ENHANCING COGNITION OF CIRCLE THEOREMS VIA ADAPTIVE TECHNOLOGY IN RURAL-BASED ESWATINI: PRE-SERVICE TEACHERS' USAGE AND ACCEPTANCE OF GEOGEBRA

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DECLARATION

I, Mfanasibili Philemon Nxumalo, hereby declare that I am the sole author of this thesis, and I have not submitted it to any other university for a qualification. This is a true copy of the thesis, including the required final revisions, as recommended by my supervisor and examiners. All sources I have used, or quoted, have been indicated and acknowledged as complete references. I understand that my thesis may be made electronically available to the public.

______________________ **Date: December 2021**

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DEDICATION

I dedicate this work firstly to my number one friend, dear lovable, pretty, and yellow bone wife Sebentile Tsabedze-Nxumalo. Thank you for all the support you have afforded me throughout this academic journey [*Mkhololonsundvu Netinyawo Takhe*]. Secondly, I dedicate this work to my two sons, and daughter, respectively: Hlanganani, Gagu, and Angenelele. My kids, if I be your biological daddy, who I know I am, through this achievement, I impart great academic success into your own lives; all 3 of you will become medical doctors – Anaesthesiologist, Oncologist, and Neurologist, correspondingly. If I be your blood father, who I know I am, let this parental prediction come to pass in Jesus' name, Amen.

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ABSTRACT

With the mandate of addressing the inadequacy of research establishments in rural college settings of Eswatini, this study designed and employed the “Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra” Model to examine the characteristics that influence rural Eswatini pre-service teachers' usage of GeoGebra. Additionally, the Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra was used to assess the significant difference between male and female pre-service teachers’ use of GeoGebra. This model was also utilised in examining the effect of rural Eswatini pre-service teachers’ system quality, system compatibility, and user satisfaction on their Technology Task Fit of GeoGebra for circle theorems cognition. A pretest-posttest was employed to assess the effects of GeoGebra on pre-service teachers’ cognition of circle theorems. The study used a one-group quasi-experimental research design, with 187 pre-service teachers taking a pre-test on circle theorems before using GeoGebra, followed by a post-test. Option-related data were collected from the pre-service teachers using a 7 Likert-scale questionnaire. These data were analysed by making use of SmartPLS3.3’s Partial Least Squares Structural Equation Modeling. Results showed that user satisfaction and system compatibility are the determinants of rural Eswatini pre-service teachers' Technology Task Fit. Rural Eswatini pre-service teachers' perceived attitude toward use, perceived ease of use, and Technology Task Fit were found to have a direct effect on their actual use of GeoGebra for learning circle theorems. Perceived usefulness, satisfaction and system compatibility had indirect effects on the actual use of GeoGebra. The Rural Eswatini Pre-service Teachers' Acceptance of the GeoGebra Model explained 74.9% of the variance in rural Eswatini pre-service teachers' actual use of GeoGebra. The results moreover revealed a significant difference between male and female pre-service teachers’ actual use of GeoGebra. There was likewise a significant difference between rural Eswatini pre-service teachers' pretest-posttest marks. Ultimate findings implied that GeoGebra can be used to enhance rural Eswatini pre-service teachers' circle theorem cognition.

Keywords: Circle Theorems Cognition, Task Technology Fit, Technology Acceptance Model, System Utilisation

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LIST OF ACRONYMS AND ABBREVIATIONS

ICT .... Information and Communications Technology

TAM... Technology Acceptance Model

TTF.. Task Technology Fit

CBE.. Competency Based Education

UNESCO.................................. United Scientific, Educational and Cultural Organisation

MoET....................................... Ministry of Education and Training

MSTE .... Mathematics Science and Technology Education

BYOD .... Bring Your Own Device

Wi-Fi.. Wireless Fidelity

NTCM...................................... National Council of Teachers of Mathematics

MATLAB.................................. Matrix Laboratory

PU .... Perceived Usefulness

PEOU .... Perceived Ease of Use

UTAUT .... Unified Theory of Acceptance and Use of Technology

REPSTAG .... Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra

ATT .... Perceived Attitude Towards

PLS .... Partial Least Squares

SEM .... Structural Equation Modeling

CB-SEM .... Covariance Based SEM

PLS-SEM .... Partial Least Squares SEM

CR .... Composite Reliability

AVE.. Average Variance Extracted

ATT .... Perceived Attitude

CL...	Locatability
PI..	Performance Impacts
PU	Perceived Usefulness
QT	System Quality
RL...	System Reliability
USAT...	User Satisfaction
UT	System Utilisation
BI..	Behavioural Intention to use
PR	Perceived Resources
DGI...	Interactive Geometry Images
QUIL...	System Quality
CA	Cronbach's Alpha
VIF..	Variance Inflation Factor
SPSS..	Statistical Package for Social Sciences
COMP	System Compatibility
CP	System Capacity
IBM...	International Business Machines Corporation

CHAPTER ONE
BACKGROUND OF THE STUDY

1.1 Introduction

Technology usage, particularly in mathematics teaching and learning, is vital and indispensable in modern education. This is partly because technology presents in-depth opportunities for understanding mathematical concepts and theorems (Salifu, 2020a). Mahmudi (2021) noted that computers with appropriate programs have an impact on the mathematics that is taught in schools and enhances students' learning. GeoGebra is one such program as Hohenwarter and Jones (2007) argued that it enables learners to: visualise mathematical structures, and materialise their abstract nature. Moreover, GeoGebra increases students' engagement, converts a teacher-centred approach to learner-centred instruction, and enhances learners' comprehension of mathematics principles (Dogan & İçel, 2011). Learners can then perform self-exploration to build mathematical knowledge and skills when they incorporate dynamic software such as GeoGebra during instruction (Salifu, 2020).

In the body of knowledge, there exists some scholastic views about the use of GeoGebra in the teaching and learning of mathematics in South Africa, and globally (Adelabu, Makgato, & Ramaligela, 2019; Barabash, 2019; Hašek, 2019; Kustiawati, Kusumah, & Herman, 2019; Mohammad, 2019; Mushipe & Ogbonnaya, 2019). Farihah (2019) measured the rate at which pre-service teachers acquire geometric concepts when taught using GeoGebra, as opposed to when taught using paper and pencil methods – a study conducted in the urban area of the Islamic Institute of Jember – Indonesia. The results showed that pre-service teachers acquired more geometric concepts when taught using GeoGebra than when using the conservative paper and pencil methods. Barabash (2019) explored how GeoGebra teaching can assist pre-service teachers overcome geometry building challenges in mathematics education. GeoGebra was found to augment pre-service teachers' understanding of geometry building. However, there is inadequate evidence of studies that have investigated the efficacy and acceptance of GeoGebra in the enhancement of circle theorems' cognition by rural pre-service teachers.

On the other hand, (Trocado, Gonzalez-Vega, & Dos Santos, 2019) studied how GeoGebra could be used to enhance the art of geometric construction, and results showed that GeoGebra does improve learners' performance in geometric constructions. The findings further revealed that GeoGebra increases learners' motivation and mathematical enthusiasm. In a similar study, Mushipe and Ogbonnaya (2019) explored the effects of integrating GeoGebra with linear function teaching on Grade 9 learners' academic attainment. The results showed that the mean mark of learners taught without using GeoGebra (control group) was significantly lower than that of learners taught using GeoGebra (experimental group).

Another study was carried out to measure Geometric Thinking of learners with respect to the Van Hiele's Model (Adelabu, et al., 2019). The study was conducted using a pre-and post-test non-equivalent quasi-experimental control group method. The control group was taught using conservative methods, while the experimental group learned geometry using GeoGebra. The analysis of data was conducted according to the Van Hiele theory via ANOVA. Results manifested a noteworthy distinction between the experimental and control groups in the Geometric Thinking levels, but the Geometric Thinking points were the same.

It should be noted that all these studies never paid attention on investigating the impact of GeoGebra on rural school pre-service teachers in line with enhanced cognition of circle theorems. The study therefore explored the effect and acceptance of GeoGebra in the cognition of circle theorems by rural Eswatini pre-service teachers – a phenomenon that potentially could significantly impact the body of knowledge. In essence, the present study developed a conceptual model and tested it for explanation and acceptance of GeoGebra in circle theorems' cognition.

1.2 Scope of the Study

One of the focal points of ICT in Eswatini is the training of pre-service teachers who are digital natives and skilled users of new technology, as indicated by Ntshangase (2010) through the Eswatini ICT Draft Policy Document. As a result, ICT has become part of Eswatini's education system, and the Ministry of Education and Training has put in place an ICT policy document to regulate practice. Consequently, scholars in Africa, and around the globe, have conducted a lot of research to determine the effects of GeoGebra technology in mathematics teaching and learning for both pre-service and in-service teachers (Alkhateeb & Al-Duwairi, 2019; Furner, 2019; Machromah, Purnomo, & Sari, 2019; Zulnaidi, Oktavika, & Hidayat, 2020). The study likewise examined rural pre-service teachers' acceptance of GeoGebra usage to enhance cognition of circle theorems in the Kingdom of Eswatini. The study further determined the effects of GeoGebra in enhancing circle theorems' cognition among pre-service teachers in the Kingdom. The literature reviewed does not provide sufficient evidence of studies conducted within the Kingdom of Eswatini on GeoGebra and Mathematics Education (Madzima, Dube, & Mashwama, 2013; Ugulu, 2019). Madzima et al. (2013), conducted a study where they explored opportunities and challenges of ICT education in Eswatini.

The challenges identified include: lack of adequate planning for the implementation of ICTs in Eswatini schools, lack of teacher training, or lack of knowledge on the use of ICTs on the part of teachers, inequalities in the distribution of ICTs, lack of technical support, and inadequate infrastructure, particularly in schools located in rural Eswatini (Madzima, et al., 2013; Ugulu, 2019). There are therefore still more opportunities (Madzima, et al., 2013) for ICT to be used in support of education in the Kingdom. The study thus hopes to take this opportunity and fill the contextual gap within the Kingdom of Eswatini and explore the effects and acceptance of GeoGebra in the cognition of circle theorems by rural school pre-service teachers.

Moreover, several scholastic inquiries have been made to measure the effect of GeoGebra integration in mathematics' teaching and learning within the African community and at global level (Andrà, Bernardi, & Brunetto, 2019; Bhagat & Chang, 2015; Chimuka, 2017; Kustiawati et al., 2019; Mohammad, 2019). It should be remarked about these studies that they largely focused on how teachers could integrate GeoGebra during instruction to enhance learners' performance in mathematics (Mudaly & Fletcher, 2019; Olsson, 2017; Özçakir, 2019; Santos, Baeta, & Quaresma, 2019). There seems to be insufficient research focusing on the effects of GeoGebra in the learning of circle theorems by rural-based pre-service teachers. This is primarily because these studies (Ng, Teo, Yeo, Ho, & Teo, 2019; Özçakir, 2019; Pfeiffer & Jabbar, 2019; Ramatlapana & Agatha, 2017) mainly focused on rural school learners.

Additionally, it has transpired from reviewed literature that the many studies done on GeoGebra and mathematics education did not sufficiently investigate pre-service teachers' acceptance of GeoGebra as adaptive technology that enhances cognition of circle theorems, rather the studies focused on how teachers could integrate GeoGebra during circle theorems instruction in order to improve learners' achievement (Mudaly

& Fletcher, 2019; Mushipe & Ogbonnaya, 2019; Safrida, Susanto, & Ambarwati, 2019). Therefore, using the Technology Acceptance Model (TAM) and Task Technology Fit (TTF), the study determined factors affecting acceptance of GeoGebra as adaptive technology enhancing cognition of circle theorems, by rural school pre-service teachers.

The TAM and the TTF have been used repeatedly to envisage acceptance of new technology in educational contexts (Bhattarai & Maharjan, 2020; Chen, 2020; Mutambara & Bayaga, 2020b). However, as stand-alone models, both the TAM and TTF have been criticised for having low predictive power (Mutambara & Bayaga, 2020b; Venkatesh, Morris, Davis, & Davis, 2003). Sánchez-Prieto, Olmos-Migueláñez, and García-Peñalvo (2017) stated that educationally related external variables should be added to the TAM to improve its descriptive power. By combining the TAM and the TTF, this study developed a model that can be used to predict the acceptance of GeoGebra by Eswatini pre-service teachers. The developed model had a higher predicting power than that of the original TAM and TTF models.

1.3 Statement of the Problem

The Kingdom of Eswatini has a dream to become a high-income country by 2022 (Dlamini, 2019). To support this dream, Information Communication Technology (ICT) has been made a cut-across issue and a core subject in the newly developed competency-based curriculum (CBE) of Eswatini's education system. Also, through the initiative of His Majesty King Mswati III; a Royal Science and Technology Park, a Biotechnology Park, and an Innovation Park have been constructed (Mndzebele, Dludlu, & Mndebele, 2018). All these institutions have been invented to promote research in Science, Mathematics and Technology to boost the country's economy in fulfilment of vision 2022. Moreover, the Kingdom's Mathematics Science and Technology Education (MSTE), as well as the ICT policies, both advocate for the inclusion of technology in mathematics and science teaching in order to advance students' performance in these subject disciplines (Mndzebele et al., 2018).

However, studies by scholars Assan-Donkoh, Susuoroka, Baah, Baah-Duodu, and Puotier (2019), Sherman, Richardson, and Yard (2019), and Trenholm, Hajek, Robinson, Chinnappan, Albrecht, and Ashman (2019), mainly in urban areas, have shown that pre-service teachers are struggling with mathematics, and in particular with the cognition of circle theorems. This problem is also echoed by the findings of

Shadaan and Leong (2013) who reported that pre-service teachers still lack the correct understanding of mathematics typically, and circles' teaching and learning, precisely.

Consequently, to mitigate pre-service teachers' underperformance, several studies have been carried out by mathematics teachers in which technology intervention has been used during training (Assan-Donkoh et al., 2019; Sherman, et al., 2019; Trenholm, et al., 2019). It is very disappointing to note, however, that up-to-date pre-service teachers, particularly the rural-based, are still struggling with mathematics as a subject – a state that puts vision 2022 at risk.

Davis (1989) stressed that the use of any information system is subject to the acceptance of the user. In the case of GeoGebra, Mahmudi (2012) reported that its acceptance is highly dependent on user attitudes. As a result of the Mahmudi (2012) assessment, it could be argued that GeoGebra usage by rural teacher trainees in the Kingdom of Eswatini requires investigation of their attitudes.

Despite the call by the Kingdom's Mathematics Science and Technology Education (MSTE) and ICT policies that promote technology usage in mathematics and science teaching to advance students' performance, inadequate knowledge exists about the efficiency and acceptance of technology in rural teaching institutions. The current research therefore, sought to establish the efficacy of GeoGebra on the cognition of circle theorems by rural pre-services teachers. The research also aspired to establish essential factors for pre-service teachers to embrace GeoGebra towards cognition of circle theorems.

In investigating the effects and factors that impact rural Eswatini pre-service teachers' acceptance of GeoGebra for circle theorems' cognition, the study was organised to answer the research questions enumerated below:

i) What is the effect of rural Eswatini pre-service teachers' system quality, system compatibility, and user satisfaction on their Technology Task Fit of GeoGebra for circle theorems' cognition?

ii) What are the factors that rural Eswatini pre-service teachers consider important when accepting GeoGebra?

iii) What are the effects of gender on the acceptance of GeoGebra by Eswatini pre-service teachers?

iv) What are the effects of GeoGebra on pre-services teachers' cognition of circle theorems?

1.4 Purpose of the Study

The purpose of this study is to enhance cognition of circle theorems through adaptive technology in rural Eswatini. GeoGebra is the technological intervention that was earmarked for the exploits of the investigation via its acceptance through rural-based pre-service teachers. Using contemporary technology acceptance models under information systems, the research took a quantitative survey method approach during which 187 pre-service teachers' acceptance of GeoGebra was measured.

1.5 Aim and Objectives of the Study

The study investigated pre-service teachers' acceptance and the effect of GeoGebra technology in the cognition of circle theorems. This phenomenon was explored through circle theorems' lesson focus group on pre-service teachers. That is, the researcher conducted lessons on circle theorems during which GeoGebra was utilised as a cognitive enhancement tool to explore rural-based Eswatini pre-service teachers' acceptance and the effect of GeoGebra in the cognition of circle theorems. The following research objectives were formulated to:

1.5.1 Determine the effects of rural Eswatini pre-service teachers' system quality, system compatibility, and user satisfaction on their Technology Task Fit of GeoGebra for circle theorems cognition.

1.5.2 Find the factors that rural Eswatini pre-service teachers consider important when accepting GeoGebra.

1.5.3 Investigate the effects of gender on the acceptance of GeoGebra by Eswatini pre-service teachers.

1.5.4 Find the effects of GeoGebra on pre-service teachers' cognition of circle theorems.

1.6 Potential Contribution

By investigating the factors that rural Eswatini pre-service teachers consider important when accepting GeoGebra for circle theorems' cognition, while its importance is realised by the theoretical and practical significance outlined in the following subsections, this study has improved the body of knowledge.

1.6.1 Potential Theoretical Contribution

In predicting the acceptance and adoption of ICTs in an educational context, like any other model, TAM has also been condemned by some researchers (Carlsson, Carlsson, Hyvonen, Puhakainen, & Walden, 2006b; Mallat, Matti, Tuunainen, & Oorni, 2008). Carlsson et al. (2006b) stated that the TAM is more general and applicable to technology acceptance in a wide range of fields. Carlsson et al. (2006) stressed that ICT in education is exclusive, customised and centres on the skills offered by the system. One more criticism of the TAM is its limited descriptive power of user attitudes regarding the information system (Venkatesh et al., 2003). The TAM alone is insufficient to predict and explain the acceptance of ICT in rural education (Venkatesh et al., 2003). In addition, Lim (2018a) averred that the TAM affords an intangible lens that offers the fundamental ideologies for user relations (ease of use and usefulness) that ought to be stretched to acquire a fully-fledged model that can vindicate and envisage the recognition of technology in numerous situations, comprising the contextualisation of technology acceptance paradigms (Lim, 2018a, 2018b).

Based on Lim (2018a) and Lim (2018b) who collectively indicated that the TAM should be extended to a complete model, the results of the study identified factors that could be used to extend the TAM to forecast the reception of GeoGebra in non-urban areas of low-economy countries. The study also impacted the body of knowledge via the provision of dynamics that can be attached to the TAM to increase its instructive dominance. This study also provided factors, unique to the educational context.

1.6.2 Potential Practical Contribution

It is important, for the successful implementation of ICT in the Kingdom of Eswatini, to consider the determinants of the acceptance of GeoGebra by rural pre-service teachers, and its effects in improving the cognition of mathematics, before investing in it. As a pre-requisite to implementing GeoGebra in tertiary institutions of Eswatini, the government and other stakeholders should anticipate factors that influence the acceptance of GeoGebra by pre-service teachers. This information may enable the government to feature these elements into the proposal and execution phases that are crucial to the thriving implementation of GeoGebra. This study provided information which in turn establishes the prospects to make useful economic and didactic conclusions concerning GeoGebra in tertiary institutions.

1.7 Methodology

1.7.1 Research Paradigm

The researcher, working within the positivist paradigm, believes that absolute truth can never be achieved, and that social phenomena and their meanings exist independently of social actors. According to science, human actions are influenced by genuine reasons that precede their actions. As a result, all of reality, even adoption of GeoGebra, is in some ways predetermined, and absolute truth can be discovered. As a positivist, 'determinism' means that behaviours are caused by preceding conditions, and that grasping such relationships is crucial for prediction.

1.7.2 Research Design

A one-group pretest-posttest design was used in this study. A one-group pre-test design is a quasi-experimental study design in which the same dependent variable is evaluated in the same group of participants before (pre-test) and after (post-test) treatment (Creswell, 2014). In this investigation the participating members were third-year (final year) teacher trainees from one of the rural colleges in Eswatini. The final year students were utilised because they were the only group that had the relevant subject combination of Mathematics and Computer Science. So, the third-year pre-service teachers were given a pre-test and post-test and their results were used to gauge the effects of GeoGebra to improve cognition in circle theorems. After the pre-service teachers were given their post-test, they were also given a questionnaire to collect their views on the use of GeoGebra for learning circle theorems.

1.7.3 Sampling Procedure

There are four teachers' colleges in Eswatini. Three of these colleges are in urban areas, while one is in the countryside. The study used the only college from the countryside. All Mathematics and Computer Science pre-service teachers at the college were invited to participate in the study. The college had 187 rural pre-service teachers majoring in Mathematics and Computer Sciences. These 187 pre-service teachers were the ones doing Circle Theorems at the college. This study had the sample size and population of 187 participants.

1.7.4 Data Collection

The study used questionnaires (See appendix A, pages 124 to 125) to collect data. Questionnaires are the most frequently utilised method for gathering quantitative data

(Creswell, 2013). When the number of respondents is relatively high, questionnaires are the most effective method for collecting primary data (Creswell, 2013). As a result, a survey was used in this study because previous studies did not reveal details about Eswatini pre-service teachers' acceptance of GeoGebra, and the sample size was 187, which was large for this report.

1.8 Limitations

The findings and their implications come from a single college. Generalisation to other colleges should be done with caution. Additionally, since there is one rural teachers' training college in Eswatini, the population was used in this study. This might result in biases. Responses are regulated by the ability of participants to sincerely self-narrate and the capability to remember consistently.

Future research should employ the same survey instrument and haphazardly sample academies and universities across the Kingdom of Eswatini to adequately generalise, and sufficiently pinpoint connections and discrepancies. More investigation is paramount to ascertain whether there is longitudinal evidence to support the authenticity of the findings of this thesis.

1.9 Chapter Division

This thesis consists of seven chapters, including this one.

Chapter 2 – Literature

This chapter reviewed literature related to the study.

Chapter 3 – Theoretical Framework

This chapter presented the Technology Acceptance Model and the Technology Task Fit as the theories underpinning the study. It also presented the conceptual framework of the study. The model hypotheses were also presented in this chapter.

Chapter 4 – Methodology

The philosophical position was presented in this chapter, positivist paradigm, epistemological, ontological, and axiological positions were also discussed. The chapter presented and discussed the methodological approach, the research design, and approach. Population, sampling and data collection methods were also uncovered in the chapter.

Chapter 5 – Data Analysis

This chapter is a data analysis chapter in which the data collected was analysed using quantitative methods.

Chapter 6 – Findings

This chapter presented findings of the study.

Chapter 7- Conclusions

This chapter presented the recommendations, research limitations and conclusion.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Chapter 1 briefly outlines the background of the study, research questions, and purpose of the study, with the aim of investigating the factors that affect the acceptance of GeoGebra and its effects on rural-based Eswatini pre-service teachers' performance on circle theorems. The chapter further summarises the role played by technology in the process of learning mathematics. This literature review additionally looks at the contributions of GeoGebra in developing and understanding mathematical concepts. Likewise, the chapter focuses on the factors that pre-service teachers consider important when accepting GeoGebra for learning circle theorems. Ultimately, this literature review served to highlight gaps in the literature which the study could bridge.

