyasa, B., Jannah, I. M., & Rejeki S. (2020) Designing Mathematics learning media based on mobile learning for 10 graders of vocational high school. *Universal journal of educationresearch*, 8(11), 5638-5647.

Nenty, H. J. (2010). Analysis of some factors that influence causal attribution of mathematics performance among secondary school students in Lesotho. *Journal of social sciences*, 22(2), 93-99.

Nenty, H. J. (2009). Writing a quantitative research thesis. *International journal of educational sciences,*1(1), 19-32.

NUL student creates learning app. (2020, May 27). The reporter. https://www.thereporter.co.ls/2020/05/27/nul-student-creates-learning-app.

Odede, I. (2021). An assessment of students' perception and self-efficacy towards mobile learning: A case of university of Zululand. *South African journal of information management*, 23(1). http://dx.doi.org/10.4102/sajim.v23i1.1268.

Ozdamli, F. & Uzunboylu, H. (2015). M-learn adequacy and perceptions of students and teachers in secondary *schools. British journal of education technology*, 46(1), 159-172 doi:101111/between.12136

Panteli, P., & Panaoura, A. (2020). The Effectiveness of using mobile learning methods in geometry for students with different initial mathematical performance. *Social Education Research*, 1(1), 1-10. doi:10.37256/ser.112020128.1-10.

Perry, D.R., & Steck, A. K. (2015). Increasing students engagement, self-efficacy, and meta-cognitive self-regulation in the high school geometry classroom: Do ipads help? *Computers in school in the school,* 34(2), 122-143.

Qiong, O. U. (2017). *A brief introduction to perception: studies in literature and language.* 15(4). http://doi.org/10.3968/10055

Iqbal, S., & Bhatti, Z. A. (2015). An investigation of university students' readiness towards M-learning using technology acceptance model. *International review of research in open and distributed* learning, 16, 83-103.

Iqbal, S., Khan N. M., Malik I. R. (2017). Mobile phone usage and students's perception towards m-learning: A case of undergraduate students in Pakistan. *International journal of e-learning & distance education,* 32(2).

Lin, E. (2006). Learning in science classroom. *Science. Teach*., 73(5), 35-39.

Research and Statistics Unit. (2022). *The 2019 Lesotho general certificate of secondary education statistical bulletin*. Examination council of Lesotho.

Rifa, A., & Sugiman. (2018). Students perceptions of mobile blended learning using smartphones. *Journal of physics: conference series.* doi:10.1088/1742-6596/1097/1/01

Safie, A., Wahid, S. Z., & Idris, N. (2017). Evaluating students' perception of mobile learning.*E-proceeding national innovation and invention competition through exhibition.* https://researchgate.net/publication/328899371

Sepiriti, S. (2021). Investigating the effects of using thuto learning management system: a case of national university of Lesotho. *International journal of online and distance learning*, 2(1), 1-11.

Seyal A. H., & Rahman M.N.A. (2009) An extension of the technology acceptance model the case of Bruneian managers. *Asian journal of business an accounting*, 2, 25-45.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology & Distance Learning*, 2, 3-10.

Sincuba, M., & John, M. (2017). An exploration of learners' attitudes towards mobile technology based instruction module and its use in Mathematics education. *International electronic journal of mathematics education*, 12(3), 845-858.

Talan, T. (2020). Effects of mobile learning on learning performance: a meta-analysis study. *Educational sciences: theory and practice,* 20(1), 79-103.

Tay, L.Y., Lee, S.S., & Ramachandran, K. (2021). Implementation of online home-based learning and students' engagement during the covid-19 pandemic: A case study of Singapore mathematics teachers. *Asia-pacific education researcher*, 30, 299–310.

Thomas, T.D., Singh, L., & Gaffer, K. (2013). The utility of UTAUT model in explaining mobile learning adoption in higher education in Guyana. *International journal of education and development using information and communication technology*, 9(3), 71-85.