2.2 Educational Technology

In this contemporary lifestyle, people use technology in their routine and daily activities. Currently, the use of technology is not just confined to industrialised states, but is common in developing countries (Kalogiannakis & Papadakis, 2019). Technology has contributed immensely to the education sphere of life and especially in teaching and learning mathematics (Safrida, Setiawan, Yudianto, Ambarwati, & Putri, 2020). In the context of Eswatini, there is a glimmer of hope considering the newly introduced competency based education (CBE) framework that has mainstreamed ICT – making it a core subject discipline. Educational, also known as instructive, technology, was largely defined as hardware and software that support scholastic ambitions (Delgado, Wardlow, McKnight, & O'Malley, 2015). Over the years, radio and television has been the most frequently integrated technology into the classroom.

The use of technology in the classroom tracks back in the 1920s when teachers introduced radio and television during instruction (Delgado et al., 2015). However, around the 1990s computer technology was for the first time integrated into the classroom during instruction (Lee, 2012). With the ubiquitous use of computers and mobile devices, teachers and learners are finding different ways of integrating technology during instruction (Delgado et al., 2015). Delgado et al. (2015) highlighted that learners and teachers interact with technology through the following ways:

- **Bring your own device (BYOD)**: This is when learners are allowed to bring their own devices to school for learning. For example, some schools in Eswatini have Wireless Fidelity (Wi-Fi) hotspots along which learners connect to internet using either their laptops or smart phones.
- **Blended learning**: This is learning that amalgamates diverse event-based undertakings, including face-to-face classrooms, live e-learning, and self-paced learning (Valiathan, 2002). This is one form of learning some schools and tertiary learning institutions in Eswatini have adopted during the era of Covid_19. Platforms like WhatsApp and other learning management system like Moodle, Zoom, Google Classroom, and Edmodo have been employed to enhance the online wing of blended learning.
- **Online learning**: This means learners are using the internet to acquire learning materials and courses. This form of learning has been engulfed by some challenges in Eswatini. Some issues Eswatini learners have faced towards online learning include lack of resources like: smart phones, data, and network coverage which they need to connect to the internet. Generally, data charges are exorbitant in the Kingdom of Eswatini. The most affordable mobile network in terms of data charges is Eswatini Mobile. However, its network signal is not strong enough, and there are some parts of the country that are still without coverage.
- **Investment in education technology**: This is when schools, districts or provincial education departments invest in educational instruments such as desktops, tablets, laptops, iPads, and other devices. The government of Eswatini, with support from organisations like the United Scientific, Educational and Cultural Organisation (UNESCO) has respectively built computer laboratories, and supplied computers in some schools.

In the 1990s, computer programs focused on facilitating lower-level cognitive skills (Delgado et al., 2015; Flick & Bell, 2000). This was achieved through routine memorisation of details and digits (Flick & Bell, 2000), but the advancement in technology, and gaming technology has shown to be an effective tool to enhance learners' first order intellectual skills (Delgado et al., 2015). The inclinations in technological advancement saw the development of many mathematics laboratory activities and games that can engage learners and drive them towards deeper learning (Shonhiwa, 2020). The Ministry of Education and Training (MoET) has introduced ICT Fares for the schools in Eswatini as an initiative to urge learners to embracing ICT as a tool that aids their learning.

According to Delgado et al. (2015), several enquiries have been conducted to investigate the effects of technology in the teaching space. Many researchers found that technology improves learners' performance in mathematics (Ganesan & Eu, 2020; Nwoke & Chidi, 2020; Safrida et al., 2020; Shonhiwa, 2020). Studies have also shown that technology can be applied in different topics of mathematics (Belbase, 2020; Ganesan & Eu, 2020; Mukamba & Makamure, 2020). For instance, Mukamba and Makamure (2020), reported that technology improved learners' performance in geometric transformations. Ganesan and Eu (2020) resolved that technology necessitated an optimistic inspiration on learners' understanding of circle geometry. Technology was also found to influence learners' cognition of probability (Belbase, 2020). The next section expands on technology integration in mathematical instruction.

2.3 Use of Technology in Mathematics

The integration of technology during mathematical instruction enables teachers to create an ambience and chances that aid learners to construct their own knowledge and skills. Furthermore, technology can help the teacher to meet most learners' needs and preferences. Additionally, the incorporation of technology into mathematical instruction assists the teacher to cater for learners with different potential or capabilities in the same class – curriculum differentiation (Graham & Fennell, 2001). For example, gifted learners can be supported by nurturing their interest and mathematical skills, at the same time, struggling learners can be given activities that meet their needs, and they can be supported in surmounting their challenges.

Notwithstanding the aforementioned, there is some inconsistency in the body of knowledge on the impact of technology in a mathematical classroom (Samuelsson, 2007; Shadaan & Leong, 2013; Wan Salleh & Sulaiman, 2013). Wan Salleh and Sulaiman (2013) reported that technology can create opportunities that improve learners’ learning conditions, especially in rural areas. In supporting this assessment, Shadaan and Leong (2013) provided empirical evidence that learners who use technology in learning mathematics out-performed their peers who were not incorporating technology into mathematical instruction. In Malaysia, the National Council of Teachers of Mathematics (NCTM, 2000) in the document “*Principles and Standards for School Mathematics”* recorded technology as one of the crucial interventions to improve the worth of mathematics. Some schools in Eswatini have learnt to prepare home lessons online, and either broadcast them via radio, television, or internet (YouTube) during the trying times of Covid_19. So, in that way it can be concluded that Eswatini learners have used technology to learn and search for information.

Amevor and Bayaga (2021) conducted research in South Africa to determine the impact of MATLAB software on pre-service teachers' performance in Vector Calculus. The results showed that after using MATLAB software, pre-service teachers' performance in Vector Calculus improved academically. Adhikari (2021) employed a quasi-experimental method to investigate the effects of utilising GeoGebra on learners' mathematics performance in Nepal. Their findings revealed that after utilising GeoGebra to teach mathematics, the experimental group's achievement score was much greater than the control group.

The record stated that, “teachers should use technology to enhance their students’ learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well – graphing, visualizing and computing.” (NCTM 2000, p. 10). On the contrary, (Samuelsson, 2007), highlighted that there is no significant difference in learners’ mathematics performance amongst those using technology and those who do not. Notwithstanding the findings of Samuelsson (2007), studies have shown that there is a growth in use of technology in the teaching and learning of mathematics (Weinhandl, Lavicza, Hohenwarter, & Schallert, 2020). Such can be said to be the trend even in Eswatini, though the rate of this computer-aided learning innovation is being slackened by inadequate funds to support this technological invention.

The use of technology in mathematics does not only assist learners construct their visual representation of mathematical ideas and concepts, summarise and analyse data, and interpret data (NCTM, 2000), but it also facilitates their exploration of every area of mathematics, such as geometry, algebra and statistics (Boo & Leong, 2016). This implies that technology use in the pedagogy of mathematics can provide opportunities in facilitating and enriching the learning environment and continuously improving and enhancing the quality of the instructional process. In Eswatini, technology has mainly been used as a medium of learning, and a research, rather than a manipulative, tool. This is probably caused by insufficient ICT capacity building amongst practising teachers; so, the country, in particular the MoET, still has to improve on this regard.

Studies have indicated that technology has been used in a wide range of mathematics topics (Adeniji, Ameen, Dambatta, & Orilonise, 2018; Belbase, 2020; Ganesan & Eu, 2020; Mukamba & Makamure, 2020; Shonhiwa, 2020). Belbase (2020) assessed the effect of mobile augmented reality-based applications into a series of mathematics lessons on probabilities in junior secondary school level. Learners from the same class were divided into experimental and control groups, and the control group had a similar pre-test mean to that of the experimental group. The results showed that there was a significant difference between learners' means in the posttest. The results revealed that learners who did not use the augmented reality application in probability learning had lower learning gains than learners in the experimental group. Learners in the experimental group attributed this improved performance to mobile augmented reality-based applications' ability to enhance learners' engagement in the classroom.

In another study, Mukamba and Makamure (2020) investigated the effects of technology in Ordinary level geometric transformations at 'O' level. The Ordinary level learners were divided into two groups (the control and experimental groups). The pre, and post, tests were administered to both groups, and results showed that even though the traditional method improved learners' performance, the use of technology exponentially enhanced learners' performance in geometric transformations. This is because learners in the experimental group were able to use technology to explore the behaviour of a particular geometric figure as they play around with the diagram in the program, and thus enhance their understanding of geometric transformations.

Technology was also found to influence learners' performance in circle geometry (Ganesan & Eu, 2020; Shonhiwa, 2020). Ganesan and Eu (2020) used the quasi-experimental study to investigate the effects of technology on learners' performance on circle geometry. The participants were form 2 learners who were divided into experimental and control groups. Results revealed that learners in the experimental group obtained significantly better mean test scores compared to the students in the control group which learned via traditional methods without any technological intervention. The results were similar to the findings of Shonhiwa (2020) who reported that using technology enhances learners' understanding of circle properties.

Several applications have been developed and used in the classroom for teaching and learning mathematics (Falcade, Laborde, & Mariotti, 2007; Larkin, 2016; Nordin, Zakaria, Mohamed, & Embi, 2010; Safrida et al., 2020). A study by Larkin (2016) revealed that there are more than 53 mathematics applications that can be utilised in the classroom. However, mostly used applications are GeoGebra, Cornerstone maths, and Cabri. Falcade et al. (2007) investigated the effects of Cabri on learners' performance in mathematics, and results showed that Cabri positively influences learner' performance. In another study, Cornerstone Maths was used to teach learners geometry (Safrida et al., 2020). Results from this study confirmed the findings of Clark-Wilson (2015) who in turn reported that Cornerstone Maths improves learners' performance in geometry. Unlike Cabri and Cornerstone, GeoGebra is an open source, and many researchers have confirmed its effects on learners' understanding of geometry (Belgheis & Kamalludeen, 2018; Em & Roman, 2020; Mukamba & Makamure, 2020; Safrida et al., 2020). Additionally, GeoGebra is considered to be the most useful and versatile dynamic geometry software (Boo & Leong, 2016). Furthermore, GeoGebra can be used to support the teaching and learning processes of mathematics at a variety of levels such as: elementary level, middle school, high schools, and university levels. Eswatini still needs to introduce these teaching/learning tools in the classroom, in particular it is mathematics teachers who need to spearhead this initiative. This is because generally some learners in Eswatini have disregarded the mathematics subject discipline, yet the subject is crucial if Eswatini is to develop into first world status in the near future.

2.4 GeoGebra

2.4.1 History of GeoGebra

Hohenwarter (2009) created GeoGebra as a master's thesis project at the University of Salzburg, Austria. The thesis received a lot of support in Austria and other European countries (Hohenwarter, Jarvis, & Lavicza, 2009). Hohenwarter continued developing GeoGebra through PhD studies (Hohenwarter et al., 2009). At PhD level, Hohenwarter et al. (2009) examined the pedagogical application of GeoGebra in Austrian schools. They found that GeoGebra enhances geometry cognition. GeoGebra was well received in Europe, America, and other countries. As a result, it was translated into 40 languages. Hohenwarter et al. (2009) reported that in 2009, a GeoGebra website received more than 350 000 visitors per month from 188 countries, and the website was used by thousands of teachers worldwide. Based on on-line activity and resource sharing, recent studies have shown that GeoGebra is now being used by millions of people globally (Ganesan & Eu, 2020).

2.4.2 What is GeoGebra?

GeoGebra is an open-source (non-profit making) dynamic mathematics software program developed by Markus Hohenwarter. The software can be freely downloaded from the internet: www.geogebra.org. GeoGebra was developed to complement other software like Derive, Maple, and MuPad which are used for the teaching and learning of mathematical algebra. The dynamic software also complements other programmes, like Geometry Sketchpad and CABRI Geometry that are used for the teaching and learning of geometry. However, unlike this software which teaches geometry and algebra separately, GeoGebra was developed with the idea of teaching and learning geometry, algebra, and calculus simultaneously (Hohenwarter et al., 2009). It is a flexible teaching and learning tool that enhances visualisation of mathematical ideas at all levels of learning. Mukamba and Makamure (2020) noted that the visualisation enhanced by GeoGebra software provides learners with a clear view of both simple and complex mathematical constructions.

GeoGebra is a geometry application that is interactive - presenting learners and teachers techniques to draft teaching units and allow the learning of mathematics in a consequential way (Boo & Leong, 2016). The application allows learners to work with vectors, lines, conic, segments, and points (Hohenwarter, Hohenwarter, Kreis, &

Lavicza, 2008). Additionally, GeoGebra also allows learners to enter functions algebraically, and it then changes them dynamically afterwards. This dynamic software presents an influential opportunity to create a collaborative learning setting that permits scholars to discover diverse geometric models (Diković, 2009). It also offers a novel dynamically connected learning environment (Hohenwarter et al., 2009).

Dikovic (2009) noted the following advantages of GeoGebra:

- GeoGebra is user-friendly.
- GeoGebra encourages learners' project in mathematics, multiple presentations and experimental and guided discovery learning.
- GeoGebra can produce a sketch of geometry quickly and more accurately than by using a pencil or ruler.
- Manipulation facility (dragging) can provide a clearer visual experience to students' understanding of the concept of geometry.
- GeoGebra can be used to evaluate a geometrical construction.

Research has shown that GeoGebra can be integrated into mathematical learning activities, and can develop learning tasks based on learner capability (Hohenwarter et al., 2008). Dikovic (2009) had resolved that GeoGebra turns out to be a modern learning tool that fuses technology in the teaching and learning of mathematics as it enhances visualisation and simulation. Another challenge facing the integration of technology in the classroom in Eswatini, could be the teacher – student ratio, particularly in public schools. Besides the unavailability of relevant infrastructure, there is the concern of understaffing in public schools, that is likely inhibiting teachers from infusing technology during instruction. The subsequent section describes GeoGebra application in the classroom.

2.4.3 The Application of GeoGebra in the Classroom

Korenova (2017) investigated the use of GeoGebra among children between 9 and 11 years of age on students' attitudes and their achievements. The study followed mixed methods approach, and findings revealed that GeoGebra improved learners' performance in geometry. Additionally, the results indicated that learners had a positive attitude towards GeoGebra. These outcomes were harmonious with the conclusion of Boo and Leong (2016) which stated that learners were capacitated to convey their geometric visualisations and discernment of mathematical models post

GeoGebra usage. The results of the study also revealed that GeoGebra can render the teaching space more pleasurable and thought-provoking (Boo & Leong, 2016).

A study carried out by Safrida et al. (2020) to investigate the effects of GeoGebra on university learners' performance in geometry indicated a sizeable demarcation between learners' pretest-posttest marks. The results showed that GeoGebra is a useful supplement in traditional teaching. These results were in line with the findings of Baltaci and Yildiz (2015) who added that GeoGebra is dynamic, easy to apply, and can improve learners' performance.

Another study was carried out in Zimbabwe by Mukamba and Makamure (2020) on the effects of teaching and learning geometric transformations at Ordinary Level. The results were in line with the findings of Arbain and Shukor (2015), who found that learners had progressive attitudes concerning the use of GeoGebra, and had better learning achievement using GeoGebra. Arbain and Shukor (2015) added that it can benefit learners' mathematics learning and diversify their learning in classrooms.

In another study, Tay and Wonkyi (2018) investigated the consequence of using GeoGebra on high-grade students' attainment in circle theorems. The investigation followed a quasi-experimental design during which learners were divided into two groups; the experimental group and the control group. The control group was taught circle theorems using the traditional paper-and-pencil method, and the experimental group were taught using GeoGebra. Results showed that learners who were taught using GeoGebra outperformed their counterpart who were taught using the traditional paper-and-pencil method. Later, these results corroborated the findings of Bayaga, Mthethwa, Bossé, and Williams (2019), who found that the use of GeoGebra had a numerically weighty impact on the learners' potential to accurately answer questions on circle geometry theorems. A lot still needs to be done before rural Eswatini teachers could be able to use technology as a teaching/learning tool during instruction. For instance, some schools yet do not have electricity, let alone internet connection and computers.

Sheikh Qasem (2020) used a quasi-experimental design to investigate the effects of GeoGebra on learners' understanding of quadratic functions in the 10th grade. Eighty-five Grade 10 learners were randomly divided into control and experimental groups.

The result of the post-test exhibited an arithmetically substantial point of preference of using GeoGebra for the trial group over the control group.

Borambaev (2020) conducted a study to investigate the effects of GeoGebra on teaching mathematics at the level of 10^{th} – 11^{th} grades. In the study, the effects of GeoGebra in several topics such as algebra, geometry, graphing, and 3D were investigated. Results showed that GeoGebra had a positive effect on learners' understanding of mathematics, especially integrals, polyhedrons, volume, and surface area of geometric shapes. In this same study, questionnaires were used to solicit learners' perceptions on the use of GeoGebra, and results indicated that learners had a positive attitude towards GeoGebra.

Kusumah, Kustiawati, and Herman (2020) carried out a study to explore the effects of GeoGebra on three-dimensional geometry learning, and learners' mathematical communication ability based on students' prior mathematical abilities. During this study, a quasi-experimental research design was employed, and results showed that after using GeoGebra, there was a significant difference on learners' pre and post-test marks for learners with high and medium mathematical prior abilities. However, GeoGebra did not make a significant impact on learners' performance for learners with high and medium mathematical prior abilities.

Birgin and Acar (2020) similarly employed a quasi-experimental design to investigate the impression of using GeoGebra on 11^{th} Grade learners' performance in exponential and logarithmic functions. Data were collected from both the control and experimental groups using the pretest-posttest. The t-test was used to analyse data, and results revealed that using GeoGebra software had a significant effect on learners' achievement in exponential and logarithmic functions.

Based on the studies by Tay and Wonkyi (2018), Bayaga et al. (2019), Sheikh Qasem (2020), and (Mukamba & Makamure, 2020) one can conclude that GeoGebra can be used to improve the performance of high school learners in mathematics. Particularly, GeoGebra was found to improve learners' performance in circle theorems (Bayaga et al., 2019; Tay & Wonkyi, 2018), exponential and logarithmic functions (Birgin & Acar, 2020), quadratic functions (Sheikh Qasem, 2020) and geometric transformations (Mukamba & Makamure, 2020). Furthermore, the study by Borambaev (2020) showed that GeoGebra positively influenced learners' performance in algebra, graphing and 3D.

Borambaev (2020) revealed that GeoGebra is not restrained to oral, but it also provides more diverse, and dynamic, learning which assists learners in clarifying the meaning of learning materials. Moreover, GeoGebra displays interesting, transferable, and translatable forms and magnitude to afford learners more prospects of visualising mathematical concepts easily. It is these advantages that GeoGebra brings into the mathematics classroom that enhance learners' cognition of mathematical concepts. GeoGebra also encourages learners to be active and participate in their construction of knowledge as they actively use the learning tool. Additionally, GeoGebra transforms the teacher-centred, into learner-centred approach – an undertaking that stimulates deep holistic learning amongst learners.

2.4.4 The Effect of GeoGebra on Pre-service Teachers' Cognition of Circle Theorems.

Geometry is the study of shapes and space (Safrida et al., 2020). It is considered one of the most important topics in mathematics because it is a rich source of visualisation for arithmetical, algebraic and also statistical concepts (Ganesan & Eu, 2020). Kusumah et al. (2020) stressed that geometry is linked with every component in the mathematics curriculum, and a multitude of situations in real life. It enables one to comprehend the world by contrasting objects, figures, and correlations (Gunhan, 2014). According to Alkhateeb and Al-Duwairi (2019), GeoGebra weighs in to plausible and inferential thought about three-dimensional objects and correlations. Consequently, the mastery of geometry knowledge should be developed effectively in mathematics learning.

Studies have shown that learners have lack of background knowledge, reasoning and make basic operation mistakes that lead to several misconceptions about circle geometry (Crowley, 1987; Pamungkas, Rahmawati, & Dinara, 2020; Shonhiwa, 2020). Ganesan and Eu (2020) attributed the challenges learners have on circle properties' manipulation and understanding, to these numerous misconceptions. Other studies also show that geometry learners have some shortcomings such: as lack of ability to produce proofs based on direct visual elements, incomplete comprehension of the problem, and mathematical symbols' interpretation (Ganesan & Eu, 2020; Kim, 2014).

A lesson that can be learnt from these studies (Ganesan & Eu, 2020; Pamungkas et al., 2020; Shonhiwa, 2020) is that learners are having challenges in mastering circle theorems.

Another study was carried out to investigate pre-services teachers' understanding of realities of the Taylor series convergence (Kim, 2014). The study moreover investigated a teaching method using GeoGebra regarding the understanding-realities. The study revealed that pre-service teachers were able to compute the Taylor series and radius, but failed to understand theoretical puzzles which bestow meaning of the equality between an arbitrary function and its Taylor series at a specific point (Kim, 2014). This further highlighted a challenge in that pre-service teachers failed to determine the change of radius of convergence with respect to the change of Taylor series' centre (Kim, 2014). The results proved that the use of GeoGebra enhances teacher-trainees' command of theoretical problems that present the implication of equivalence in a random function. Some Eswatini pre-service teacher training colleges have cited their packed curricula as the challenge preventing them from incorporating ICT tools during lectures. ICT integration during instruction has proven to be difficult even after adopting a semesterised curriculum in Eswatini Teacher Colleges. This is because before an ICT tool can be introduced during instruction, the instructor would have to first educate students on this tool. So, the teaching time may not be adequate to accommodate all these novelties.

In Ghana, Salifu (2020b) used a quasi-experimental design to investigate the effects of GeoGebra on pre-service teachers' performance in circle theorems. The learners were divided into trial and control groups during which the two sets of groups were subjected to pre-test and post-test. The results of the study showed that learners who were taught circle theorems, using conventional method, achieved a lower mean score than those taught using GeoGebra. The paired sample t-test also confirmed that the experimental group gained a mean difference of 9.83 in post-test with a large effect size. Contrary to the results of Salifu (2020b), findings from a study by Fabian and Topping (2019) revealed that there was no distinction established in the groups' post-test performance scores after an evaluation of covariance with pre-test as covariate. The next section describes a combination of two models for the purpose of understanding learner acceptance of a new information system during the study.

2.5 Effects of Technology Acceptance Model and the Technology Task Fit

The Technology Acceptance Model (TAM) and the Technology Task Fit (TTF) model were both developed to understand users' acceptance of a new information system like GeoGebra. The outcome variable for both TAM and TTF, is the actual use of an information system. That is, the TAM and TTF were both used as standalone models, however, these models overlap significantly and, if integrated, could provide an even stronger model than either standing alone (Dishaw & Strong, 1999; Pittalis, 2020).