Valconi, R. (2018). Mobile technologies and mobile learning. Technology and the curriculum:

summer 2018. Pressbook. https://pressbook.pub/techandcurricullum/chapter/principles-and-apllications-of-mlearning/

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425-478.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: four longitudinal field studies. *Management Science*. Vol. *45(*2) p. g.186–204.

Vinterre, A. (2018). A constructivist approach to the teaching of mathematics to boost competences needed for sustainable development. *Rural Sustainability Research*.

Vyas, N., & Nirban V. S. (2014). Students' perception on effectiveness of mobile learning in an institutional context. *International association of research in foreign language education and applied linguistics elt research journal*, 3(1), 26-36.

Wang, Z., Chen, L., & Anderson, T. (2014). A Framework for Interaction and Cognitive Engagement in Connectivist Learning Contexts. *International Review of Research in Open and Distributed Learning*, 15(2), 121–141.

Wang, Y.S., Wu, M.C., & Wang, H. Y. (2009). Investigating the determinants and age and gender differences in the acceptance of mobile learning. *British journal of educational technology,* 40(1). 92-118. http://doi:10.1111/j.1467-8535.2007.00809

Yosiana, Y., Djuandi, D., Hasanah, A. (2021). Mobile learning and its effectiveness in Mathematics. *Journal of physics:Conference Series* 1806(1).

Zhonggen, Y., & Xiazhi, Y. (2019). An extended technology acceptance model of a mobile learning technology. *Computer Application in Engineering Education,*1-12.

Appendix A: Confirmation to carry out research study – Ministry of education and training-MOET

THE GOVERNMENT OF THE KINGDOM OF LESOTHO
MINISTRY OF EDUCATION AND TRAINING – MASERU

P.O.BOX 47 MASERU 100

TEL:22322816

The Principal
……………………………… high school
Maseru 100.
16th February 2023

Dear Sir/Madam

Re: PERMISSION TO CARRY OUT RESEARCH STUDY

Permission is hereby granted to **MOTEBANG LIKOTSI (Mr.)** to undertake a study whose Topic is – "Mobile learning and Learners 'Mathematics achievement in a Secondary School in Maseru".

It is the hope of the Ministry that the findings of this study will help in the advancement of the Ministry's efforts to provide quality education.

I hope this will reach your favourable considerations.

Yours Sincerely

Teboho Moneri - Regional Inspector Central

MINISTRY OF EDUCATION
AND TRAINING
REGIONAL INSPECTOR - CENTRAL
17 FEB 2023
TEL: 22322316, P.O. BOX 47
MASERU 100 LESOTHO

Appendix B: Request to carry out research study- Ministry of education and training-MOET

Pitseng London
P.O. Box 19
Pitseng 320
4th February 2023

The Regional Inspector – Central
Ministry of Education and Training
Maseru 100
Lesotho

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH.

My name is Motebang Likotsi. I am a Master of Science Education student at National University of Lesotho.

I would like to request permission to conduct a research study at two selected high schools in Maseru district. The study focuses on effects of mobile learning on learners' performance in Mathematics and learners' perceptions of Mathematics mobile learning using Google Classroom. This study is titled: **Mathematics Mobile Learning Using Google Classroom: Perceptions and Effects on Performance of Grade 10 Learners**

This experimental study will last for four weeks, one school will become the experimental group and the other school will become the control group. The experimental group will adopt an intervention of Mathematics mobile learning. The participants of this study will be subject teachers and learners. The findings of this research will inform the policy-makers and other stakeholders about effects of using mobile learning on learners' performance and how learners perceive use of mobile technology in teaching and learning of Mathematics. So that they further explore the possibilities that mobile learning can offer in teaching and learning.

This study will take little or no time of participants' normal teaching and learning time however it will affect their personal time because the intervention of mobile learning will only be used after school. Identities of schools and participants will be treated with utmost confidentiality. The data gathered from this research will be used for purposes of this research and its publications only. Teachers will be informed that being in this study is voluntary and they are under no obligation to consent to participation. Also if they decide to take part, they will be asked to sign a written consent form. They will further be informed that they are free to withdraw from the study at any time and without giving a reason.

For any further information please contact my supervisor Dr Maboi Mphunyane at +266 5875 5552 or mzmphunyane@gmail.com.

Yours sincerely

Motebang Likotsi
(Email: abrahamabrahamson@gmail.com ; Cell number +266 5713 1354)

Appendix C: Request for permission to carry out research study - Principals

Pitseng London
P.O. Box 19
Pitseng 320
4th February 2023

The Principal

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH.

My name is Motebang Likotsi. I am a Master of Science Education student at National University of Lesotho.

I would like to request permission to conduct a research study at your school. The study focuses on effects of mobile learning on learners' performance in Mathematics and learners' perceptions of Mathematics mobile learning using Google Classroom.

This experimental study will last for four weeks and it will compare two schools, one with intervention of mobile learning the other without mobile learning. One school will become the experimental group and the other school will become the control group. The experimental group will adopt an intervention of Mathematics mobile learning. The participants of this study will be subject teachers and learners. The findings of this research will inform the policy-makers and other stakeholders about effects of using mobile learning on learners' performance and how learners perceive use of mobile technology in teaching and learning of Mathematics. So that they further explore the possibilities that mobile learning can offer in teaching and learning.

This study will take little or no time of participants' normal teaching and learning time however it will affect their personal time because the intervention of mobile learning will only be used after school. Identities of schools and participants will be treated with utmost confidentiality. The data gathered from this research will be used for purposes of this research and its publications only.

Teachers will be informed that being in this study is voluntary and they are under no obligation to consent to participation. Also if they decide to take part, they will be asked to sign a written consent form. They will further be informed that they are free to withdraw from the study at any time and without giving a reason.

For any further information please contact my supervisor Dr Maboi Mphunyane at +266 5875 5552 or mzmphunyane@gmail.com.

Yours sincerely

MotebangLikotsi
(Email: abrahamabrahamson@gmail.com ; Cell number +266 5713 1354)

Appendix D: Invitation to participate in a research study -Teachers

Pitseng London
P.O. Box 19
Pitseng 320
4th February 2023

The teacher
Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH.

My name is Motebang Likotsi. I am a Master of Science Education student at National University of Lesotho.

I would like to request permission to conduct a research study at your school. The study focuses on effects of mobile learning on learners' performance in Mathematics and learners' perceptions of Mathematics mobile learning using Google Classroom.

This experimental study will last for four weeks and it will compare two schools, one with intervention of mobile learning the other without mobile learning. One school will become the experimental group and the other school will become the control group. The experimental group will adopt an intervention of Mathematics mobile learning. The participants of this study will be subject teachers and learners. The findings of this research will inform the policy-makers and other stakeholders about effects of using mobile learning on learners' performance and how learners perceive use of mobile technology in teaching and learning of Mathematics. So that they further explore the possibilities that mobile learning can offer in teaching and learning.

This study will take little or no time of participants' normal teaching and learning time however it will affect their personal time because the intervention of mobile learning will only be used after school. Identities of schools and participants will be treated with utmost confidentiality. The data gathered from this research will be used for purposes of this research and its publications only. Teachers will be informed that being in this study is voluntary and they are under no obligation to consent to participation. Also if they decide to take part, they will be asked to sign a written consent form. They will further be informed that they are free to withdraw from the study at any time and without giving a reason.

For any further information please contact my supervisor Dr Mphunyane Maboi at +266 5875 5552 or mzmphunyane@gmail.com.