Hence, the study combined both the Task Technology Fit and the TAM to explore Eswatini pre-service teachers' acceptance of GeoGebra. This section appraises the alterations and additions of the TAM in connection to the earlier investigations that were carried out on pre-service teachers. Furthermore, the unit equally evaluates past extensions of the TAM with the TTF.

2.6 The Effects of Rural Eswatini Pre-service Teachers' System Quality, System Compatibility, and User Satisfaction on their Technology Task Fit of GeoGebra for Circle Theorems' Cognition

2.6.1 System quality

System quality can be explained to be the passion with which the user deems a system's ease of operation, connection, and learning, as well as gratification of use (Isaac, Aldholay, Abdullah, & Ramayah, 2019). System quality is a measure of the degree to which the system is technically sound, flexible, and sophisticated (Aldholay, Abdullah, Ramayah, Isaac, & Mutahar, 2018). In the study, system quality denotes the quality of GeoGebra which includes its ease of use, shapes' manipulation using the software, and the software's provision of prompt feedback.

In another study, the DeLone and Mclean Information Systems Success (DMISS) model was used to investigate factors that affect the adoption and use of technology in Yemen's universities (Aldholay et al., 2018). Results revealed that technology task fit is influenced by system quality. These findings were in line with those of Alrajawy, Daud, Isaac, and Mutahar (2016) who state that the quality of the system influences its actual usage via the mediating effect of Technology Task Fit.

Isaac et al. (2019) investigated the influence of system quality on Technology Task Fit, and the conclusions were that system quality had a progressive effect on

Technology Task Fit. In the study, Isaac et al. (2019) reported that the greater the system quality of technologies, the more likely these will mirror desires and lifestyles of their users. Based on the assessment of Isaac et al. (2019), the study would accordingly imply; the greater the quality of GeoGebra, the greater the likelihood that it will reflect Eswatini pre-service teachers' learning requirements. The literature in the education field has yet to pay significant attention to this variable (Isaac et al., 2019)

2.6.2 System Compatibility

Another variable that researchers in the education field have not given the attention it deserves, is system compatibility (Cheng, 2015). However, in other information systems, system compatibility was found to influence system Technology Task Fit and actual usage (Rogers, 2004). System compatibility is considered as one of the crucial technology acceptance constructs by users (Cheng, 2015; Isaac et al., 2019). Furthermore, Isaac et al. (2019) described system compatibility as the intensity with which inventions are alleged to resonate with the modern essentials, fashions, principles, and past occurrences of the inventions' apparent users.

Islam and Azad (2015) carried out a study to compare the perceptions of Finnish university instructors and learners with a Learning Management System (LMS). The results revealed that learners' system compatibility influences their actual usage of the LMS. The results further exposed that learners' system compatibility does not a have a significant effect on learners' Technology Task Fit. However, for instructors, system compatibility influenced both actual use and Technology Task Fit.

In yet another study, Isaac et al. (2019) probed the tolerance of online learning by Yemen universities' learners using the Technology Task Fit model. The results showed that system compatibility influenced actual usage and technology Task Fit. In online learning applications, Isaac et al. (2019) found that high compatibility begets desirable acceptance of mobile systems.

In the study, the inclination is pronounced as the extent to which GeoGebra fits Eswatini pre-service teachers' beliefs, values, and lifestyles. Islam and Azad (2015) revealed that compatibility has a substantial impact on actual usage, while Cheng (2015) reported a profound liaison among usage and compatibility with respect to mobile learning packages in Taiwan. This research investigated the arbitration effects of technology task fit, system compatibility, and actual usage.

2.6.3 Technology Task Fit

Technology Task Fit was portrayed as the intensity with which systems address interests, match or fit tasks, and meet standards (Isaac et al., 2019). Task-technology Fit was also defined as the extent to which an innovation supports an individual in executing an assigned task (Goodhue & Thompson, 1995). They correspondingly referred to the disposition as the scope to which a system is fit or appropriate for aiding in the accomplishment of missions, in connection to work obligations (Lu & Yang, 2014). In the study, Technology Task Fit is described as the extent to which GeoGebra meets Eswatini pre-service teachers' learning needs of circle theorems.

Several researchers examined the positive effects of technology task fit regarding usage behaviours (Isaac et al., 2019; Lu & Yang, 2014). Glowalla and Sunyaev (2014) assessed the positive impacts of TTF on factors regarding information system efficacy, including the influence on operation, and the net benefits. Isaac et al. (2019) calculated the mediation impressions of TTF on the correlation among real use and performance, as well as among user satisfaction and the influence on performance, based on the direct and substantiated effects of real usage, and user satisfaction on performance. Little is known about the effect of Technology Task Fit on perceived usefulness, perceived ease of use, and perceived attitude of pre-service teachers. This study sought to close that gap by finding the effects of Technology Task Fit on Eswatini pre-service teachers' perceived usefulness, perceived attitude towards, and perceived ease of use of GeoGebra to learning circle theories.

2.6.4 User Satisfaction

User satisfaction is the degree to which users perceive systems as useful and to desire their reuse (DeLone & McLean, 2016). In the study, user satisfaction refers to the intensity with which Eswatini pre-service teachers find contentment in their exclusive resolve to use GeoGebra to learn circle theorems. It is one of the key success indicators used to evaluate the adoption of a new system (DeLone & McLean, 2016). Isaac et al. (2019) stated that many studies have confirmed the effect of user satisfaction on Technology Task Fit. In the same study, Isaac et al. (2019) investigated the effects of user satisfaction on Technology Fit and actual usage. The results showed that user satisfaction had a positive influence on both Technology Task Fit and actual usage. The study suggests that the more satisfaction Eswatini pre-service teachers have with GeoGebra; that is, whether it meets their expectations, the more GeoGebra will help them understand circle theorems.

2.7 Factors Affecting Pre-service Teachers' Acceptance of GeoGebra

2.7.1 Perceived Usefulness (PU)

Perceived usefulness is defined as the degree to which a person believes that using a particular technology will enhance his or her job performance (Davis, Bagozzi, & Warshaw, 1989). In the educational context, PU is explained as a person's opinion that using ICT will expand his or her teaching and learning. According to Mac Callum and Jeffrey (2014) the teachers' perception, that using technology is going to have a progressive impact on their teaching, is one of the reasons they incorporate it into teaching and learning. Therefore, the assessment of Eswatini pre-service teachers about the perceived usefulness of a GeoGebra is one of the main determinants of its future use.

In another study by Kalogiannakis and Papadakis (2019), the TAM was extended to examine if there is correlation between pre-service kindergarten teachers' intention to use Information and Communication Technologies (ICTs), and perceived usefulness. The results showed that pre-service kindergarten teachers' perceived usefulness positively influences their intention to use ICT. These findings were echoed by Joo, Park, and Lim (2018), who stated that pre-service teachers' intention to use technology in class is influenced by their belief that it improves their performance. Furthermore, Khlaisang, Teo, and Huang (2019); Joo et al. (2018) also reported that pre-service teachers' behavioural intention to use ICT is influenced by perceived usefulness.

In another study by Aman, Prasojo, Sofwan, Mukminin, Habibi, and Yaqin (2020), research findings suggested that pre-service teachers' perceived usefulness influences their attitude. In line with these findings of Aman et al. (2020), Eksail and Afari (2019) stated that pre-service teachers' perceived usefulness does not only influence their intentions to use a technology, but it also influences their mind-sets towards the technology. In a similar study by Khlaisang et al. (2019), results revealed that pre-service teachers' attitudes towards the use of technology are influenced by their perceived usefulness.

Bhattarai and Maharjan (2020) conducted a study during which these scholars investigated student teachers' perceptions towards acceptance of digital alteration in teaching-learning activities amongst members enrolled at different levels in the Kathmandu Valley in Nepal. Results of this investigation were in contradiction with the results of Kalogiannakis and Papadakis (2019), Khlaisang et al. (2019) and Aman et al. (2020) who found that perceived usefulness influences pre-service teachers' attitudes. On another note, Bhattarai and Maharjan (2020) found that pre-service teachers' perceived usefulness is not a predictor of their attitudes toward the integration of technology into teaching and learning.

What can be learnt and concluded from these studies is that pre-service teachers' perceived usefulness predicts their attitudes and intentions to use technology in the classroom (Eksail & Afari, 2019; Kalogiannakis & Papadakis, 2019; Teo, Lee, Chai, & Wong, 2009). Pre-service teachers' belief is that technology can be used to enhance learning and influences their attitudes and intentions to use the technology. If perceived usefulness is strong, it invents a constructive mind-set towards ICT, and as a result, it amplifies pre-service teachers' intention to use the ICT (Mutambara & Bayaga, 2020a). It can thus be argued that Eswatini pre-service teachers' perceived usefulness will influence their attitudes and intentions to use GeoGebra to improve their performance in circle theorems.

2.7.2 Perceived Ease of Use (PEOU)

Perceived ease of use was defined by Davis et al. (1989) as the perception that the use of mobile learning will be free of cognitive effort. Davis et al. (1989) avowed that in the primitive phases of embracing any information system, the idea that the system is problematic to operate can be a hurdle that may acclimatise the users' views, usefulness, and behavioural intention. Since the use of GeoGebra for learning circle theorems is still an innovation in Eswatini universities and teacher colleges, then recognising GeoGebra usage for learning circle theorems may not be resounding. This could discourage and inhibit Eswatini pre-service teachers from using GeoGebra during the teaching and learning of circle theorems.

Studies have shown that perceived ease of use of an innovation, enforces a constructive effect on perceived attitude towards use of the innovation (Kalogiannakis & Papadakis, 2019; Sánchez-Prieto et al., 2017). If Eswatini pre-service teachers feel that GeoGebra is easy to use, then they will most likely have a positive attitude towards it. Additionally, the use of GeoGebra produces more workload for Eswatini pre-service teachers, and this workload increases if these pre-service teachers feel the use of GeoGebra is difficult and confusing.

Perceived ease of use influences users' perceived usefulness (Davis et al., 1989; Joo et al., 2018). In a study in Malaysia, Wong (2013), found that pre-service teachers' perceived ease of use influences their perceived usefulness. Contrary to the findings of Joo et al. (2018), the results of the study by Sánchez-Prieto, Hernández-García, García-Peñalvo, Chaparro-Peláez, and Olmos-Migueláñez (2019) indicated that perceived ease of use does not influence pre-service teachers' perceived usefulness. Sánchez-Prieto et al. (2019) stated that the conviction that the use of a technology will strengthen instruction causes pre-service teachers to use the technology, even though they may feel that the technology is difficult to use. It is possible that pre-service teachers may believe that the use of GeoGebra is difficult but continue to use it because the benefits outweighed the effort needed to learn to use it.

In line with the results of Mutambara and Bayaga (2020c), Mac Callum and Jeffrey (2014) found that pre-service teachers' perceived ease of use influences their behavioural intention to use technology in the classroom. Comparable conclusions were equally recounted by Stols, Venter, and Louw (2016), who stated that easy-to-use technology encourages pre-service teachers to use it. Contrary to the findings of Stols et al. (2016) and Mutambara and Bayaga (2020b), the outcomes of the enquiry by Sánchez-Prieto et al. (2019) found that pre-service teachers' perceived ease of use does not influence their intention to use technology in the classroom.

Notwithstanding the results of the study by Sánchez-Prieto et al. (2019), and several other studies have shown that pre-service teachers' perceived ease of use influences their perceived attitude, usefulness and actual usage (Joo et al., 2018; Mac Callum & Jeffrey, 2014; Mutambara & Bayaga, 2020b; Stols et al., 2016), based on the results of these studies, it can be contended that Eswatini pre-service teachers' perceived ease of use will influence their perceived usefulness, perceived attitude and actual usage.

2.7.3 Perceived Attitude Towards (ATT)

Perceived attitude guides actual usage and is defined as the manner in which one responds, and the way one is disposed, towards an object (Teo et al., 2009). This disposition may be affirmative or non-affirmative (Teo et al., 2009). The success of integration of a technology in the classroom is dependent on users' attitudes. Teo et al. (2009) reported that pre-service teachers' attitude, of a technology, predicts their actual usage of this technology. Similar findings were made by Aman et al. (2020) who conveyed that pre-service teachers' actual use of technology is influenced by their attitudes.

In another study by Eksail and Afari (2019) attitude towards technology use, subjective norm, perceived usefulness, facilitating conditions, perceived ease of use, and behavioural intention to use technology for teacher trainees were measured. Results of the study showed that perceived attitude does not only influence pre-service teachers' actual usage, but also plays a mediating role between predictors (perceived usefulness and perceived ease of use) and actual usage.

Another study conducted by Teo, Luan, and Sing (2008), explored pre-service teachers' self-reported future intentions to use computers in Singapore and Malaysia, and the results showed that perceived attitudes of pre-service teachers in Singapore and Malaysia influenced their actual usage. The results delegated the integration of technology into the classroom by pre-service teachers, and implied that the attitude of pre-service teachers towards technology plays a big role towards integration of the technology. A lesson that can be learnt from the studies is that perceived attitude towards use, plays a pivotal role on pre-service teachers' actual usage (Eksail & Afari, 2019; Teo et al., 2008). Consequently, projections can be made that, for Eswatini Pre-service teachers to accept and use GeoGebra in the learning of circle theorems, they should first demonstrate a positive attitude towards GeoGebra itself. The next section is the discussion on the effects of gender on the acceptance of GeoGebra.

2.8 The Effects of Gender on the Acceptance of GeoGebra

Teo and Milutinovic (2015) conducted a study during which these authors examined the variables that influence Serbian pre-service teachers' intention to use GeoGebra to teach geometry. The multiple indicators, multiple causes (MIMIC) modeling was used to assess if there are major discrepancies in the behavioural intention to use

GeoGebra by Serbian pre-service teachers' gender. The results revealed that Serbian pre-service teachers' intent to use technology for instruction was not inspired by gender.

In a similar study, Belgheis and Kamalludeen (2018) used the technology acceptance model to assess the acceptance of GeoGebra as per the two genders of pre-service teachers in Malaysia. The results revealed that the acceptance of GeoGebra was influenced by gender (Belgheis & Kamalludeen, 2018). Congruent to the findings of Belgheis and Kamalludeen (2018), the results of the study by Admiraal, van Vugt, Kranenburg, Koster, Smit, Weijers, and Lockhorst (2017) also indicated that pre-service teachers' intention to use GeoGebra is not influenced by their gender.

Papadakis (2018) used the technology acceptance model to study the factors that Greek pre-service teachers consider important when accepting the use of technology in the classroom. In the same study, Papadakis (2018) also investigated if there is significant difference between male and female perceptions towards the use of technology in the classroom, and the results indicated that there was no significant difference between male and female pre-service teachers' acceptance of technology.

The acceptance model was used to explain and understand pre-service teachers' acceptance of digital innovation in the classroom (Teo, Fan, & Du, 2015). The findings of the study showed that, while the gender groups showed no statistical difference on perceived usefulness, attitudes toward technology, and intention to use technology, female pre-service teachers had lower scores on perceived ease of use, suggesting that technology use is more challenging for female pre-service teachers than it is for their male counterparts (Teo et al., 2015).

Contrary to the findings of studies (Belgheis & Kamalludeen, 2018; Papadakis, 2018; Teo & Milutinovic, 2015), results from a study by Teo and Noyes (2014) revealed that gender, among pre-service teachers, moderates technology acceptance and use in the classroom. Teo and Noyes (2014) used the Unified Theory of Acceptance and Use of Technology (UTAUT) to evaluate the acceptance of technology by pre-service teachers, and the authors found that the strength and influence of the core determinants of the UTAUT may work differently when applied to different genders. In the next section, a summary of these gaps in literature is given.

2.9 Summary of Gaps in Literature

Several studies have shown that pre-service teachers have challenges in understanding circle theorems (Ganesan & Eu, 2020; Pamungkas et al., 2020; Shonhiwa, 2020). However, some studies (Kim, 2014; Salifu, 2020b) found that GeoGebra can be used to improve pre-services teachers' performance in circle geometry. One thing of note in these studies (Ganesan & Eu, 2020; Kim, 2014; Pamungkas et al., 2020; Salifu, 2020; Shonhiwa, 2020) is that even though pre-service teachers have challenges with understanding circle theorems, GeoGebra can be used to improve their performance.

There is however, some inconsistency about the effects of GeoGebra on pre-service teachers' performance (Fabian & Topping, 2019; Kim, 2014; Salifu, 2020b). Fabian and Topping (2019) reported that there was no dissimilarity found in the groups' post-test achievement scores after an Analysis of covariance with pre-test as covariate. On the contrary, Kim (2014) and (Salifu, 2020b) found that GeoGebra can improve learners' performance in circle theorems. Furthermore, these studies (Fabian & Topping, 2019; Kim, 2014; Salifu, 2020b) were carried out in developed countries, where the settings are contextually different from rural universities of developing countries. Consequently, there was need for the study to be conducted.

Still, researchers have not given the effects of system compatibility and system quality, on TTF, the attention they deserve (Isaac et al., 2019). Few studies have shown that system quality and system compatibility influence technology task fit (Aldholay et al., 2018; Alrajawy et al., 2016; Cheng, 2015; Isaac et al., 2019). Aldholay et al. (2018) and Alrajawy et al. (2016) reported that system quality affects technology task fit. Cheng (2015) and Isaac et al. (2019) concluded that system compatibility influences technology task fit. Following the assessment by Isaac et al. (2019), which disclosed only a few studies have been carried out to investigate the effects of system quality and system compatibility on technology task fit, the study suggests that more studies are needed to close this gap. Moreover, these studies (Aldholay et al., 2018; Alrajawy et al., 2016; Cheng, 2015; Isaac et al., 2019) were carried out in the Middle East and developed countries; very little is known about the effects of system quality and system compatibility on Technology Task Fit in rural areas of developing countries like Eswatini.

A plethora of studies have stated that acceptance of GeoGebra is a complicated process (Bhattarai & Maharjan, 2020; Eksail & Afari, 2019; Kalogiannakis & Papadakis, 2019). To understand this complex phenomenon, several studies were conducted in tertiary institutions (Khlaisang et al., 2019; Teo, Lee, Chai, & Wong, 2009), that led to GeoGebra acceptance and use in developed countries. It could thus be argued that for GeoGebra to be successfully implemented for circle theorems in rural universities of developing countries, more studies are needed on the acceptance of GeoGebra.

Additionally, there is some inconsistency in the body of knowledge on the relationships between the factors that influence pre-service teachers' acceptance of GeoGebra. Kalogiannakis and Papadakis (2019) found that perceived usefulness does not affect perceived attitude of pre-service teachers towards the use of GeoGebra, while Khlaisang et al. (2019) and Aman et al. (2020) determined that perceived usefulness influences pre-service teachers' attitude towards GeoGebra. On the relationship between perceived ease of use and perceived usefulness, the results suggest that Milrad et al. (2013) and Joo et al. (2018), reported a positive influence, while Sánchez-Prieto et al. (2019) reported no significant influence. Stols et al. (2016) reported that perceived ease of use influences behavioural intention, while Mac Callum and Jeffrey (2014) found no significant effect.

There was therefore need for a study like this to be conducted in rural universities of developing countries, to clarify these contradictions in the body of knowledge. Table 1 shows the factors that need to be examined to clarify some contradictions in the body of knowledge. Some factors were never researched in rural universities of developing countries to the best of researcher knowledge.

Table 1 : Emerging Themes and Potential Factors to be Examined

THEME	CHALLENGES	POTENTIAL FACTORS TO BE EXAMINED	SOURCES
Behavioural intention	Inconsistencies in the body of knowledge. Have not been adequately examined in rural universities	Perceived ease of use.	Mac Callum and Jeffrey (2014); Stols et al. (2016)
		Perceived usefulness	Joo et al. (2018); Kalogiannakis and Papadakis (2019)
	Have not been adequately examined in rural universities	Perceived attitude towards	Teo et al. (2009); by Aman et al. (2020)
Perceived usefulness	Have not been adequately examined in rural universities	Technology task fit	Have not been examined in rural universities
	Inconsistencies in the body of knowledge. Have not been adequately examined in rural universities.	Perceived ease of use.	Milrad et al. (2013), Joo et al. (2018)
Perceived ease of use.	Have not been adequately examined in rural universities.	Technology task fit	Have not been examined in rural universities
Perceived attitude towards	Inconsistencies in the body of knowledge. Have not been adequately examined in rural universities.	Perceived ease of use.	Aman et al. (2020); Eksail and Afari (2019);
	Have not been adequately examined in rural universities	Perceived ease of use.	Kalogiannakis and Papadakis, (2019); Sánchez-Prieto et al. (2017)
		Technology task fit	Have not been examined in rural universities
Technology task fit	Have not been adequately examined in rural universities	System quality	(Cheng, 2015; Isaac et al., 2019); Islam and Azad (2015); (Rogers, 2004)
		System Compatibility	(Aldholay et al., 2018); Alrajawy et al . (2016); Isaac et al. (2019)
		User Satisfaction	DeLone & McLean (2016); Isaac et al. (2019)

2.10 Summary

The history of the use of technology in education was explained in this chapter; and also discussed the use of technology in mathematics. In this chapter, the history and the definition of GeoGebra were equally outlined. Subsequently, GeoGebra applications in the classroom were also described, and effects of GeoGebra on pre-service teachers' cognition of circle theorems were presented**.** Factors that influence Technology Task Fit were discussed in this chapter, and then factors that influence pre-service teachers' acceptance of GeoGebra were discussed. The chapter ends by outlining the gaps in the body of knowledge that this study is meant to close. The second part of the literature review is presented in the next chapter, concentrating on the theoretical models underpinning the study.

CHAPTER THREE
THEORETICAL FRAMEWORKS

3.1 Introduction

This chapter presents the theoretical foundation for the research model during which special attention was given to the Technology Acceptance Model (TAM) and the Task-Technology Fit (TTF). The TAM and the TTF were employed consequently to the research questions to simplify factors that conceivably affect rural Eswatini pre-service teachers' acceptance and use of GeoGebra for circle theorem learning. Building from the TAM and TTF, a conceptual framework for the study was developed. Hence, the conceptual framework for the study consists of variables from the TAM and TTF. Moreover, research propositions for this study were formulated in line with the TAM and TTF variables. The TAM was presented first, followed by the TTF.

3.2 Technology Acceptance Model (TAM)

The TAM was proposed by Davis et al. (1989) to extrapolate users' intention to welcome a new information system. The TAM is deemed the most frequently used model to guess and elucidate users' intention to use a new information system (Cheng, 2015; Mutambara & Bayaga, 2020a; Van der Heijden, 2003). Over the past three decades the TAM has been authenticated by numerous applications and expansions. These include: e-government (Dahi & Ezziane, 2015; Sari, Akkaya, & Abdalla, 2017), web-based information systems, (Mun & Hwang, 2003; Van der Heijden, 2003), e-commerce, (Fuller, Serva, & Baroudi, 2009), e-health, (Wahyuni, 2017), and mobile learning (Chen, 2020; Mutambara & Bayaga, 2020b; Pittalis, 2020). The TAM encompasses five constructs, namely: perceived usefulness, perceived ease of use, attitude towards using, behavioural intention to use, and actual system use.

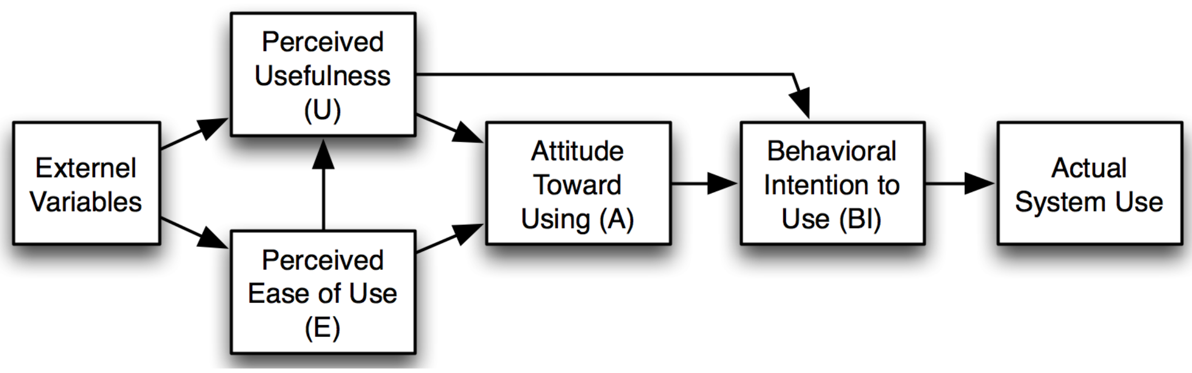

Figure 1 depicts the TAM.

Figure 1 : The TAM Model (Davis et al., 1989)

The TAM contends that the person's behavioural intention (BI) to use a new information system would be mutually settled by perceived usefulness (PU) and his/her attitude towards (ATT) it (Davis et al., 1989). That is, the individual's attitude towards the information system is acclimatised by the utility and exploits needed to learn to use the information system (Mutambara & Bayaga, 2020a). Thus, the TAM hypothesises that perceived usefulness is predicted by perceived ease of use (PEOU), which are both influenced by external factors (Davis et al., 1989).

In TAM, perceived ease of use is an individual's opinion that using a new technology will be simple and hassle-free (Davis et al., 1989). Hence, in the study, perceived ease of use can be defined as rural Eswatini pre-service teachers' perceptions that using GeoGebra will be free from effort. Perceived usefulness (PU) was defined by Davis et al. (1989) as an individual's view that using a new technology will enhance or improve his/her execution. Deriving from the definition of perceived usefulness, the study described PU as rural Eswatini pre-service teachers' perceptions that using GeoGebra will improve their performance in circle theorems. Perceived usefulness and perceived ease of use were found to influence attitude towards use. Attitude towards use was defined as a person's inclusive emotional response toward the utility of a new technology (Venkatesh et al., 2003). In the study, perceived attitude towards use was defined as rural Eswatini pre-service teachers' holistic expressive response toward the use of GeoGebra for learning circle theorems. Perceived attitude towards the use influences users' behavioural intention to use the new information system (Venkatesh et al., 2003). Behavioural intention (BI) was defined by Fang, Kayad, and Misieng (2019) as the cognitive representation of a person's readiness to perform a given behaviour. Behavioural intention is the best single predictor of acceptance and thus actual usage (Davis et al., 1989; Venkatesh et al., 2003). The actual usage is usually measured by the amount of time of using, frequency of use, actual number of usages, and diversity of usage (Huang, 2014). The TAM does not provide the external variables, and yet these external variables are context related. It is for this reason that the TAM is considered robust and can be used to explain the acceptance of a new information system in different settings.

Over the past three decades, the TAM has evolved, and new variables were introduced as exterior variables prompting perceived ease of use (PEOU), perceived usefulness (PU), perceived behavioural intention, and actual usage. According to Lee, Kozar, and Larsen (2003), system quality, compatibility, computer anxiety, enjoyment, computing support, and experience are the most frequently referenced external variables to the TAM. In an effort to provide external variables of the TAM, Venkatesh and Davis (2000) proposed TAM2 by extending the TAM. The variables which were added were subjective norm, image, job relevance, output quality, result demonstrability, experience, and voluntariness. Figure 2 shows the TAM2. After adding these external variables, Venkatesh and Davis (2000) found that the exploratory power of the model increased.

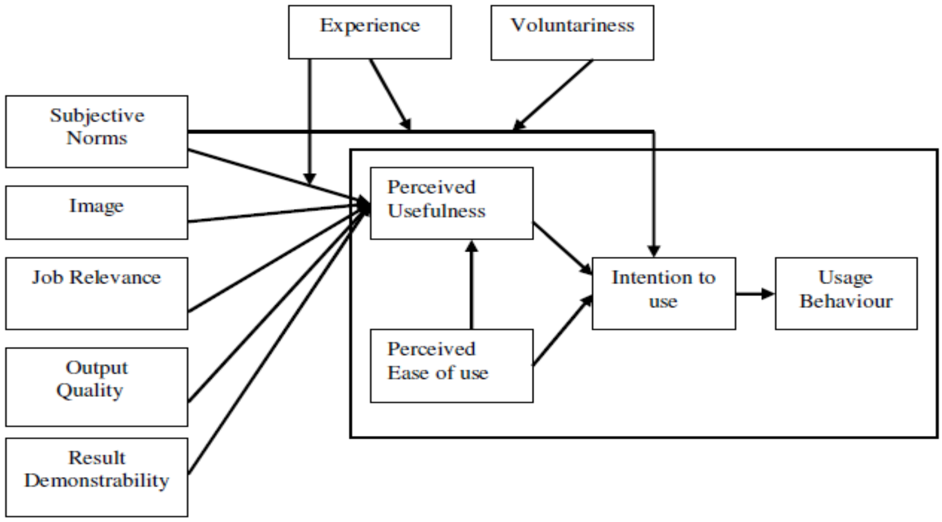

Figure 2 : The TAM2 Model (Venkatesh & Davis, 2000)

3.2.1 Reasons for Selecting the TAM

In the study, the TAM was selected for its established ability to predict technology acceptance. So, in this case, TAM was used to predict the acceptance of GeoGebra by rural Eswatini pre-service teachers. The TAM is also considered a well-established technology acceptance theory (Joo et al., 2018; Mutambara & Bayaga, 2020b). It has also been used by other researchers in the educational context, (Huang, 2014; Joo et al., 2018; Mutambara & Bayaga, 2020c), to predict the acceptance of GeoGebra (Nair & Das, 2012; Pittalis, 2020). The TAM gives the researcher the ability to choose external constructs that apply to GeoGebra and the holistic setting where the inquiry was carried out.

The TAM was also selected in this study because it can easily be combined with other models to form a new model that can explain the acceptance of a new system better than either model alone (Dishaw & Strong, 1999; Sentosa & Mat, 2012). The TAM was combined with the Task-Technology Fit (TTF) by Dishaw and Strong (1999) to form the Integrated TAM/TTF model. The TAM was also combined with the theory of planned behaviour (Sentosa & Mat, 2012). This study combines the TAM with the TTF to form the Rural Eswatini Pre-service Teachers' Acceptance of the GeoGebra model.

3.2.2 Limitations of the TAM and TAM2

Like any other model, the TAM and its extensions have been disparaged by other researchers (Carlsson, Carlsson, Hyvonen, Puhakainen, & Walden, 2006a; Liu & Li, 2011; Mallat, Rossi, Tuunainen, & Öörni, 2008; Venkatesh et al., 2003). For instance, Venkatesh et al. (2003) criticised the TAM for its low descriptive power of users' thoughts toward information systems. In dealing with this weakness, the researcher did as other researchers did. That is, Venkatesh et al. (2003) stressed that adding external variables improves the explanatory power of the TAM, on the one hand. On the other hand, Dishaw and Strong (1999) combined the TAM and the TTF, which resulted in an increase in the explanatory power of the model. In the study, the TAM and the TTF were combined, and other variables like system quality, system compatibility, and user satisfaction, were included.

The TAM is also criticised for being exceedingly generic and appropriate to the reception of technology in countless diverse domains (Carlsson et al., 2006a). Carlsson et al. (2006) emphasised that educational contexts are more distinctive, more personalised, and more focused on utilities presented by the system. The researcher responded to this criticism by following examples of other researchers who added educational-context external variables to the TAM (Mutambara & Bayaga, 2020a; Pittalis, 2020). Thus, in the study, system quality, system compatibility, Task-Technology Fit, and user satisfaction, were added as external variables to the TAM.

Another weakness of the TAM, regarding the understanding and explaining of new technology utilisation is its lack of task focus (Dishaw & Strong, 1999). Information technology is a device by which users achieve organisational tasks (Dishaw & Strong, 1999). Dishaw and Strong (1999) stressed that the lack of task focus, in evaluating acceptance of a new information system, contributes to the mixed results in new information system evaluations. Then the task technology fit perspective of the study, addresses this weakness. In dealing with this weakness decisively in the study, the researcher combined the TAM and the TTF.

3.3 Task-Technology Fit (TTF)

The TTF was proposed by Goodhue and Thompson (1995) to explain users' actual use of an information system. The TTF posits that for an innovation to comprise constructive influence on solo performance, the invention must be applied, and it must be a relevant fit with the assignment that it corroborates (McCarthy & Claffey, 2005). Task Technology Fit also suggests that when technology provides features, and supports the fit of the requirements of the task, performance impacts will result (McCarthy & Claffey, 2005). The Task-Technology Fit construct expresses the ability of an information system to support a task, which means matching the demands of the task with the capabilities of the information technology (Dishaw & Strong, 1999). The TTF postulates that users will use the information technology if, and only if, the functions available to the user support (fit) the activities. This implies that users will only choose the information technology that enables them to complete their tasks with maximum net benefits.

The TTF stresses that information technology should be a good fit, with the tasks it supports, in order to be used, and to affect user performance (Hsiao, 2018). The task characteristics and technology characteristics can affect the Task-Technology Fit, which in turn determines users' utilisation of technology and their task performance (Hsiao, 2018). There are five key constructs in the TTF model: task characteristics, technology characteristics, Task-Technology Fit, utilisation, and performance impact. Technology characteristics were defined as the tools used by individuals in carrying out their tasks (Goodhue & Thompson, 1995). According to Goodhue and Thompson (1995), task characteristics are the actions carried out by individuals in turning inputs into outputs. Goodhue and Thompson (1995) defined Task-Technology Fit as the degree to which a technology assists an individual in performing his or her portfolio of tasks. Utilisation was defined as the behaviour of employing the technology in completing tasks (Goodhue & Thompson, 1995), and performance was defined by Goodhue and Thompson (1995) as accomplishment of a portfolio of tasks by an individual. Higher performance implies some mix of improved efficiency, improved effects, and/or higher quality. Figure 3 shows the TTF Model.

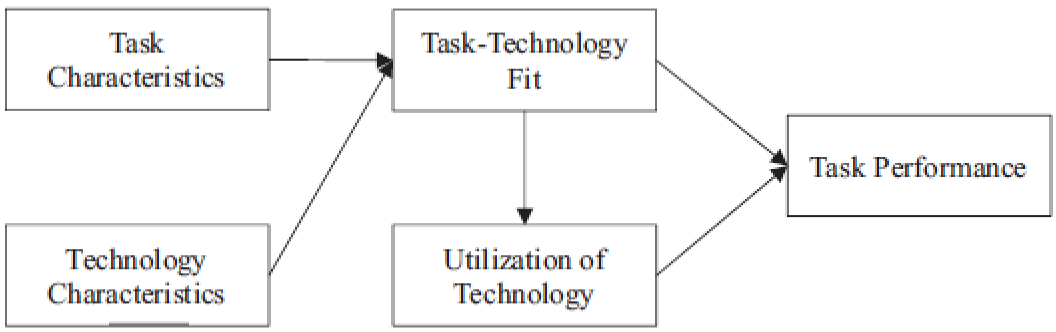

Figure 3 : The TTF Model (Goodhue & Thompson, 1995)

3.3.1 Weakness of the TTF

The TTF focuses on the match between the task and the technology. The TTF asserts that in order for the technology to be used, and positively affect user performance, the technology should be a good fit with the task (Hsiao, 2018). However, the TTF does not take into consideration the users' belief and attitude. According to Dishaw and Strong (1999), TTF models assume that users choose to use information technology that improves their job performance, and lacks a consideration of their attitude towards the IT. According to Davis et al. (1989), users' acceptance of a new information system depends on their attitude or belief of the system. Users (especially in educational contexts where there are many choices) rarely use an information technology they do not want, simply because it improves their performance. This means that user attitude in TAM still plays an important role in predicting IT use behaviour (Hsiao, 2018).

Unlike the TAM, the TTF is not a well-established model in explaining users' acceptance of an information system (Lu & Yang, 2014). According to Lu and Yang (2014), the TTF model still needs further studies to obtain more insights into its validation across different contexts. To support the assessment of Lu and Yang (2014), Hsiao (2018) noted that the TTF's constructs, and the relationship between these constructs, vary with each study. Additionally, the TTF has been applied mainly at organisational, rather than at end user levels (Hsiao, 2018).

Considering the strengths of the TAM and the TTF, one can conclude that combining the two models together, to form one model, will result in a model that better explains the acceptance of GeoGebra by rural Eswatini pre-service teachers. The TAM model explicitly includes the users' attitudes towards an information system. This is the weakness of the TTF, as it does not explicitly include the task characteristics, and yet this is the core of the TTF. Instead of arguing for the TTF as an alternative to the TAM, the study proposed adding the strengths of the TTF model to the TAM, to produce an integrated model.

3.4 Justification of Combining the TAM and the TTF

For the past three decades, the TAM and the TTF have been used to predict, and to explain the acceptance and utilisation of information systems (Hsiao, 2018; Klopping & McKinney, 2004). Both models were developed to explain and understand users' acceptance and evaluations of information systems. While TTF was developed to explain and understand users' utilisation, the TAM model is used to explain and predict computer-usage behaviour. According to Dishaw and Strong (1999), the TAM usually focuses on intention to use, or actual use. Whereas the TTF focuses on actual use, or the individual performance attributable to actual use.

The reason for expanding the TAM to contain unequivocal references to task and technology, is afforded by the opinions of Goodhue (1995). Goodhue (1995) combined the technology usage model of Bagozzi (1982) to his TTF model. Like the TAM, the technology usage model was developed from attitude/behaviour models to explain technology utilisation. In linking up these two models, the study argued that the TTF and the TAM capture two different aspects of rural Eswatini pre-service teachers' acceptance and usage of GeoGebra for circle theorems. The TAM assumes that Eswatini pre-service teachers' beliefs and attitudes toward GeoGebra fundamentally establish whether they exhibit the conduct of using it. However, for some cases in the educational context, users use technology they despise because it enhances their operation (Mutambara & Bayaga, 2020b). The TTF models take a distinctly rational approach by assuming that Eswatini pre-service teachers' choice to use GeoGebra is based on how well GeoGebra (technology) fits the requirements of learning circle theorems (tasks) and can improve their performance, regardless of their attitude towards it.

Both aspects, attitude toward the GeoGebra and rationally determined expected consequences from using the GeoGebra, are likely to affect rural Eswatini pre-service teachers' choices to utilise GeoGebra for learning circle theorems. Consequently, combining the TAM and the TTF is likely to provide a better explanation of Eswatini pre-service teachers' acceptance of GeoGebra for learning circle theorems, than either of the models alone. Additionally, a combined model of these two models will have a high explanatory power than either of the two.

3.5 The Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra (REPSTAG) Model

For the study, the acceptance of a crossbreed TAM/TTF model was rational, as the two separate prototypes examined different segments of rural Eswatini pre-service teachers' acceptance of GeoGebra for circle learning circle theorems. Most of the TAM variables and hypotheses were retained in this new model. The TTF model, extends the TAM by considering how the task affects its use. The study posits that TTF influences perceived usefulness, perceived attitude towards, and actual usage, while the TTF itself is predicted by perceived ease of use, system quality, system compatibility, and user satisfaction. System compatibility also influences actual usage. **Error! eference source not found.** shows the proposed hybrid model.

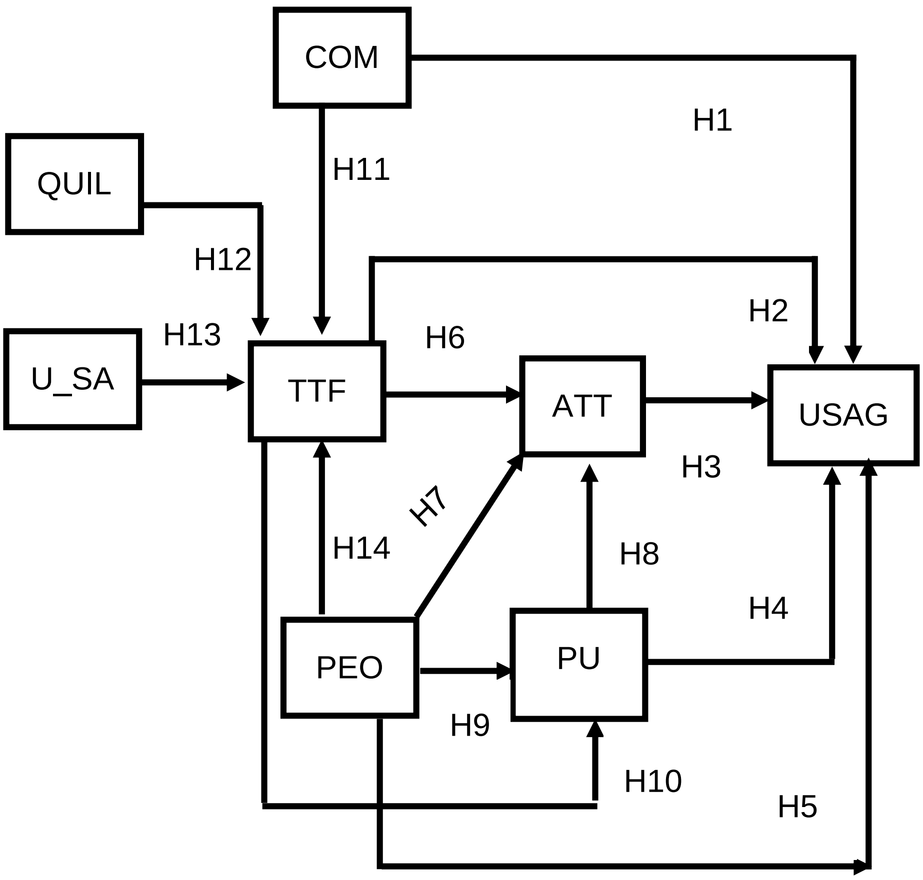

Figure 4 : Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra Model, Source: Researcher

3.5.1 User Satisfaction (USAT)

User satisfaction was defined as the affective attitude towards a specific computer application by someone who interacts with the application directly (Doll & Torkzadeh, 1988). It was also defined as the degree to which users perceive a system as useful and desire to reuse it (DeLone & McLean, 2016). In this study, user satisfaction refers to the intensity with which rural Eswatini pre-service teachers find gratification in their lone judgement to use GeoGebra to learn circle theorems. User satisfaction is deemed one of the extremely crucial measures of information systems' (IS) success (Gharbawi & Bassam, 2016a).

Studies had concentrated on elucidating what user satisfactory is, by pinpointing its elements (DeLone & McLean, 1992; Doll & Torkzadeh, 1988; Gharbawi & Bassam, 2016a). DeLone and McLean (1992) and Doll et al. (1994) considered user satisfaction as a multi-attribute construct, while Gharbawi and Bassam (2016a) considered it to be a single construct. Following Gharbawi and Bassam (2016a), this study considers user satisfaction to be one construct that measures rural Eswatini pre-service teachers' affective attitude towards GeoGebra for learning circle theorems. It measures the Eswatini pre-service teachers' 'GeoGebra after use' affective attitude. In other words, it measures the extent of fulfilment of rural Eswatini pre-service teachers after using GeoGebra for learning circle theorems. Additionally, user satisfaction can be considered as the extent to which Eswatini pre-service teachers consider GeoGebra fit to enhance circle theorems cognition.

3.5.2 Perceived Usefulness

Perceived usefulness was defined in the educational context as a person's perception that using ICT will improve his or her teaching and learning (Mutambara & Bayaga, 2020a). Studies have shown that perceived usefulness influences perceived attitude towards, and actual usage (Lin & Huang, 2008; Siegel, 2008; Wu & Chen, 2017). Siegel (2008) reported that learners' perceived usefulness does not only influence their perceived attitude, but it also influences their actual usage. Similar results were found by Wu and Chen (2017) who reported that if learners perceive technology to be useful in their studies, they will frequently use the technology.

Perceived usefulness is also reported to influence learners' actual usage (Lin & Huang, 2008). Lin and Huang (2008) reported that learners' belief that using a technology will improve their peformance, influences their desire to use the technology. In another study, Yang (2007) reported that undergraduate learners' actual usage of Webct as a collaborative tool is influenced by perceived usefulness.

Several studies confirmed the effects of perceived usefulness on perceived attitude towards the use in the educational context (Mutambara & Bayaga, 2020b; Pittalis, 2020; Teo et al., 2009). Mutambara and Bayaga (2020b) found that high school learners and teachers' perceived usefluness influenced their perceived attitude towards mobile learning. Teo et al. (2008) have found that the perceived usefulness variable explains (69%) of the variance in attitude towards computer use among pre-service teachers enrolled at the National Institute of Education in Singapore. In another study, perceived usefulness was found to influence pre-service teachers' viewpoints towards the utilisation of GeoGebra. This means that pre-service teachers' attitudes towards the use of technology for learnig, whether positive or negative, are shaped by their percieved usefulness. It can be proposed that rural Eswatini pre-service teachers' perceived attitude towards the use is influenced by their belief that using GeoGebra for learning circle theorems will improve their performance.

3.5.3 Perceived Ease of Use

Perceived ease of use is user's perception that the utilisation of an information system will not need mental reasoning (Davis et al., 1989). Davis et al. (1989) noted that the belief that an information system is difficult to use might be a barrier to its use in the first stages of system use. Following the assessment by Davis et al. (1989), it is anticipated that perceived ease of use will influence rural Eswatini pre-service teachers' actual use of GeoGebra for circle theorems' learning, as it is relatively new to them.

Several studies have shown that perceived ease of use influences pre-service teachers' perceived usefulness (Pittalis, 2020; Teo et al., 2015; Teo et al., 2009). The use of technology for learning involves additional effort of learning the technology (Pittalis, 2020). This work load increases when the technology is difficult or confusing to use (Teo et al., 2015). Hence, perceiving that it is difficult to use GeoGebra to learn circle theorems will likely discourage rural Eswatini pre-service teachers from using it. Additionally, Teo et al. (2009) noted that even though pre-service teachers believe that technology can improve their performance, they do not use it if they perceive it as difficult.