Yours sincerely

Motebang Likotsi
(Email: abrahamabrahamson@gmail.com ; Cell number +266 5713 1354)

If you consider agreeing to participate in this research, please read and sign the consent letter below:

Consent letter for participants

I ...., have read and understood contents of this consent form. That:

a) I participate in this research voluntarily and I am not in any way obliged to agree to participate,
b) I can withdraw from participating in this research at any time, without being required to give a reason,
c) I am aware that my privacy will be protected and my identity will be concealed,
d) I agree that audio and video recorders can be used by the researcher (and research assistant where needed) to gather data during my participation in Mathematic tutorial.

I therefore hereby agree to take part in this research.

Signature: _________________________; Date: ____________________

Appendix E: Pre-Test

You must answer on the question paper.

INSTRUCTIONS

● Answer all questions.

● Use a black or dark blue pen.

● Write your answer to each question in the space provided.

● You should use a calculator where appropriate.

● You must show all necessary workings clearly.

● Give non-exact numerical answers correct to 3 significant figures, unless a different level of accuracy is specified in the question.

INFORMATION

● The total mark for this paper is 30.

● The number of marks for each question or part question is shown in brackets [ ]

Question 1

Simplify.

(i) $4a - 3b + 5a + 6b$

.... [2]

(ii) $6(2x+1)-5(x-2)$

.... [2]

Question 2

$j = 3p + 5q$

Find the value of j when $p = -4$, $q = 6$.

j =................................... [2]

Question 3

Factorise completely.

$$14x^3 + 49x$$

.... [2]

Question 4

Factorise completely.

$$3y - 12$$

.... **[1]**

Question 5

Solve these equations.

(i) $\frac{y}{4} = 10$

$y =$...[1]

(ii) $7x - 4 = 3x + 2$

$x =$ .... [2]

(iii)

$8(3t - 9) = 108$

$t =$ .... [3]

Question 6

(a)

The total of the areas of rectangles A and B is $20\,\text{cm}^2$.

(i) Show that $3x^2 + 6x - 22 = 0$.

…………………………………..[3]

(ii) Factorise $y^2 - 7y - 18$

...[2]

(iii) Solve the equation $y^2 - 7y - 18 = 0$

....[2]

Question 7

Solve the simultaneous equations.
You must show all your working.

$$5x - 2y = 44$$
$$2x + 3y = 10$$

$x =$ ....

$y =$ .... [4]

Question 8

Write as a single fraction in its simplest form.

$$\frac{2}{5-x}+\frac{3}{x+7}$$

……………………………………………[4]

Total 30

Appendix F: Post-Test

You must answer on the question paper.

INSTRUCTIONS

- Answer all questions.
- Use a black or dark blue pen.
- Write your answer to each question in the space provided.
- You should use a calculator where appropriate.
- You must show all necessary working clearly.
- Give non-exact numerical answers correct to 3 significant figures, unless a different level of accuracy is specified in the question.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ]

Question 1

(a) Simplify.

$$3a - 5b + 2a + b$$

.... [2]

(b) Expand and simplify

$$5(2x + 1) - 6(x + 1)$$

.... [2]

Question 2

$j = 4k + 7m$

Find the value of j when $k = -5$ and $m = 6$.

$j =$ .... [2]

Question 3

Factorise completely.

(i) $6x - 18$

.... [1]

(ii) $25x^2 + 10x$

.... [2]

Question 4

Solve these equations.

(i) $\frac{x}{6} = 12$

$x =$ .... [1]