Pre-service teachers' perceived attitude is influenced by perceived ease of use (Joo et al., 2018; Papadakis, 2018). Papadakis (2018) found that pre-service teachers' perceived ease of use influences their attitude towards the acceptance of mobile devices for learning. Similar results were reported by Joo et al. (2018), who found that pre-service teachers' attitude towards technology is influenced by their effort needed to learn to use the technology. If rural Eswatini pre-service teachers perceive the use of GeoGebra to be easy, they are mostly likely to have good perceptions towards its use.

In the early stages of information system adoption, perceived ease of use becomes an internal barrier that may condition not just the behavioural intention to use a technology (BI), but also its actual use (Sánchez-Prieto et al., 2019). Sánchez-Prieto et al. (2019) found that pre-service teachers' actual use of educational games is influenced by the effort needed to learn to use the technology. If rural Eswatini pre-service teachers found GeoGebra easy for the learning of circle theorems, then they will use it for the learning.

3.5.4 Perceived Attitude Towards (ATT)

Venkatesh et al. (2003) defined ATT, in the perspective of technology acceptance research, as an individual's overall passionate response toward the utilisation of modern innovations. Perceived attitude in the study was described as the overall affective reaction of Eswatini pre-service teachers towards the use of GeoGebra. This affection can be positive or negative. For GeoGebra to be adopted by rural Eswatini pre-service teachers, they should have a positive attitude towards it.

Prior studies have shown that pre-service teachers' perceived attitudes towards technology usage, influence their actual use (Montrieux, Grove, & Schellens, 2014; Siyam, 2019). Siyam (2019) emphasised the importance of managing pre-service teachers' attitudes towards, as it (ATT) is the best predictor of their technology adoption. Teo et al. (2009) reported that pre-service teachers' attitude predicts their actual usage. Similar results were reported by Aman et al. (2020) that pre-service teachers' actual use is influenced by their attitudes. If rural Eswatini pre-service teachers have a positive attitude towards the use of GeoGebra, they will use it for learning circle theorems.

3.5.5 Task-Technology Fit (TTF)

The task-technology fit model is a widely used theoretical model for evaluating how information technology leads to performance, assessing usage impacts, and judging the match between the task and technology characteristics (Wu & Chen, 2017). The TTF was defined by Goodhue and Thompson (1995) as a matter of how the capabilities of the information systems match the tasks that the user must perform, is a major factor in explaining job performance levels. Wu and Chen (2017) suggested that the perception of whether a particular technology fits well with the present values of users that is perceived usefulness can be a basis for forming perceptions of actually utilising the technology. Furthermore, empirical results have proved that perceived usefulness is influenced by task-technology fit; that is, when fit between the task and innovation is superior, users recognise the technology to be convenient (Wu & Chen, 2017).

System features of GeoGebra are expected to influence pre-service teachers' circle theorem cognition. The prerequisite for the perceived usefulness of GeoGebra is that pre-service teachers find a match between task and technology. When pre-service teachers choose to use GeoGebra for learning circle theorems, the mechanism behind this choice is quite likely that Task-Technology Fit influences their actual use.

Previous studies in the educational context have empirically established that TTF positively influences both users' attitude towards technologies and actual usage of technologies (Alamri, Almaiah, & Al-Rahmi, 2020; Gan, Li, & Liu, 2017; McGill & Klobas, 2009). For instance, Alamri et al.

(2020) found that TTF significantly affects user attitude towards the use of social networking applications as sustainability in higher education. Gan et al. (2017) noted that TTF significantly affects the actual usage of mobile learning in higher education. McGill and Klobas (2009) reported that TTF extensively influences both users' attitudes and actual usage.

For a technology to perfectly fit the task, it should be easy to use. This thesis proposes that if the technology fits the task, but users perceive it to be confusing and difficult to use, they might not recognise its usefulness. For GeoGebra to be considered fit for learning circle theorems, pre-service teachers should perceive it easy to use. In other words, this study proposes that pre-service teachers' perceived ease of use, influences their task-technology fit.

3.5.6 System Quality

Ali and Younes (2013) noted that systems quality is a multivariate procedure centring on diverse facets, since a system has multiple parts that include system parts, quality parts, and other parts related to technical issues. Isaac et al. (2019) described system quality as the passion with which an individual believes that systems are easy to control, learn, and fix, as well as pleasurable to use. System quality was defined by Aldholay et al., (2018) as the degree to which the system is technically sound, flexible, and sophisticated. Based on the definitions of Ali and Younes (2013), Isaac et al. (2019), and Aldholay et al. (2018), one can conclude that system quality is a multidimensional process which is task or context related. Therefore, the study considers system quality as the quality of GeoGebra which includes how easy it is to learn to use it, to manipulate shapes using the software, and get feedback. The higher the system quality, the higher the task-technology fit. Empirical studies have shown that task-technology fit is influenced by system quality (Aldholay et al., 2018; Isaac et al., 2019). Aldholay et al. (2018) found that Yemen university learners' task-technology fit is influenced by system quality. Isaac et al. (2019) reported that the greater the system quality of technologies, the more likely these will mirror desires and lifestyles of their users. This study proposed that the greater the system quality of GeoGebra, the more likely it will mirror rural Eswatini pre-service teachers' learning needs of circle theorems.

3.5.7 Compatibility

In the information systems (IS) field, compatibility is considered one of the fundamental antecedents to user adoption of new technology or application (Alamri et al., 2020; Cheng, 2015). Isaac et al. (2019) described system compatibility as the extent to which innovations are seen to resonate with contemporary requirements, ethics, and past understandings of their apparent users. Alamri et al. (2020) noted that literature in the education field has yet to pay significant attention to this variable. In one of the rare studies which involves system compatibility in education, Cheng (2015) found that high compatibility leads to preferable adoption of mobile learning.

Few studies have focused on the effect of system compatibility on Task-Technology Fit and actual usage (Alamri et al., 2020; Isaac et al., 2019; Islam & Azad, 2015). Isaac et al. (2019) found that system compatibility is the influencer of university students' TTF and actual usage of online learning applications. Congruent with the findings of Isaac et al. (2019), Alamri et al. (2020) reported that both system actual usage and TTF are influenced by system compatibility.

3.6 Model Hypotheses

The first three research questions are as follows;

(i) What is the effect of rural Eswatini pre-service teachers' system quality, system compatability, and user satisfaction on their Technology Task Fit of GeoGebra for circle theorems' cognition?

(ii) What are the factors that rural Eswatini pre-service teachers consider important when accepting GeoGebra?

(iii) What is the effect of gender on the acceptance of GeoGebra by Eswatini pre-service teachers?

To answer these research queastions, this study proposed the Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra Model depicted in Figure 4. The model was developed using statistical hypotheses H1 to H14. The statitical hypotheses H1 to H14 were used to test the predictive validity of the Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra Model to predict the acceptance of GeoGebra for learning circle theorems. The statistical hypotheses are as follows.

H1: Eswatini pre-service teachers' system compatibility influences their actual use of GeoGebra.

H2: Eswatini pre-service teachers' Task-Technology Fit influences their actual use of GeoGebra.

H3: Eswatini pre-service teachers' perceived attitude towards, influences their actual use of GeoGebra.

H4: Eswatini pre-service teachers' perceived usefulness influences their actual use of GeoGebra.

H5: Eswatini pre-service teachers' perceived ease of use influences their actual use of GeoGebra.

H6: Eswatini pre-service teachers' Task-Technology Fit influences their perceived attitude towards the use of GeoGebra.

H7: Eswatini pre-service teachers' perceived ease of use influences their perceived attitude towards GeoGebra.

H8: Eswatini pre-service teachers' perceived usefulness influences their perceived attitude towards GeoGebra.

H9: Eswatini pre-service teachers' perceived ease of use influences their perceived usefulness of GeoGebra.

H10: Eswatini pre-service teachers' Task-Technology Fit influences their perceived usefulness of GeoGebra.

H10: Eswatini pre-service teachers' Task-Technology Fit is influenced by their perceived ease of use.

H11: Eswatini pre-service teachers' system compatibility influences their Task-Technology Fit of GeoGebra.

H12: Eswatini pre-service teachers' system quality influences their Task-Technology Fit.

H13: Eswatini pre-service teachers' user satisfaction influences their Task-Technology Fit.

H14: Eswatini pre-service teachers' Task-Technology Fit is influenced by their perceived ease of use.

3.7 Summary

This chapter presented two technology acceptance theories (Technology Acceptance Model and Task-Technology Fit) that are used to explain users' acceptance of a technology in the educational context. The Technology Acceptance Model and its extension (TAM2) were presented first, and then their weakness. Thereafter, the Task-Technology Fit was then presented with its weakness in explaining acceptance of technology in the educational context. Also, justification of why the combination of the two theories (TAM and TTF) were presented, as well as the conceptual framework of this enquiry. Factors that influence Eswatini pre-service teachers' acceptance of GeoGebra were identified though reviewing past studies. The next chapter presents the methodology followed in this study.

CHAPTER FOUR
METHODOLOGY

4.1 Introduction

In the previous chapters of this thesis, prior studies by different researchers were described and analysed to highlight similarities and differences in their findings. The Technology Acceptance Model and Task-Technology Fit were presented as the two theories informing the study, and their weaknesses were presented. A conceptual framework which was a hybrid of the Technology Acceptance Model and Task-Technology Fit was invented. This chapter mainly looks at how the information for the inquiry was generated, and the methods employed for data analysis.

4.2 Philosophical Position

The functions of research are to produce new knowledge and to establish novel facts. The new knowledge is intended to inform academics, policymakers, planners, and governments, for developmental and economic purposes. A researcher is therefore directed by a set of values, practices, principles, concepts, and assumptions to produce a trajectory for the scholarly environment. Consequently, the researcher should hold a basic set of opinions that guide action (Guba & Lincoln, 1994). The two primary worldviews described in the past, interpretivist and positivist can serve as the primary philosophy that guides people embarking on a study (Fetters, Curry, & Creswell, 2013).

Ontology (the nature of reality, feeling, existence or being), epistemology (what counts as knowledge and how people know), logic (what is acceptable as rigour and interference in the judgments of developments) and axiology (what counts as fundamental values (moral choices, ethics), are the main points of departure of the two world views, that is, positivism and interpretivism. The positivism view of the world serves as a reference for this thesis.

4.2.1 The Positivistic Paradigm

The goal of an investigation is to provide new knowledge in the body of knowledge; and therefore, the researcher should be concerned about the existence of this knowledge. Ontology is the study of the existence of knowledge (Fetters et al., 2013). In other words, what constitutes fact. Thus, the assumptions and positions taken on what is the nature of reality, being, or existence, is the ontological position of the study. This position is about the object to be examined, its outlook, what elements constitute it, and how these elements interconnect with each other (Fetters et al., 2013). Operating within the positivist paradigm, the researcher believes that absolute truth can never be found, societal occurrences and their connotations have an actuality that does not rely on social players.

Science claims that human activities are induced by actual causes preceding their behaviour. Accordingly, all of reality and, for that matter, acceptance of GeoGebra is already in a sense pre-determined, and therefore, absolute truth can be found. As a positivist, 'stoicism' means that actions are instigated by previous instances and therefore consideration of such spontaneous links is necessary for projection. Thus, it is imperative to understand factors that affect the acceptance of GeoGebra by pre-service teachers to understand GeoGebra acceptance in Eswatini.

4.2.2 Epistemological Positions

A standard scientific approach is required in the generation of new knowledge on the factors that influence Eswatini pre-service teachers to accept GeoGebra for learning circle theorems. Epistemology is what counts as knowledge and the way people know what they know (Fetters et al., 2013). The position of positivists and interpretivists again differs in what it counts as knowledge and advocates different methods of knowledge acquisition.

A positivist takes the view that, regardless of the viewpoint of the researcher, there is a single version of what is real; the only way to discover this reality and 'believable' evidence is to calculate or analyse the world with as little interference as possible from the researcher and other factors. By contrast, an interpretivist takes into account the multiple and varied perspectives of what may be real (Ryan, 2018). Is reality what people see and feel, or is it that which we can measure? Interpretivists assert that reality is our own perceptions, experiences and feelings (Ryan, 2018).

The position, as held by the researcher, is that of a positivist who believes that knowledge exists, and there are identifiable factors that influence Eswatini pre-service teachers to accept GeoGebra. Consequently, the researcher believes that this knowledge can only be measured objectively using a hypothesis or knowledge generated deductively from the technology acceptance model because it is constant in all contexts (Pham, 2018).

4.2.3 Ontological Position

As already indicated in the preceding sections, the objective of research is to generate new knowledge, and the researcher should be concerned about the existence of such knowledge. Ontology is a study of knowledge existence. In other words, ontology is basically what constitutes a fact. Thus, the assumptions and positions taken on what is the nature of reality, being, or existence, is the ontological position of the study. This position concerns what objects should be studied, what they look like, what elements they make up, and how these elements engage with each other (Creswell & Creswell, 2017). Operating within the positivist paradigm, the researcher believes that absolute truth can be found, and that societal events and their connotations have an animation that is autonomous and free from social actors.

The researcher believes that human actions are triggered by real causes that precede their behaviour. In this view, all reality and, for that matter, the acceptance of GeoGebra, is already predetermined, and therefore absolute truth can be found. As a positivist, 'determinism' means that actions are caused by previous circumstances; and therefore, understanding such casual links is necessary for prediction. It is therefore imperative to understand the factors that have an impact on the acceptance of GeoGebra by Eswatini's pre-service teachers.

4.2.4 Axiological Positions

Axiology is the study of what comprises fundamental principles and the consciousness of the researcher. It deals with ethics, moral decisions, and normative judgements. Axiology was designed to clarify the role of the researcher and participants in the study process (Saunders & Lewis, 2012). This philosophy branch studies judgments about the value. It also contributes to the evaluation of the role played by the researcher in all research processes. Axiology attempts to clarify positions on forecasting the future, or simply attempting to grasp or justify it. Axiology concentrates on what the researcher values in his/her study.

Positivists believe that research must be carried out on a freeway basis, and that the researcher is independent of the data, and maintains an objective stance (Creswell & Clark, 2017). The researcher believes that to establish the factors that influence Eswatini pre-service teachers to accept GeoGebra, the researcher should carry out the study without affecting the participants in any way. As a positivist, the researcher believes that the concept is independent of the data collected and was analysed and interpreted objectively.

4.2.5 Methodological Approach

The researcher was guided by the ontological, epistemological, and axiological positions of the research to select a specific methodology. According to Guba and Lincoln (2005), the two major methodologies in existence are qualitative and quantitative. On the one hand, quantitative research is the arithmetic demonstration and exploitation of enquiries with the intent of portraying and elucidating the experience signalled in those enquiries. It is applied in a broad range of natural and social sciences such as physics, biology, psychology, sociology, and geology (Sukamolson, 2007). On the other hand, qualitative research is the procedure of amassing, evaluating, and deciphering non-arithmetic data, such as linguistic (Creswell & Clark, 2017). In the study, a quantitative approach was followed. That is; data about Eswatini pre-service teachers' acceptance of GeoGebra were collected using a questionnaire and were analysed using the software called the SmartPLS's partial least squares structural equation modeling.

4.3 Research Design

The research design refers to the overall approach that the researcher chooses to combine the various components of the study in a coherent and logical way, thereby ensuring that the research problem is addressed effectively; it is the blueprint for data collection, measurement and analysis (Creswell & Clark, 2017). This research followed a one-group pretest-posttest design. One-group pre-test design is a quasi-experimental research design in which the same dependent variable is evaluated before (pre or intelligence-test) and after (post-test) treatment in the same group of participants (Creswell, 2013). The researcher chose this research design because of its two main characteristics. The first feature is the use of one group of participants (that is, a one-group design). Participants in this group were third year pre-service teachers in the same department of the same college. These teacher trainees were doing their ultimate year at the college, and Circle Theorems is one of their core modules. They needed to go through the module to complete their diplomas. It was therefore difficult to choose a pre-service teacher to be in the control group. The researcher also felt that, since these trainees were at a similar setting, there would be contamination, that is pre-service teachers in the control group could use GeoGebra behind the back of the researcher. This was going to influence the outcomes of the enquiry.

The second feature is a linear order that requires an assessment of the dependent variable before and after treatment (that is, a pretest-posttest design). This feature allowed the researcher to assess the effects of GeoGebra on the performance of pre-service teachers in circle theorems. This design made it possible for the researcher to give Eswatini pre-service teachers a pre-test on circle theorems, expose them to GeoGebra, and then give them a post-test. The effect of GeoGebra on the performance of pre-service teachers was then assessed by using t test to find that there was a significant difference between their pre-test and post-test marks.

4.4 Research Approach

The study followed the one-group pretest-posttest design. An overview of the study design is presented in Figure 5.

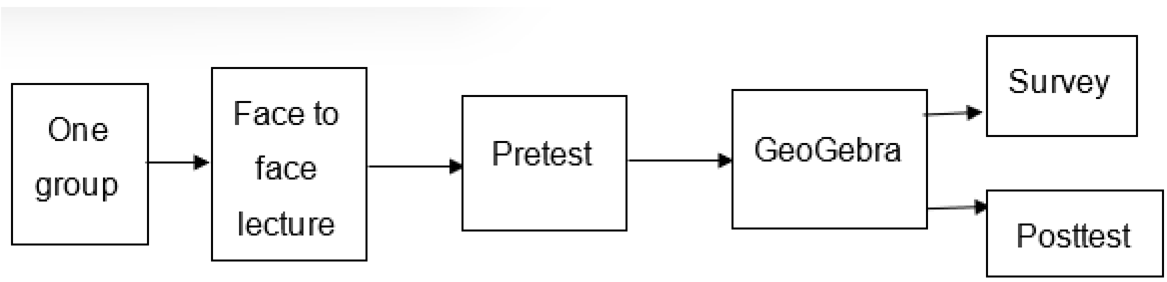

Figure 5 : Study design overview, Source: Researcher

As it can be seen from Figure 5, all the third year Mathematics and Computer Science pre-service teachers formed one group. They were then exposed to face-to-face lecture methods for two weeks, and they were given a pre-test. After the pre-test, they were then introduced to GeoGebra. The first two weeks were used to train pre-service teachers on how to use GeoGebra for learning circle theorems. Then the pre-service teachers were taught circle theorems for four weeks using GeoGebra. At the end of the fourth week, the pre-service teachers were then given a post-test and a questionnaire. The question papers of the pre and post-test were extracted from a past examination paper. These question papers were moderated before they were given to pre-service teachers. After the six weeks of GeoGebra exposure, the pre-service teachers were given a post-test and a questionnaire.

4.5 Rural Setting of a College in Eswatini

A rural school setting, such as the one under which the research was conducted, as defined by Atchoarena and Gasperini (2003, p. 21), is "an area located in a space where human settlement and infrastructure occupy only a small share of the landscape." It is a college, Atchoarena and Gasperini (2018, p. 21) add, within "a natural environment dominated by pastures, forests, mountains and deserts." For instance, the college in which this research was done, is time and again rocked by cattle, goats, chickens, and other domestic animals marking its rurality. Due to the college's geographical isolation the financially affordable Eswatini Mobile Network (commonly known as Swazi Mobile) is not operational within the college premises, such that students at this college struggle with researching their schoolwork using their smart phones under the Swazi Mobile network.

Even though the college has its own cable and wireless internet access, the internet is usually dysfunctional because the companies who installed and are responsible for maintaining it, are based in faraway cities, either Manzini or Mbabane – a distance over 100 kilometres. The only small and underdeveloped town near the college, about 5 kilometres away, is Nhlangano town. Hence, this is a vulnerable college found in a place where most people labour on farmlands, where the obtainability of land is comparatively of a diminished cost (Atchoarena & Gasperini, 2018, p. 21). In a rural college setting, such as the one in which the study was conducted, events are generally influenced by exorbitant operation costs that can be linked with extensive distance from cities, and inadequate public service (Gjelten, 2015, p. 1). As a result, researchers are not eager to conduct studies within such rural academic institutions, and this has probably left rural-based learners behind in terms of awareness of adaptive technologies that enhance cognition of circle theorems.

Gjelten (2015, p. 1) lists five types of rural school settings, namely: "stable rural school setting, depressed rural school setting, high growth rural school setting, reborn rural school setting, and isolated rural school setting." Each rural type has its own set of strengths and weaknesses, but to empower rural schools, equal educational opportunities, including material, and human, infrastructure should be established (Gjelten, 2015, p. 1). This rural-based college located at the Shiselweni district of Eswatini has on record lost human personnel transferring from the college to educational institutions located either in the Manzini, or Mbabane, city. Reasons for this out-migration include the remoteness of the college in terms of its geographical location and overall under-development. In some instances, educators decline posts in this college due to its secluded, and rural-based, location. Hence, the researcher targeted this rural-based college in the Shiselweni district of Eswatini because it has been avoided by other researchers. In the next section, adaptive technology for mathematics education in the context of a rural-based school of Eswatini is explained.

4.6 Population and Sampling

4.6.1 Population

The population of this research can be defined as pre-service teachers studying Circle Theorems in rural Eswatini Colleges and Universities. Based on the Ministry of Higher Education (2013), there are four teachers' colleges and universities in Eswatini. Three of these are in urban areas, while one is in a rural area (Ministry of Higher Education, 2013). Therefore, the populace of this study is all the pre-service teachers studying Circle Theorems at that rural teachers' training college in Eswatini.

4.6.2 Sampling

It then becomes essential that selecting the manner in which, and from which, information is obtained, is done with sound judgment, expressly because no analysis can compensate for data wrongly generated. Sekaran and Bougie (2016) described sampling as a procedure for picking an adequate number of facets from the populace. Sample is a principal practice, particularly when geographical boundaries, survey costs, or time limits, make it difficult, or impossible to survey the entire research population (Saunders, Lewis, & Thornhill, 2003). The entire population was used in the study since they were all studying at the same rural college in Eswatini. All the pre-service teachers at the rural teachers' college doing Circle Theorems were invited to participate in this study. The total number of pre-service teachers selected was 187.

According to Hair Jr, Hult, Ringle, and Sarstedt (2014), the minimum sample size for a formative partial least squares structural equation modeling should be 10 times the number of indicators of the construct with most indicators. The research consisted of eight independent variables, user satisfaction, perceived attitude towards, task-technology fit, system quality, compatibility, usage, perceived usefulness, and perceived ease of use. Perceived usefulness is the construct with most indicators that stood at five indicators. Following the recommendations of Hair Jr, Hult, et al. (2014), the minimum expected sample size for this study was 50. The actual sample size for this study was 187, which is far greater than 50.

4.7 Data Collection

In this step, the researcher gathered quantitative data which were analysed to address the research questions of the study. Proper preparation was essential to the achievement of consistent and reliable data. The data used were primary data, which were unique to the study.

For the collection of data, the study used questionnaires. Questionnaires are known to be the most used method for quantitative data collection (Creswell, 2013). Questionnaires are the most effective method for primary data collection when the number of respondents is relatively high (Creswell, 2013). Consequently, in the study, a survey was appropriate, as previous studies do not disclose details of the acceptance of GeoGebra by Eswatini pre-service teachers, and the sample size was 187, which is relatively large for this report. Questionnaires also have their limitations; for example, respondents respond falsely, do not answer all the questions, or simply misunderstand the question, and possibly the researcher could not be there to explain the questions.

Although there are drawbacks in the use of questionnaires, they were used in this study as a method for collecting quantitative data because they could produce the quantitative data that this study needed to address research issues. Although the respondents may misunderstand the questions, the presence of the researcher would not have influenced their answers.

Open-ended and closed-ended questionnaires are two types of questionnaires that can be used for data collection purposes. Fin (200) avers that open-ended questionnaires allow respondents to give answers in their own language. On the other hand, a list of the answers to be chosen from the questionnaire is given to the respondents in the closed-ended questionnaire (Saunders, Lewis, & Thornhill, 2009). This study used a closed-ended questionnaire, as respondents need minimal writing (Saunders & Lewis, 2012). For the respondents, it is simple, and it does not take them a lot of time to answer the questionnaire. In addition, questionnaires on the part of researchers are usually cheap to administer; and once completed, they can be easily and quickly analysed (Wilkinson & Birmingham, 2003). Structured questionnaires, which have been used, have enabled the researcher to obtain quantifiable data on the respondents' opinions on GeoGebra.

To avoid incorrect answers, the researcher gave clear, simple definitions of the main terms in the cover letter questionnaire. In addition, the cover letter explained the purpose of the study. Respondents were provided with contact details of the researcher in case they wanted some clarification.

4.7.1 Questionnaire Design

The questionnaires were designed to collect data on factors affecting Eswatini pre-service teachers' acceptance of GeoGebra. Data response rate, reliability, and data internal validity may be affected by the design of the questionnaire, as this stage is very critical for the data collection process

(Saunders et al., 2009). The creation of the questionnaire had to be subjected to several phases so that questions are understood by the respondent in the way the researcher wanted them to, and also, for the respondents' responses to be understood by the researcher in the manner the respondents wanted (Foddy, 1993). The quality of data gathered increases when the researcher and the respondents have a common interpretation of the questions on the questionnaire paper.

The first stage was to select questions to be included in the questionnaire. Three approaches that can be followed when designing a questionnaire are; modifying questions from previous related studies, accepting questions used in previous studies, and inventing own questions (Saunders et al., 2012). The questionnaire for this study has been modified from other researchers' instruments. Most of the questions used in this investigation have been adapted and modified to befit teacher trainees and the pastoral setting of the enquiry. Based on the assessment of Saunders et al. (2012, p. 431), which stated that "the adaptation of questions used in other questionnaires is more efficient," the researcher decided to adapt the questionnaire. Authors have been granted permission to adopt and modify questionnaires.

The next and second phase was to hand-pick a relevant question type. Several caveats were considered in choosing the appropriate questions. The second stage was to pick a suitable form of issue. In selecting the right questions, several caveats were taken into consideration. For example, the use of language that was too complex was avoided because of the rural setting of the study, questions that prompted the respondent to respond in a specific way were also avoided, and double-barrel questions (questions that ask more than one answer) were also avoided. For this research, the Likert-scale form of questions was found to be fitting, as it measured the feelings of pre-service teachers towards the use of GeoGebra for learning circle theorems. A seven-point Likert-scale was used in the study with strongly disagree as the lowest scale and strong consensus as the highest scale. In an agreement statement, where Eswatini pre-service teachers choose whether they agree or disagree with the statement using seven scale points, the questions were typed.

The third stage was the questionnaire's layout. Dillman and Smyth (2007) indicated that when designing a questionnaire, the general layout of the questionnaire, clear instructions, and question order, are very important. To decrease mistakes and non-response rates, simple instructions and definitions of key terms were written. The general questionnaire layout made it simple for pre-service teachers to read and respond to questions. In addition, Dillman and Smyth (2007) stated that there is a relationship between a good cover page and answer rate. The researcher developed questionnaire covering pages that clearly outlined and clarified the intent of the analysis, keyword meanings, the time taken to answer the questions in the questionnaire, the voluntary participation and confidentiality aspects of the data collected.

The questionnaire of Eswatini pre-service teachers (*See Appendix A*) was used to collect data on factors affecting Eswatini pre-service teachers to accept GeoGebra for learning circle theorems. Three sections comprise the questionnaires. A brief overview of the research and the aims and significance of the study is found in the first section (cover letter). The time required for the questionnaire to be completed was provided and key concepts were also defined. Section A included demographic data from Eswatini Pre-service Teachers. It collected data on demographic information from respondents and only questioned about demographics related to gender and education. Section B contained the questions which were adopted from previous research studies (Gharbawi & Bassam, 2016a; Mutambara & Bayaga, 2020a; Mutambara & Bayaga, 2020c) that asked respondents to provide their feeling and attitudes towards learning circle theorems using GeoGebra. The questionnaire (see Appendix A) presents the proposed latent variable, adapted measurement items for each latent variable and its references.

4.7.2 Piloting the Questionnaire

The researcher selected second year students to participate in the pilot study, whose majors were mathematics and computer sciences. Questionnaires, which were to be completed in two weeks, were given to all the second-year students. Three Ph. D holders from the University of Zululand were also chosen to be part of the pilot study. They were asked for input, and their input was considered and appropriate revisions to the questionnaire were made. A total of 57 valid questionnaires were collected. In view of the input, the researcher re-assessed the questionnaire, and the following improvements were made:

- Explanation of GeoGebra was provided.
- Explanation of what circle theorems are.
- Some of the statements on the questionnaire were re-worded.

Appendix A shows the questions that were used in the questionnaire and their sources.

4.7.2.1 Reliability of the Questionnaire

The composite reliability was used to assess the internal consistency reliability (CR) using SmartPSL3. Composite reliability assesses internal consistency reliability more precisely than the Cronbach alpha test (Hair et al., 2014). The CR values of BI, CL, CP, PEOU, PI, PU, QT, RL, TTF, USAT, and UT were 0.943, 0.922, 0.929, 0.900, 0.882, 0.901, 0.892, 0.910, 0.911, 0.952, and 09.44, respectively. The grey horizontal line in Figure 6 represent the threshold value of 0.7. All the bars on the graph represent the contract's' CR values. Figure 6 demonstrates that all CR (bars) values were higher than the threshold value of 0.70 (grey line) (Hair et al., 2017). This indicates that the average strength of connection among indicators of each latent variable in the model was strong. This means that each construct had internal consistency reliability of the model.

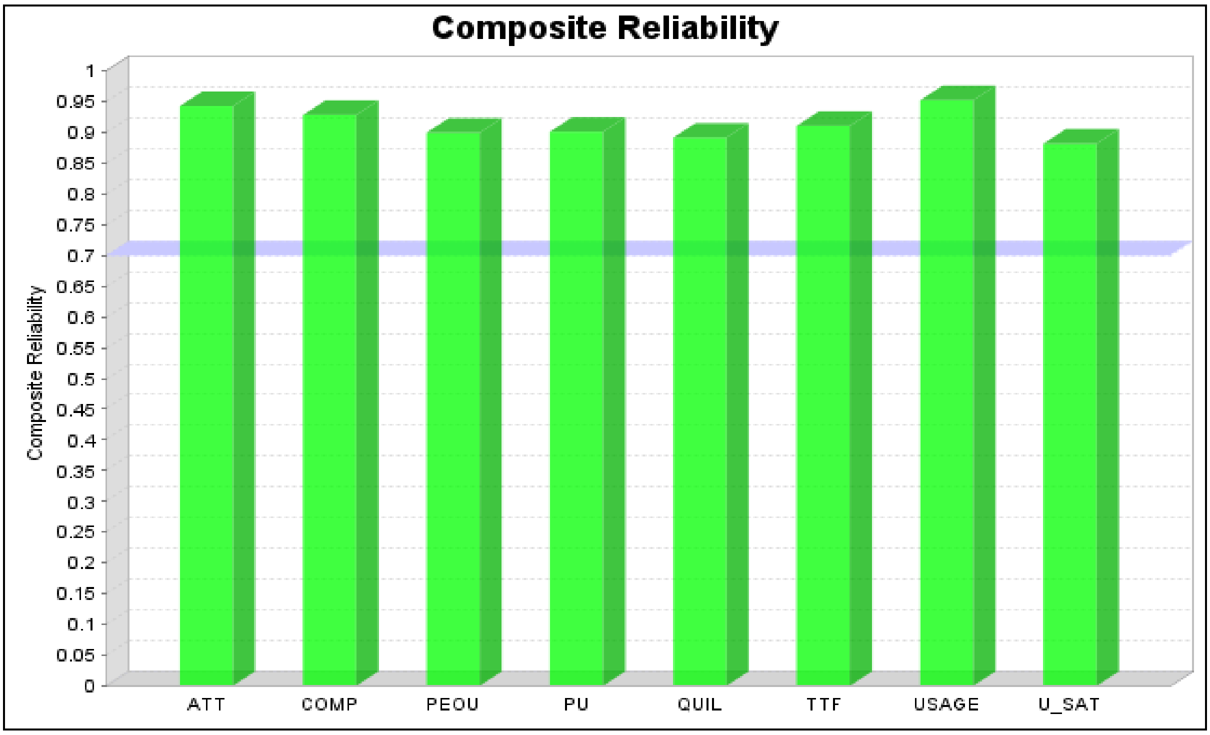

Figure 6 : Composite Reliability, Source: Researcher

4.7.2.2 Convergent Validity

The outer loadings and the average variance extracted (AVE) values are used to assess the convergent validity (Fornell & Larcker, 1994; Tabachnick, Fidell, & Ullman, 2007). Figure 7 showed that all the outer loadings of the measurement model were greater than 0.7, which suggests that less than (50%) of an item's variance was owing to error. The average variance extracted value was also used to access the convergent validity. According to Hair et al. (2017), constructs that have an AVE value of 0.5, or more, are considered to have adequate convergent validity. The AVE values of BI, CL, CP, PEOU, PI, PU, QT, RL, TTF, USAT, and UT were 0.805, 0.855, 0.876, 0.692,0.790, 0.696, 0.805, 0.836, 0.836, 0.801, and 0.894, respectively. The grey horizontal line in Figure 7 represent the cut-off value of 0.5. All the bars on the graph represent the contract's' AVE values. Figure 7 shows that all the AVE values were greater than the cut-off value of 0.5. These results means satisfactory convergent validity.

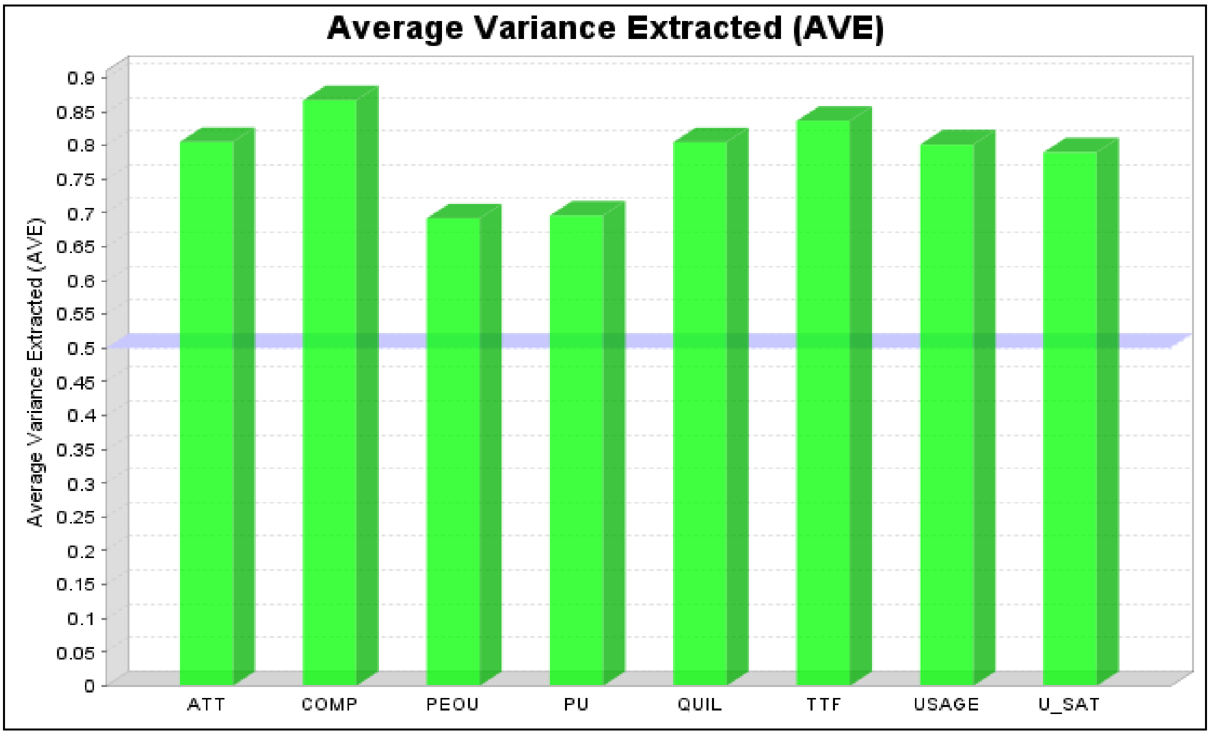

Figure 7 : Average Variance Extracted, Source: Researcher

4.7.2.3 Discriminant Validity

Discriminant validity was assessed using the Fornell-Larcker criterion. The results of the Fornell-Larcker criterion are shown in Table 2. The non-bolded numbers in Table 2 represent the inter-correlation value between constructs, and the bolded numbers in Table 2 represent the square roots of the AVE. The results show that the square root of each construct's AVE was greater than its highest correlation with any other construct. This shows that none of the inter-construct correlation values were greater than the square-root of the AVE and satisfied the Fornel-Larcker of the discriminant validity criterion (Hair et al., 2017; Tabachnick & Fidell, 2007) and indicated that all the constructs differed from each other. These results means that each construct was different from any other construct on the model. Additionally, each construct was measuring a different aspect of rural Eswatini pre-service teachers' acceptance of GeoGebra for circle theory learning.

Table 2 : Fornell-Larcker Criterion

	ATT	COMP	PEOU	PU	QUIL	TTF	USAGE	U_SAT
ATT	**0.897**							
COMP	0.195	**0.925**						
PEOU	0.680	0.158	**0.931**					
PU	0.427	0.118	0.512	**0.832**				
QUIL	0.383	0.273	0.229	0.167	**0.889**			
TTF	0.614	0.154	0.519	0.359	0.496	**0.834**		
USAGE	0.607	0.187	0.575	0.525	0.461	0.609	**0.897**	
U_SAT	0.381	0.719	0.289	0.125	0.324	0.352	0.331	**0.914**

4.8 Data Collection Procedure

This subsection provides details of how the researcher carried out the survey. The required adjustments to the questionnaire were made after the pilot test of the questionnaire, the research sample was selected, and the next step was to obtain access to the sample. The researcher applied for permission to conduct research from the principal of one of the teacher's colleges in Eswatini, and was granted verbal permission to conduct the study. The researcher then visited the respondents and set the dates for the survey to be administered, and the date for the completed questionnaires to be obtained.

The following ethical procedures were ensured by the researcher:

- Informed consent (*See appendix B*) accompanied each questionnaire.
- Respondents were informed of the purpose of the study.
- Respondents were informed that participation in the study was voluntary, and they could withdraw at any time.
- Respondents were also informed that all collected questionnaires would be treated confidentially and kept safe.
- Respondents were informed to remain anonymous.

4.9 Data Analysis

4.9.1 Structural Equation Modeling (SEM)

Structural equation modeling is a group of statistical models used to test theoretical models for a set of variables involving possible causal associations (Schumacker & Lomax, 2017). According to Schumacker and Lomax (2016, p. 2), SEM "uses different types of models to illustrate the relationship between the variables observed, with the same basic objective of providing a quantitative test of a theoretical model that is hypothesized by the researcher." The SEM is also defined as a multivariate technique combining aspects of factor analysis and multiple regression that allows the researcher to simultaneously examine a series of interdependent relationships between measured variables and latent constructs (variates) as well as between several latent constructs (Hair et al., 2014).

The SEM offers greater advantages when correctly implemented over the first generation of analysis techniques (factor analysis or multiple regression), since it allows the researcher to link data and theory (Chin, 1998). The SEM enables the investigator to 1) calculate model errors for observed variables; 2) construct non-observable (latent) variable; 3) model relationships between several independent variables and dependent variables; and 4) test a priori hypothesis statistically and measure empirical data assumptions.

There are two key methods for estimating relationships in a structural equation model, according to Hair et al. (2010) and Hair et al. (2014): component-based or variance-based approaches such as Partial Least Square (PLS-SEM) and co-variance-based approaches (CB-SEM). Both approaches have different underlying statistical assumptions (Gefen, Straub, & Boudreau, 2000). The two approaches also differ based on the existence of the fit statistics provided by them (Gefen et al., 2000). Each approach is consistent with a particular point of view of the analysis, and researchers need to consider differences in the implementation of the correct method (Hair et al., 2017). The PLS-SEM is used in exploratory research to establish hypothesis, while CB-SEM is used primarily to validate (or reject) theories (Hair et al., 2017). The advantages of CB-SEM are the disadvantages of PLS-SEM, and vice versa, therefore the two methods are considered dissimilar but harmonising numerical approaches for SEM (Hair et al., 2014).

To diminish the disparity between the sample covariance and those forecasted by the theoretical model, the CB-SEM applies the maximum likelihood function (Hair et al., 2017). The calculated parameters seek to replicate the covariance matrix of the observed values (Hair et al., 2017). The maximum likelihood function allows data to be disseminated ordinarily and the observations should be independent of each other (Chin, 1998; Hair Jr, Hult, et al., 2014). In contrast, PLS-SEM maximizes the covariance between the independent unobservable variable and the dependent unobservable variable (Sosik, Kahai, & Piovoso, 2009). According to Chin (1998), PLS uses the least square estimate for single and multi-component models and canonical correlations.

4.9.2 Rules of Thumb for Selecting CB-SEM or PLS-SEM

To decide which statistical approach is acceptable, the researcher must consider the assumptions underlying PLS-SEM and CB-SEM (Hair et al., 2012). The selection of these two SEM numerical methods can be made based on the research objective, the data attributes, the specification of the type of measurement model, the modeling of the structural model and the model evaluation (Hair et al., 2012; Hair et al., 2014). These five rules may be used to guide a researcher to choose between PLS-SEM and CB-SEM (Hair et al., 2014).

Firstly, the research objective should guide the researcher in the selection process between PLS-SEM and CB-SEM (Hair et al., 2014). The PLS-SEM is the appropriate method to be used in situations where the theory is less developed and the objective is to predict and explain the variance of key target constructs (Hair et al., 2012). The PLS-SEM uses the available data to "estimate the path relationship in the model to minimize the error of the endogenous constructs" (Hair et al., 2012, p. 14). The path model relationship in PLS-SEM maximizes the R-square values of the (target) dependent variables. Thus, when the research objective focuses on the advancement of theory and the interpretation of variance, PLS-SEM is the selected SEM method. On the other hand, CB-SEM, where the research target is to test or validate a theory, is the preferred process. This is based on the suggestion of Barclay, Higgins, and Thompson (1995), who stated that the ability to show how well a theoretical model fits the data observed is very important when testing theory.

Secondly, PLS-SEM can be used to evaluate a research model that is made up of both formative and reflective structures, according to Chin (1998). The PLS-SEM offers the investigator the versatility to apply either formative, reflective or reflective structures within the equivalent prototype (Hair et al., 2017). In addition, PLS-SEM can handle single-item constructs easily, with no identification issues. In comparison to CB-SEM, PLS-SEM can handle complex models with many constructs and many measurable variables with ease (Hair et al., 2017). In contrast, in CB-SEM, researchers are limited to reflective constructs only (Hair et al., 2017). Henseler, Ringle, and Sinkovics (2009) have stated that the use of CB-SEM formative constructs leads to identification problems.

Thirdly, PLS-SEM uses calibration mechanisms that modify any data that is not normally distributed to data that meets the central limit theorem, so that data normality is not a demand standard (Beebe, Pell, & Seasholtz, 1998). The CB-SEM, on the other hand, needs several assumptions to be met before further research can be carried out (Beebe et al., 1998; Hair et al., 2012). The CB-SEM assumptions that need to be fulfilled are: 1) normal multivariate data, 2) independence of observation and 3) uniformity of variable metrics (Hair et al., 2014; Sosik et al., 2009). In contrast to CB-SEM, PLS-SEM can also be used in situations where the sample size is relatively small, such as 10 times the number of items on the construct with the most items in the model.

Table 3 summarizes the rules of thumb when choosing between CB-SEM and PLS-SEM. As a result, the current PLS-SEM study was used as an analytical technique in this study based on the above-mentioned thumb rules.

Table 3 : Thumb Rules between the CB-SEM and the PLS-SEM selections

Criteria to evaluate		CB-SEM	PLS-SEM	This study
1	**Research goal**			
	i. Predicting key target constructs		√	√
	ii. Theory testing, theory confirmation or comparison of alternative theories	√		
	iii. Exploration of an extension of an existing structural theory		√	√
2	**Measurement model specification**			
	i. If formative constructs are part of the structural model		√	√
	ii. If error terms require additional specification such as co-variation	√		√
3	**Structural model**			
	i. If a structural model is complex		√	√
	ii. If a structural model is non-recursive	√		
4	**Data characteristics and algorithm**			
	i. Data meet distributional assumptions	√	√	√
	ii. Data did not meet distributional assumptions		√	√
	iii. Small sample size consideration		√	√
	iv. Large sample size consideration	√	√	
	v. Non-normal distribution		√	√
	vi. Normal distribution	√	√	
5	**Model evaluation**			
	i. Use latent variable scores in subsequent analyses		√	√
	ii. Requires global goodness of fit criterion	√		
	iii. Need to test for measurement model invariance	√		

4.9.3 Justification for Using PLS-SEM

The PLS-SEM is the appropriate method to be used in instances where the hypothesis is less formed, with the aim of predicting and explaining the variance of the main endogenous variable (Hair et al., 2012). The PLS-SEM was appropriate for the study as it seeks used TTF to expand the TAM to develop and evaluate a new model that can be used to predict the acceptance of GeoGebra for circle theorem learning by Eswatini pre-service teachers.

The PLS-SEM works effectively with limited sample sizes, such as 10 times the number of indicators of a construct with most indicators, complex models, and no data distribution assumptions are required (Vinzi, Chin, Henseler, & Wang, 2010). The CB-SEM compels a least sample size of 200.