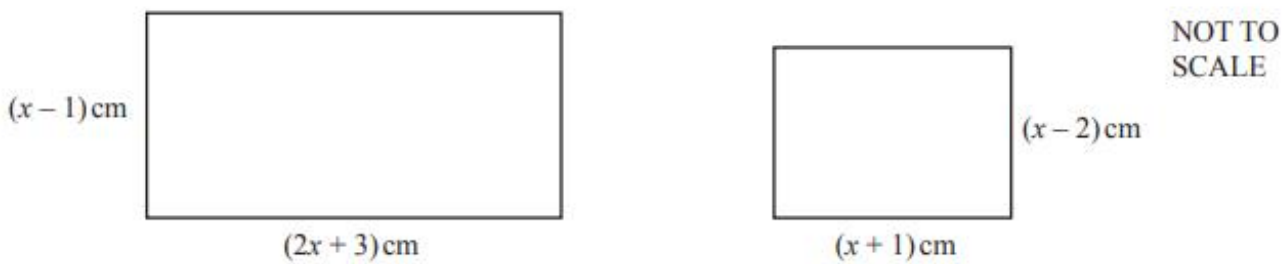
(ii) $7x - 4 = 3x + 2$

$x =$ .... [2]

(iii) $4(2y + 3) = 84$

$y =$……………………………………………..[3]

Question 5



The difference between the areas of the two rectangles is 62 cm^2.

(i) Show that $x^2 + 2x - 63 = 0$.

[3]

(ii) Factorise $x^2 + 2x - 63$.

.... [2]

(iii) Solve the equation $x^2 + 2x - 63 = 0$

……………………………………………..[2]

Question 6

(a) Solve the simultaneous equations.
You must show all your working.

$$6x + 5y = 27$$
$$5x - 3y = 44$$

$x =$ ....

$y =$ .... [4]

Question 7

Write as a single fraction in its simplest form.

$$\frac{8}{x+3} + \frac{3}{x+8}$$

..[4]

Total: 30

Appendix G: The questionnaire

Questionnaire

Thank you for taking your time to complete this questionnaire.

Section 1

Demographic information

Fill in the box

1. Age
2. gender
3. grade and class
4. Number of smart phones you have

Section 2

The UTAUT items

Rate you level of agreement with each statement by ticking inside the box.

UTAUT item (Performance Expectancy)	**Strongly agree**	**Agree**	**Undecided**	**disagree**	**Strongly disagree**
1. Mobile Technologies are useful in Mathematics education					
2. Using mobile technologies in Mathematics enable students to accomplish their tasks more quickly.					
3. Mobile technologies would improve students' performance in Mathematics.					
4. Mobile technologies would increase students' productivity in Mathematics.					
UTAUT item (Effort Expectancy)	**Strongly agree**	**Agree**	**Undecided**	**disagree**	**Strongly disagree**
5. Mobile technologies are easy to use.					
6. Finding or using features in mobile technologies is easy.					
7. Learning to operate mobile technologies is easy.					
UTAUT item (Social Factors)	**Strongly**	**Agree**	**Undecided**	**disagree**	**Strongly**

	agree				disagree
8. People who influence my behaviour think that I should use mobile Technologies in learning Mathematics.					
9. People who are important to me think that I should use mobile technologies for learning Mathematics.					
10. Mathematics teachers are supportive of the use of mobile technologies.					
UTAUT item (Facilitating Conditions)	**Strongly agree**	**Agree**	**Undecided**	**disagree**	**Strongly disagree**
11. In general, my school has support for mobile learning.					
12. In general, the country in which my school is located has support (infra-structure, policies etc.) for mobile learning.					
13. I have the resources necessary to use mobile learning.					

14. I have the knowledge necessary to use mobile learning					
15. Support from an individual or service is available when problems are encountered with mobile learning technologies.					
UTAUT item (Attitude)	**Strongly agree**	**Agree**	**Undecided**	**disagree**	**Strongly disagree**
16. Using mobile learning technologies in Mathematics is a good idea in Mathematics.					
17. I would like to use mobile learning technologies for learning Mathematics.					
18. I believe that learning Mathematics with mobile earning technologies would be fun.					
UTAUT item (Behavioural Intention)	**Strongly agree**	**Agree**	**Undecided**	**disagree**	**Strongly disagree**
19. I have a plan to use mobile learning technologies in Mathematics in the near future.					
20. I predict I will use mobile					

learning technologies in my subjects in the next semester.					
21. I have a plan to use mobile learning technologies in the near future.					