(Lacobucci, 2010). There were 187 pre-service teachers studying circle theorems at the teacher's college chosen for this investigation. The total number of potential respondents at the teacher's college was less than the 200 required for using the CB-SEM. In addition, there are 10 latent variables and 27 hypotheses in the proposed model, making it more complex. In this case, PLS-SEM was used because it deals better with complex models, more than CB-SEM does. In addition, the information to be used in this analysis is not normally distributed, and therefore PLS-SEM was preferred over CB-SEM.

The focus of the present enquiry was to judge the relationship between constructs based on prior theoretical knowledge. The PLS-SEM's ability to approximate the relations between residuals and evaluate their influence on the prototype adjudicates this technique ultimate and supreme (Hair et al., 2017). In estimating parameters, PLS-SEM is very efficient, resulting in high levels of statistical power (Garson, 2016). Greater statistical power means that PLS-SEM is likely to establish a particular and meaningful relationship when it actually exists for the population (Hair et al., 2014).

Several software packages, including but not limited to PLS-Graph (Chin & Frye, 2003), LVPLS (Lohmoller, 1988), VisualPLS (Lohmoller, 1988), PLS-GUI (LI, 2005), and SmartPLS 3, have been developed for PLS-SEM (Hair et al. 2014). In the study, all PLS-SEM analyses were performed using the SmartPLS 3 software.

4.10 Evaluating Measurement and Structural Models Using Partial Least Square

In this research, the two-step method suggested by Hair et al. (2014) was used to evaluate the research model. Firstly, the measurement (outer) model was assessed to ascertain the validity and reliability (Urbach & Ahlemann, 2010). The second step involved the assessment of the structural (inner) model. This was done to determine whether the model meets the quality criteria for empirical work (Urbach & Ahlemann, 2010). The following subsections discuss the guidelines used in this study to assess both the measurement model and the structural model.

4.10.1 Evaluating Measurement Model

The measurement prototype institutes the correlation between constructs with their indicators (Mutambara & Bayaga, 2020a). The validation of a reflective measurement model can be accomplished by checking its convergent validity, internal consistency, reliability of the indicator, and validity of discriminants (Hair et al. (2017).

4.10.1.1 Internal Consistency

Cronbach's alpha (CA) is historically used to test the internal consistency of the outer object (Hair et al., 2014). The CA provides a reliability estimate dependent on the inter-correlations of item variables observed (Hair et al., 2017). Hair et al. (2014) stressed that the CA insists that all items are equally reliable. The CA has some drawbacks in that it is responsive to the number of metrics on the scale and underestimates the reliability of internal consistency. Composite reliability (CR) is a preferable substitute to Cronbach's alpha because of CA's weaknesses (Hair et al., 2014). Composite reliability can result in greater approximations of valid reliability contrasted with Cronbach's alpha (Garson, 2016).

Like CA, the CR ranges between 0 and 1. Higher CR values indicate a higher level of reliability. The CR is interpreted in the same way as the CA. The acceptable cut-off 0.7 is considered to be satisfactory (Nunally & Bernstein, 1994). Composite reliability values of 0.6 to 0.7 are, however, acceptable in exploratory research (Chin, 1998; Hair et al., 2014).

4.10.1.2 Indicator Reliability

To assess the extent to which the variable or set of variables is consistent with what it intends to measure, the reliability of the indicators is used (Urbach & Ahlemann, 2010). The construct reliability is independent of and calculated separately from other constructs. According to Chin (1998), the outer loadings should be greater than 0.7 and the outer loadings of an indicator should be significant at a level of 0.05. According to Chin (1998) and Hensler et al. (2009), a hypothesis ought to explicate at least (50%) of the variance of their respective indicator, and Garson (2016) suggests that it is the level at which the explained variance is greater than the error variance. The significance of outer loadings can be verified using a re-sampling method, such as bootstrapping or jack-knifing (Hair et al., 2014). Indicators whose loads are less than 0.7 are normally removed. However, according to Hensler et al. (2009), a researcher should be careful when deciding to delete an item, considering the PLS consistency characteristics at large.

4.10.1.3 Convergent Validity

According to Mutambara and Bayaga (2020a), convergent validity measures the intensity to which there is a great correlation between the latent variables which are theoretically identical. Convergent validity was also defined by Hair et al. (2014, p. 102) as “the extent to which a measure correlates positively with alternative measures of the same construct.” To evaluate the convergent validity, the average variance extracted (AVE) and the outer loadings of the indicators are used (Hair et al., 2014). Fornell and Larcker (1981) posit that an AVE value of at least 0.5 and a loading factor of at least 0.7 suggest adequate convergent validity. The outer load indicators below 0.4 need to be detached from the model (Hair et al., 2011). Items with exterior loadings in the range of 0.4 and 0.7 are contenders for exclusion from the model. They can, however, be removed only if their exclusion increases the reliability of the composite to above 0.7 or the AVE to above 0.5. (Hair et al., 2017). Indicators with outer loadings less than 0.7 may also be returned due to their contribution to the content validity. The indicator deletion recommendations based on outer loadings are shown in Figure 8. The elimination of indicators has been carefully performed since the exclusion of items may aggravate the discriminant validity or reliability but at the same time reduce the validity of the measurement scale.

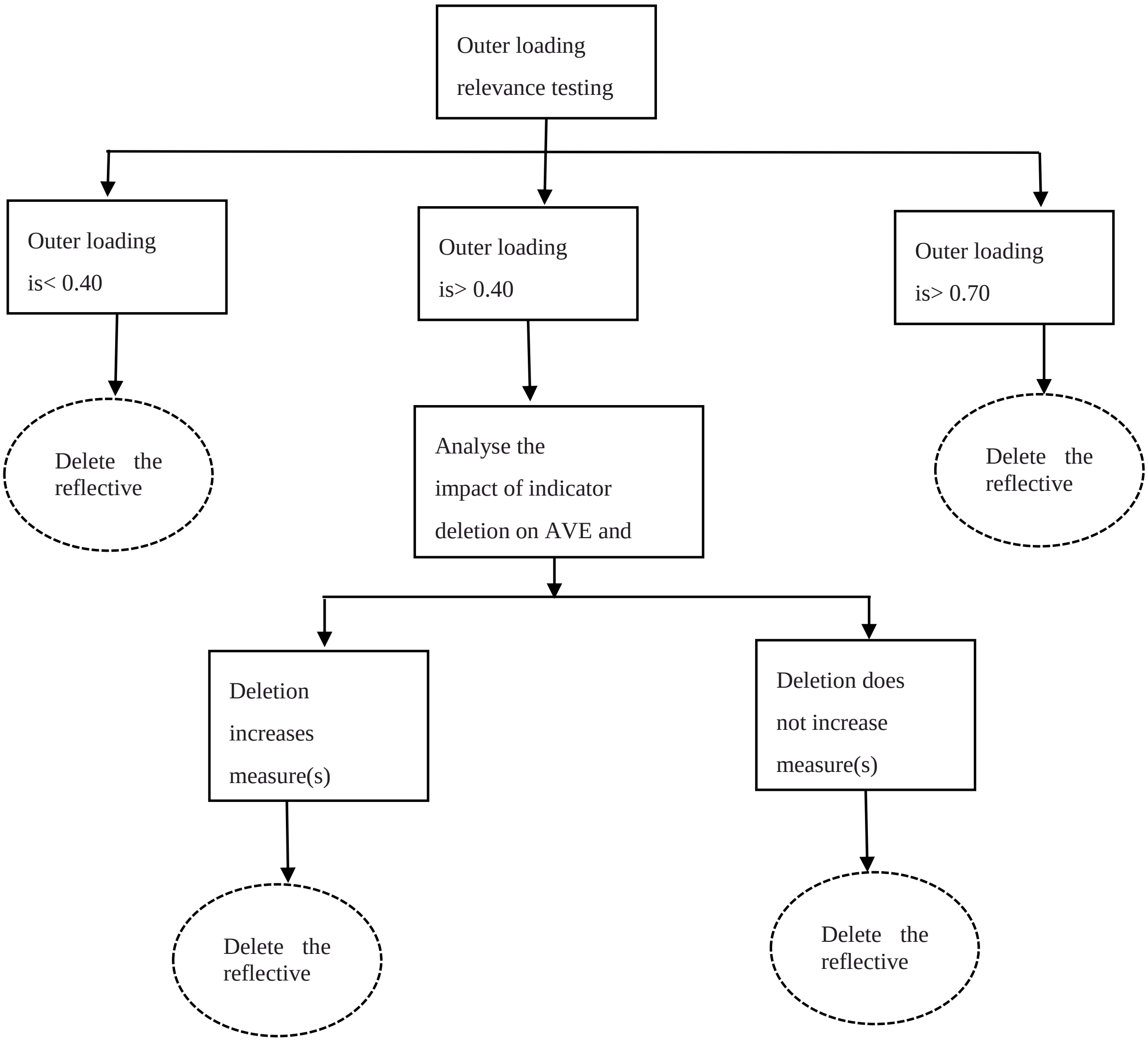

Figure 8 : Outer Loading Relevance Testing

Adapted from Hair et al. (2014, p 114)

4.10.1.4 Discriminant Validity

Discriminant validity "…is the extent to which a construct is truly distinct from other constructs by empirical standards." (Hair et al., 2014, p 10.4). Mutambara and Bayaga (2020) noted that discriminant validity assesses the degree to which a construct differs from other constructs. Thus, establishing discriminant validity indicates that the construct is different from the others and that it is the only construct in the model that captures that phenomenon. The cross-loading, the Fornell-Larcker criterion and the Heterotrait-monotrait ratio (HTMT) are the three criteria for assessing discriminant validity (Garson, 2016; Hair et al., 2014).

4.10.1.4.1 Cross-Loading

Cross-loading is achieved by correlating the score of each component with all other indicators (Chin, 1998). Discriminant structure is achieved if the indicator loads more than its load with all other constructs in its associated construct. The outer loading of the indicator on the associated construct must be greater than any of its cross-loadings on other constructs.

4.10.1.4.2 Fornell-Larcker's Criterion

Using the Fornell-Larcker criterion, the latent variable must share more variance with its assigned indicators than with any other latent variable (Hair et al., 2014). The square root of the average variance extracted should therefore be larger than its correlation with any other construct. In SmartPLS 3 output, the Fornell-Larcker criterion table, the square root of AVE appears in the diagonal cells and correlations appear below it (Hair et al., 2014). Consequently, if the number on the top of each factor column is greater than the numbers under it, discriminant validity is attained.

4.10.1.4.3 Heterotrait-Monotrait Ratio (HTMT)

The Fornell-Larcker criterion and cross-loading are generally accepted methods for determining the validity of the discriminants. However, the SmartPLS 3 documentation noted that there were deficiencies in the Fornell-Larcker criterion and cross-loading. The HTMT ratio is the preferred measure for discriminatory validity (Henseler et al., 2015). According to Hensel, Ringle, and Sarstedt (2015), the HTMT value below 0.90 indicates that discriminatory validity has been established. Gold, Malhotra, and Segars (2001) also use 0.90 cut-offs, although some researchers (Garson, 2016; Hair Jr, Hult, Ringle, & Sarstedt, 2016) use a more rigorous 0.85 cut-off. Table 4 summarizes the guidelines used to assess the reliability and validity of the reflective outer model.

Table 4 : Guidelines for Assessing Reflective Measurement Model

Validity Type	Criterion	Guidelines
Internal consistency	Cronbach's alpha test	CA greater than 0.7
	Composite reliability	CR greater than 0.6 (for exploratory study) CR greater than 0.8 (advance research) CR greater than 0.6—lack of reliability
Indicator reliability	Indicator loadings	Item's loading greater than 0.7 and significant at least at the 0.05 level
Convergent validity	AVE	AVE greater than 0.50
Discriminant validity	Cross loading	Item's loading of each indicator is highest for its designated construct.
	Fornell and Larcker	The square root of the AVE of a construct should be greater than the correlations between the construct and other constructs in the mode
	Heterotrait-monotrait ratio	HTMT less than 0.9

4.10.2 Structural Model

The second step, after the measurement model has been established to be valid and reliable, is to evaluate the structural model (Mutambara & Bayaga, 2020). Validation of the results of the structural model helps the researcher determine how well empirical data support the theory. In addition, assessing the structural model also helps to determine whether the theory has been empirically confirmed (Hair et al., 2014). The systematic approach used to assess the structural model is shown in

Figure 9.

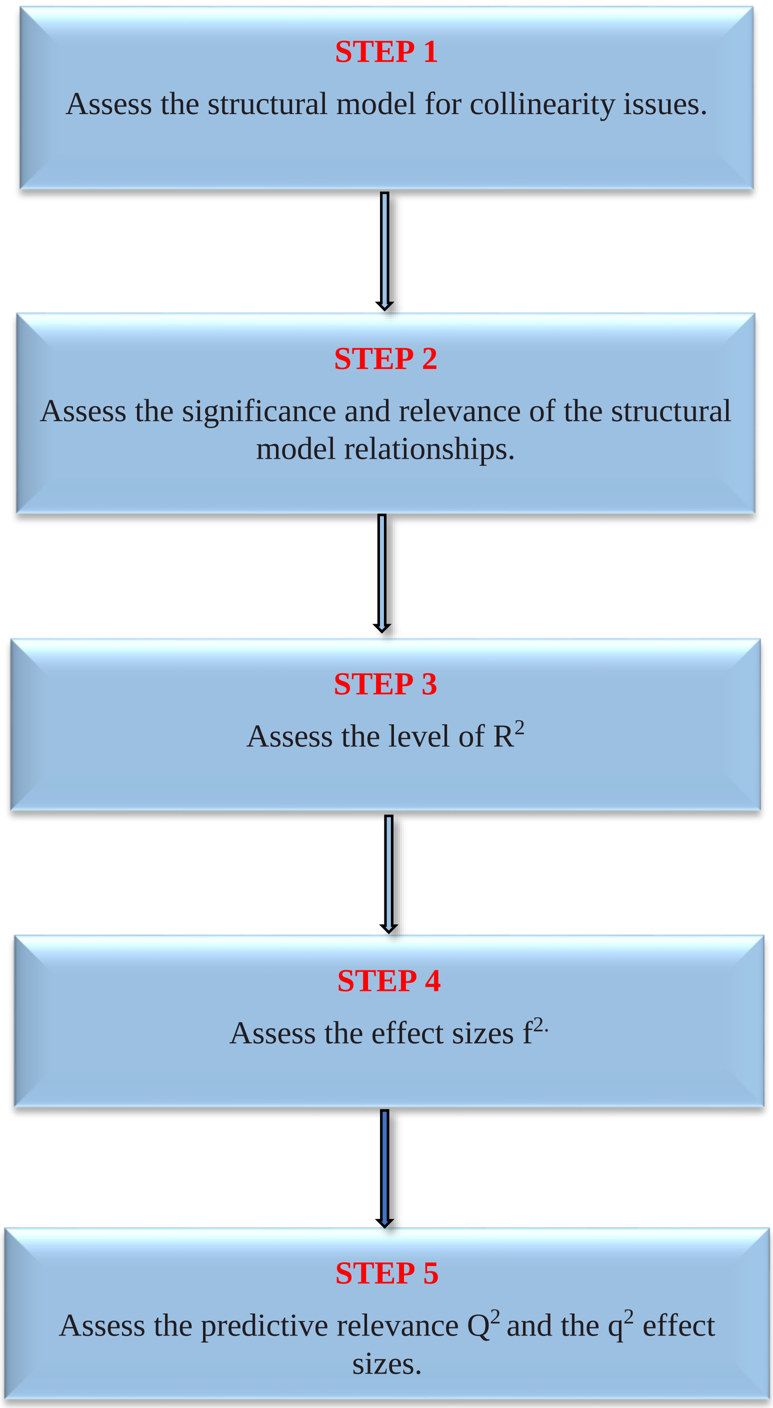

Figure 9 : Structural Model Assessment Procedure

Source: Adapted from Hair et al. (2014, p. 114)

4.10.2.1 Multicollinearity in Reflective Models

When two or more exogenous variables are closely interrelated, there is multicollinearity (Garson, 2016). Multicollinearity increases the standard errors in PLS-SEM and prevents the researcher from determining the relative significance of one exogenous variable compared to another (Hair et al., 2014). The basic rule is that the coefficient of variance inflation factor (VIF) of less than 4.0 shows that there are no problems with multicollinearity according to Garson (2016). However, researchers such as Hair et al. (2014) use a more lenient 5.0 cut-off.

4.10.2.2 Step 2: Structural Model Path Coefficients

The PLS-SEM algorithm is used to obtain a structural model relationship (path coefficient). These path coefficients are the hypothesized relationship between the latent variables. The standardized values for the path coefficient are between -1 and +1. A standardized path coefficient close to 1 indicates strong positive relationships (and the opposite is true for negative values) that are almost always statistically significant (Hair et al., 2017). The closer the path coefficient to 0, the weaker the relationship, and it is usually insignificant. A bootstrapping method has been used to determine whether a path is significant. The minimum number of subsamples for a bootstrap should be 5.000 (Hair et al., 2014). The widely used critical values for two-tailed tests, according to Hair et al. (2014), are 1 .65 (significance level = 10%), 1.96 (significance level = 5 %) and 2.57 (significance level = 1%). Due to its exploratory nature, this study assumes a significant level of (10%) (Hair et al., 2014).

4.10.2.3 Coefficient of Determination (R-squared value)

The coefficient of determination (R-squared value) is the common measure used to evaluate the structural model. The R-square coefficient is a measure of the predictive precision of the model and describes the cummulative effects of the exogenous variables on the endogenous variable. The results above the 0.19, 0.33 and 0.67 cut-offs are considered to be "*weak*" " *moderate*" and "*substantial"* according to Chin (1998) and Rouf and Akhtaruddin (2018).

4.10.2.4 Step 4: Effect Size f-squared

The R-square change effect is also known as the f-square effect size. The effect of removing an exogenous variable on the R-square value is demonstrated by the f-square equation. Hair et al. (2014) declared that the R-squared shows the contribution of the exogenous variable on the R-squared value. According to Garson (2016), the f-square values of 0.02, 0.15 and 0.35, respectively represent a small, medium and high effect of the exogenous latent variable.

4.10.2.5 Step 5: Blindfolding and Predictive Relevance Q-squared

In Smart PLS 3, the cross-validated redundancy for a reflectively model endogenous factor is the Stone-Gleisser Q- squared value (Garson, 2014; Hair et al., 2014). The cross-validated redundancy was used in this study to assess predictive relevance (Q- squared). The Q-square value above 0 indicates that the model is relevant for predicting that factor.

4.10.3 Multigroup Analysis

Section 5.6.2.1 to 5.6.2.5 gives insights on how the structural model of the study was evaluated. This section continues by giving insights about how multigroup analysis was used to assess, if there was a significant difference between male and female pre-service teachers' acceptance of GeoGebra for circle theorems. The parametric and the Welch-Satterthwait tests were used in this study. The parametric test assumes that the groups have equal variances, whereas the Welch-Satterthwait test assumes that the groups have unequal variances between the groups. These two tests will determine whether there is a significant difference between the two groups by comparing the path coefficients of these groups. The test finds that the difference is significant if the p-value is less than 0.05 or greater than 0.95 for the difference in the group-specific path coefficients (Hair et al., 2017).

4.11 Ethical Consideration

To confirm that the research complies with the University research ethics, the researcher was given an ethical clearance-Certificate (See appendix C) by the University of Zululand research ethics committee (UZREC). The investigator sought for approval to perform the study at one of the teachers' colleges in Eswatini. Verbal approval was given by the principal (See Appendix B).

A letter of consent detailing the study purpose; the approximate period of the participants' participation; the procedures used in the study; the right of participants to decline to partake; and the right to instantaneously retract contribution and the consequences of the withdrawal were given to the participants (See Appendix E).

Participants were also made aware of the study advantages and the secrecy of the amassed data. The data were gathered anonymously from the participants and no personal information was requested that could be used to identify the participants. Finally, all the data gathered from the participants was handled confidentially and was only used for the analysis.

In order to ensure the creditability of the results, the researchers used "tactics to help ensure honest informants when contributing data" (Shenton, 2004, p. 13). The researcher made sure that data were collected from enthusiastic participants. The researcher also inspired the respondents to be honest and reported as accurately as possible the findings of the study, without suppressing, falsifying, or inventing them to satisfy the researcher's needs.

4.12 Summary

This chapter addressed the methods and techniques that were used in this report. The chapter explained that positivism is the fundamental research theory. The ontological, epistemological, axiological, logical and methodological positions of the study and research design were also addressed in the chapter.

Thereafter, the population, sampling procedures and sample size of the analysis after the design of the research were outlined. The subsection of the data collection process then followed, and the instrumentation questionnaire and the reliability review of the instrument were discussed. Quantitative data analysis was used and then addressed in the research. In conclusion, the report dealt with the ethical issues.

CHAPTER FIVE
DATA ANALYSIS AND RESULTS

5.1 Introduction

The previous chapter presented how data were collected and analysed. Data evaluation and outcomes are given in this chapter, and the tools for analysis employed embody frequencies, descriptive statistics, t-test, and structural equation modeling. On the one hand, International Business Machines Corporation Statistical Package for the Social Sciences, version 25 (IBM SPSS25) was used in analysing the descriptive statistics, frequencies, and t-test. On the other hand, Structural Equation Modeling was conducted using a path modeling software called Smart PLS 3. After this introduction, section 5.2 expounds the screening of the data with essential statistical techniques and the output, such as missing data treatment, outlier examination, normality, and data screening. Using the screened data, section 5.3 gives the descriptive statistics of the respondents' demographic characteristics. The descriptive statistics of the instrument were presented in section 5.4. Section 5.5 explains the inferential analysis through Partial Least Squares (PLS) and presents the reliability and validity of the instrument and ultimately, outcomes of the t-test are accessible in section 5.6.

5.2 Data Preparation

Data preparation is the first stage of data analysis that comprises editing, coding, and data entry. According to Cooper, Schindler, and Sun (2006), data preparation ensures that the process of converting raw data to forms that are suitable for analysis is done accurately. The following sections describe coding, editing, assessment of outliers, and normality test.

5.2.1 Coding

Coding is the process of allocating numbers to the response of the respondents (Cooper and Schindler (2011); Action, Miller, Maltby & Fullerton, 2009). This technique was done to ensure that the responses provided by respondents are grouped into a limited number of categories. Both pre-coding and post-coding were used in this thesis. Hair Jr, Sarstedt, Hopkins, and Kuppelwieser (2014) describe pre-coding as the process of assigning code during the questionnaire design. In this thesis, all the questions used a 7-point Likert scale with the categories (1) strongly disagree, (2) disagree, (3) somewhat disagree (4) neutral (5) somewhat agree, (6) agree, and (7) strongly agree. This study used the 7-point Likert scale because it provides more varieties of options which in turn increase the probability of meeting the objective reality of people (Joshi, Kale, Chandel, & Pal, 2015). The 7-point Likert scale was also used in similar studies (Adhikari, 2021; Mutambara & Bayaga, 2020a). These codes were allocated during the design of the questionnaire. Post-coding, demographics regarding the present investigation, was done when the data has already been collected from the respondents. For example, the item male on the questionnaire was allocated code 1 after respondents had already provided their responses.

5.2.2 Editing

Editing ensures that data are captured correctly, accurately, consistently, and to ensure that there is no missing data (Cooper and Schindler (2011)). All entries with missing data were deleted from the data. This was critical following the suggestion by Cooper and Schindler (2011), who stated that deleting missing data entries minimises the risk of deleting certain groups of respondents. For the study, data entries that were removed, because of missing data, totalled 21. Furthermore, three more data entries were removed because the respondent provided the same answer for all the questions (for example, answered 7 for all questions). Therefore, a total of 24 data entries were removed and the stored data file for the study had a total of 255 data entries.

5.2.3 Assessment of Outliers

A value that is well above or below the rest of other cases is called an outlier (Pallani, 2010). In this study, the Statistical Package for Social Sciences' (SPSS), Mahalanobis distance was used to check for outliers. Using SPSS software, a new variable (mah_1) was created and a mah_1 value for each entry was created. This mah_1 for each entry was compared to the critical value. A mah_1 value greater than the critical value is considered an outlier (Pallani, 2010). In this study, five cases out of 187 were outliers, and were removed from the data. Hence, a data source with 182 data entries was created and saved as a comma-separated values (.csv) file which is a Microsoft excel format used by SmartPLS 3 software to analyse data.

5.2.4 Normality Test

To assess the normality of the data set, skewness and kurtosis measures were used. Kurtosis and skewness are the two main indicators of univariate normality, which refers to the shape of the distribution, and are used with both interval and ratio scale data. Exactly normal distributions have zero values for both kurtosis and skewness (Cooper & Schindler, 2011). Positive skewness indicates a greater number of smaller values, whereas a positive value for kurtosis indicates a distribution that is more peaked than normal. Negative values for skewness indicate a greater number of larger values and for kurtosis, a flatter distribution. Descriptive statistics were also inspected for signs of normality violations. The skewness value should be between -3 and +3 (Pallani, 2010). The results in Table 5 showed that ATT1, USAT 1, PR2, and DGI1 presented skewness above the acceptable threshold of -3 to +3 (Brace, Snelgar, & Kemp, 2016). Most of the kurtosis values were larger than the limit value of 3 (Brace, Snelgar, & Kemp, 2012). Therefore, the data did not follow the normal distribution curve, and thus additionally justifying the use of PLS-SEM.

Table 5 : Descriptive Statistics of the Instrument

Construct	Indicator	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
							Statistic	Std. Error	Statistic	Std. Error
User satisfaction	U SAT1	182	1	7	5.810	1.492	-1.232	0.456	2.322	0.223
	U_SAT2	182	2	7	5.840	1.224	-2.312	0.356	4.253	0.121
System Quality	QUIL1	182	1	7	5.880	1.264	-2.258	0.231	6.252	0.253
	QUIL2	182	1	7	5.790	1.192	-2.354	0.232	3.254	0.212
Perceived Usefulness	PU1	182	1	7	4.960	1.978	-2.254	0.42	5.485	0.233
	PU2	182	1	7	4.820	1.906	-0.214	0.125	5.623	0.235
	PU3	182	2	7	4.810	1.993	-2.365	0.251	6.255	0.124
	PU4	182	1	7	4.900	2.049	-1.212	0.243	3.221	0.235
	PU5	182	1	7	5.260	1.786	-2.412	0.214	6.325	0.214
Perceived Ease of Use	PEOU1	182	1	7	5.090	1.968	-2.321	0.235	4.256	0.222
	PEOU2	182	1	7	4.900	2.050	-1.245	0.255	3.245	0.215
	PEOU3	182	1	7	4.880	1.969	-2.214	0.235	7.215	0.235
	PEOU4	182	1	7	5.260	1.786	-2.412	0.214	6.325	0.214
	PEOU5	182	2	6	4.630	1.976	-0.245	0.124	8.632	0.254
Task Technological Fitness	TTF1	182	1	5	4.710	1.884	-1.142	0.246	-0.241	0.231
	TTF2	182	1	7	5.000	1.900	0.214	0.235	-1.258	0.214
	ATT2	182	1	7	4.900	2.050	-1.245	0.255	3.245	0.215
	ATT3	182	1	7	4.740	1.905	-1.242	0.365	2.321	0.145
	ATT4	182	1	7	4.680	1.966	-2.312	0.245	3.214	0.021
User Satisfaction	USAGE1	182	1	7	4.600	2.038	-3.210	0.412	3.254	0.142
	USAGE2	182	1	7	4.570	2.111	-2.321	0.221	2.212	0.256
	USAGE3	182	1	7	4.700	2.095	1.241	0.332	3.254	0.321
	USAGE4	182	1	6	4.230	2.142	-1.224	0.255	6.254	0.212
	USAGE5	182	1	7	4.320	1.241	-2.312	0.445	2.352	0.214

5.3 Descriptive Statistics

5.3.1 Gender

The majority participants in the study were female with (53 %) (a total of 96) of the partakers, whereas the males only tallied (47%) (a total of 86) of the data. Figure 10 shows the gender distribution in a bar graph.

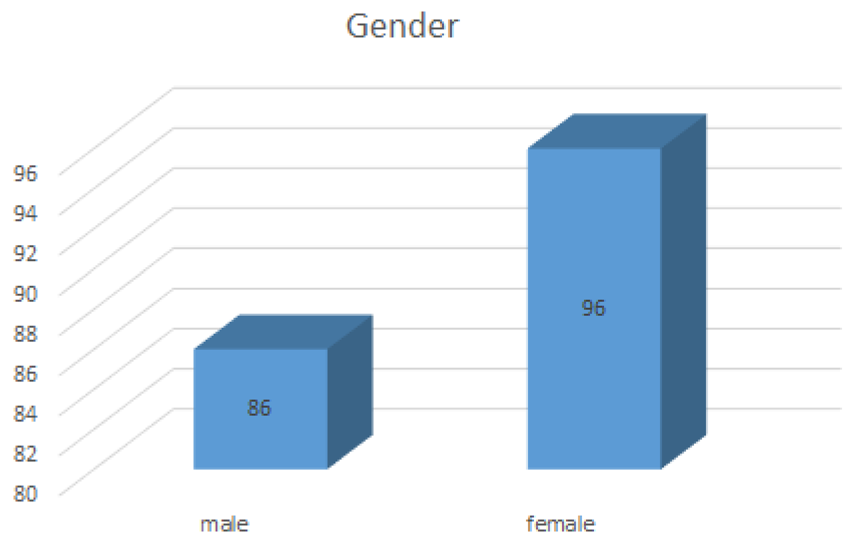

Figure 10 : Distribution of Gender, Source: Researcher

5.4 Descriptive Statistics of the Instrument

Using SPSS version 25, standard deviation, minimum value, the mean and maximum value of each indicator were assessed. The standard deviation is a measure of a dataset's average variability (Brace et al., 2012). It tells how far each number deviates from the mean. The descriptive statistics of all indicators are shown in **Error! Reference source not found.**.

5.5 Analysis and Results of the PLS Approach

SmartPLS 3 was used to test the hypotheses developed in chapter 3. A two-phase tactic evaluation model founded by Hair et al., (2017) was followed in assessing the overall model fit. The measurement model was assessed first, followed by the structural model which establishes the relationship between constructs and their respective indicators (Hair et al., 2017). Moreover, the quality of constructs to determine if they can be included in the structural model was evaluated by the measurement model. The indicator reliability, internal consistency, convergent validity, and discriminant validity are used to evaluate the measurement model (Garson, 2016). Once the quality of the outer model achieved the satisfactory standard as illustrated in Section 4.7.1, the structural model was then assessed. Secondly, the structural model assesses and establishes relationships among the constructs (Hair et al.., 2017). Relationships within the structural model were assessed by testing for their significance, expounded variance of the endogenic variables, effect size, and extrapolative power of the diverse variables (Hair et al., (2017) (see 4.7.2).

5.5.1 Measurement Model

To answer objectives 2, 3, and 4 adequately, a hypothetical model, which was evaluated using SmartPLS 3, was formed in chapter 3. The PLS-SEM's objective is to maximize the covariance between the exogenous latent variables and the endogenous latent variable (Hair et al., 2017). The main function PLS-SEM is the extrapolation of the endogenic variable; and in this case, rural-based Eswatini pre-service teachers' user satisfaction to use GeoGebra as adaptive technology in the cognition of circle theorems. Following the suggestions by Garson (2016), the measurement model's adequacy was assessed by looking at internal consistency reliability, indicator reliability, convergent validity, and discriminant validity.

5.5.1.1 Indicator Reliability

Consider this suggestion: According to Hair et al., (2014) the outer loadings are used to assess the indicator reliability and an indicator is considered reliable if its outer loading is greater than the cut-off value of 0.7. However, before the removal of indicators with loadings lower than 0.70, their potential practical significance was closely investigated (see Section 4.7.1.2). Indicators were removed if their removal increased the composite reliability and average variance extracted above their cut-off values. Table 6 shows that all the indicators used in this study were having outer loadings values above 0.7, indicating acceptable indicator reliability.

Based on the 0.7 rule of thumb (Hair et al., 2014), an iterative assessment of outer loadings was done using the SmartPLS 3 software. All the indicators with measurement loadings of less than 0.7 were removed one after the other consequent to each run. The indicators which were removed from the model were PU5 (-0.715), PU (0.321), QUAL3 (0.121), TTF (0.341), and TTF (0.332).

Table 6 : Indicator Reliability

Construct	Indicator	loadings
ATT	ATT1	0.868
	ATT2	0.885
	ATT3	0.918
	ATT4	0.916
COMP	COMP1	0.938
	COMP2	0.923
PEOU	PEOU1	0.846
	PEOU2	0.853
	PEOU3	0.833
	PEOU4	0.795
PU	PU1	0.759
	PU2	0.796
	PU3	0.890
	PU4	0.885
QUIL	QUIL1	0.909
	QUIL2	0.885
TTF	TTF1	0.910
	TTF2	0.919
USAGE	USAGE1	0.930
	USAGE2	0.756
	USAGE3	0.934
	USAGE4	0.906
	USAGE5	0.937
U_SAT	U_SAT1	0.829
	U_SAT2	0.945

5.5.1.2 Internal Consistency Reliability

The composite reliability and Cronbach’s alpha tests can be used to assess the internal consistency reliability of the model (Hair et al., 2017). On the one hand, the Cronbach's alpha test underestimates internal consistency, while on the other hand, composite reliability gives a more accurate estimate than the Cronbach’s alpha test (Hair et al., 2017). In this study, both the Cronbach’s alpha test and the composite reliability were used to assess internal consistency reliability. The composite reliability and Cronbach's alpha values of each construct should be greater than the threshold value of 0.7 (Hair et al., 2017). Figure 11 shows the results of Cronbach's alpha test. The grey horizontal line in Figure 11 represent the cut-off value of 0.7. All the bars on the graph represent the contract's' Cronbach's alpha values. Figure 7 shows that all the AVE values were greater than the cut-off value of 0.7. These results demonstrate acceptable internal consistency reliability.

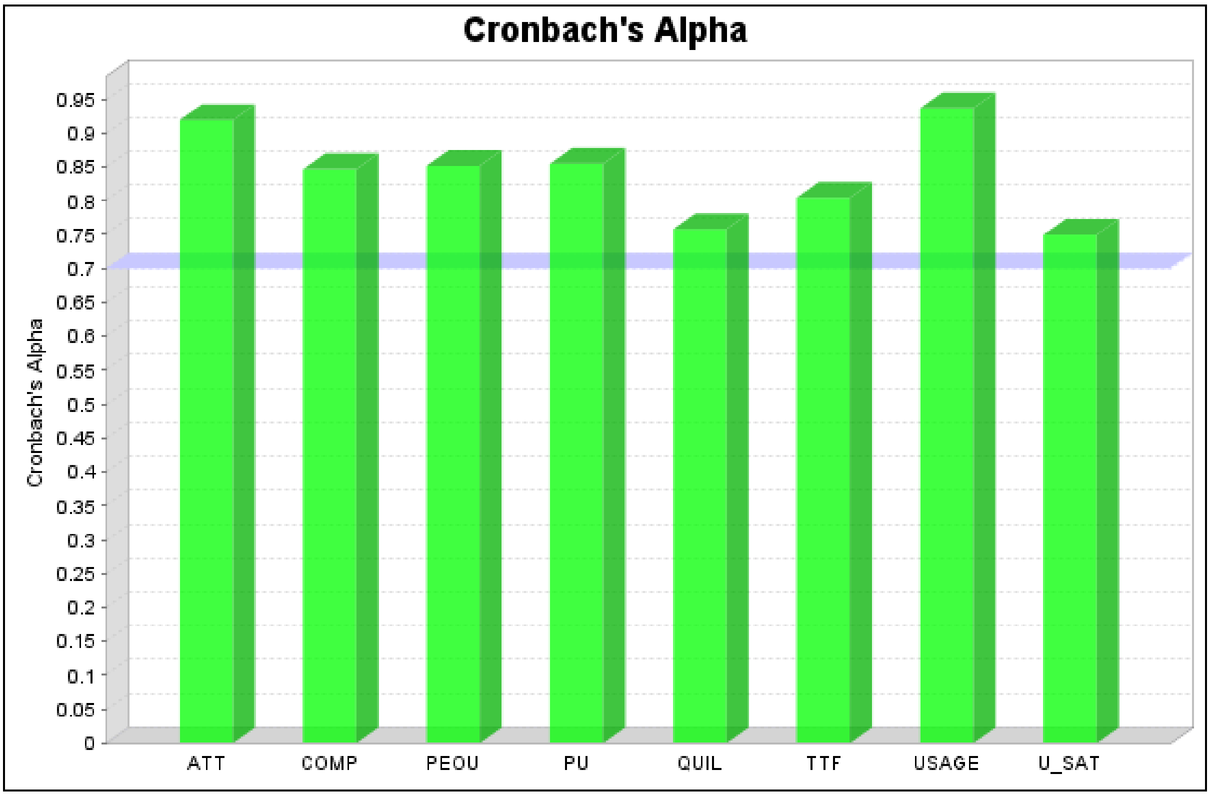

Figure 11 : Cronbach's Alpha Test, Source: Researcher

Cronbach's alpha test values ranged from 0.750 to 0.936 which means totally the values for Cronbach's alpha test were greater than the threshold value of 0.7. These outcomes showed that the magnitude prototype comprised acceptable internal consistency. Composite reliability was also assessed using internal consistency reliability. Figure 12 shows the results of the composite reliability test.

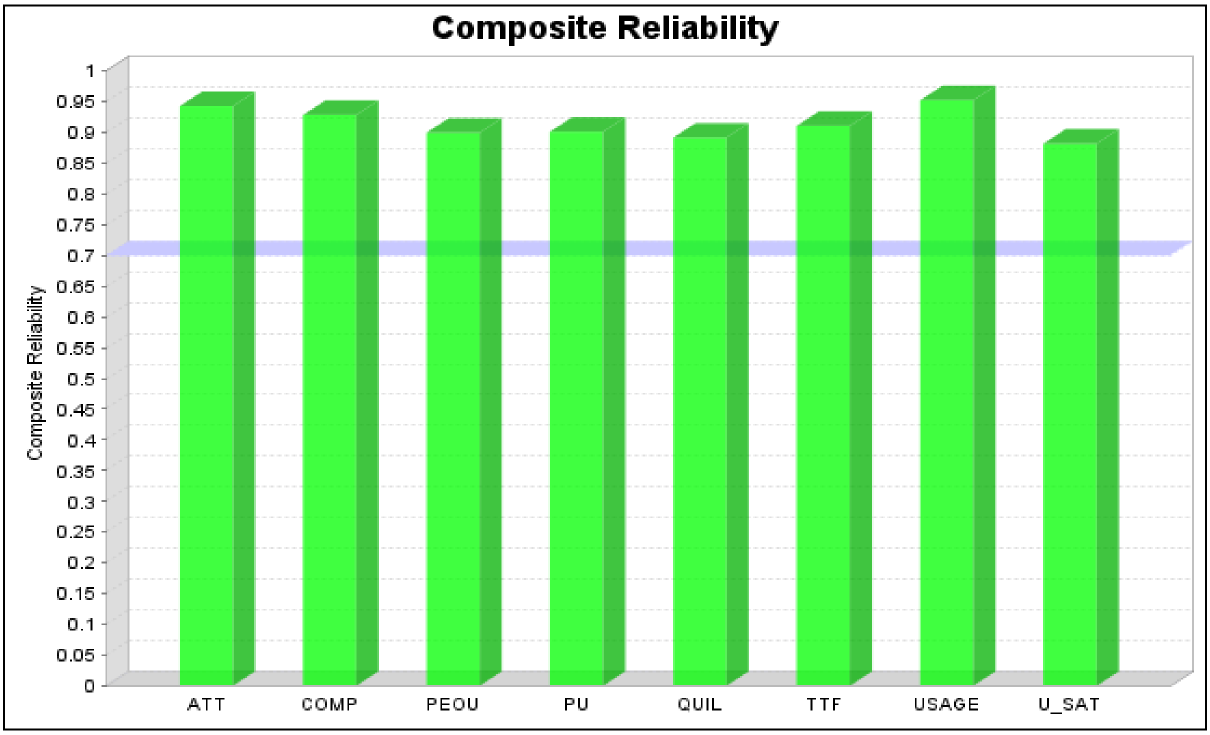

Figure 12 : Composite Reliability, Source: Researcher

The grey horizontal line in Figure 12 represent the threshold value of 0.7. All the bars on the graph represent the contract's' CR values. The results in Figure 12 show that the composite reliability values ranged from 0.882 to 0.952, all clearly greater than 0.7, indicating satisfactory internal consistency. Both the Cronbach's alpha test and the composite reliability test results indicated that all measurement models had acceptable internal consistency reliability.

5.5.1.3 Convergent Validity

The outer loadings and the average variance extracted (AVE) values are used to assess convergent validity (Fornell & Cha, 1994; Tabachnick & Fidell, 2007). Table 2 shows that all the outer loadings of the measurement model were greater than 0.7, which suggests that less than (50%) of an item's variance was owing to error. The AVE values were also used to access the convergent validity. According to Hair et al. (2017), constructs that have an AVE value of 0.5, are considered to have adequate convergent validity. Figure 13 shows the results of the average variances extracted.

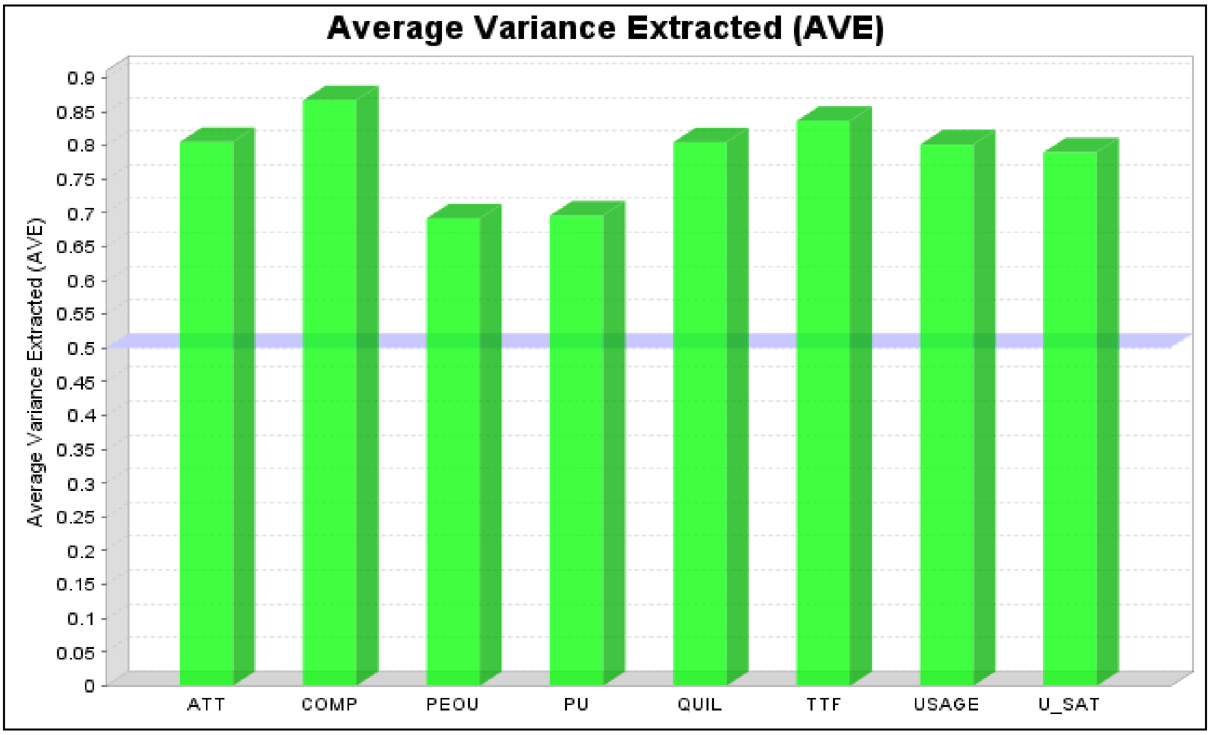

Figure 13 : Average Variance Extracted (AVE) Values, Source: Researcher

The grey horizontal line in Figure 13 represent the threshold value of 0.5. All the bars on the graph represent the contract's' AVE values. Figure 13 shows that all the AVE values were greater than the threshold value of 0.5. These results mean satisfactory convergent validity. By assessing the outer loadings and the AVE values, the measurement model has established an acceptable convergent validity, which suggests that the indicators were measuring their associated constructs well, and were not measuring other constructs.

5.5.1.4 Discriminant Validity

Discriminant validity was assessed using the Fornell-Larcker criterion. The results of the Fornell-Larcker criterion are shown in Table 7. The non-bolded numbers in Table 7 represent the inter-correlation value between constructs, and the bolded numbers represent the square roots of the AVE. The results show that the square root of each construct's AVE was larger than its biggest correlation with any other construct. This shows that none of the inter-construct correlation values were greater than the square-root of the AVE and satisfied the Fornel-Larcker (Tabachnick & Fidell, 2007) of the discriminant validity criterion (Hair et al., 2017; Tabachnick & Fidell, 2007). This means that, all the constructs differed from each other. These results entail that each construct was different from any other construct on the model. Additionally, each construct was measuring a different aspect of rural Eswatini pre-service teachers' acceptance of GeoGebra for circle theorem learning.

Table 7 : Fornell-Larcker Criterion

	ATT	COMP	PEOU	PU	QUIL	TTF	USAGE	U_SAT
ATT	**0.897**							
COMP	0.680	**0.931**						
PEOU	0.427	0.510	**0.832**					
PU	0.614	0.518	0.359	**0.834**				
QUIL	0.607	0.574	0.525	0.610	**0.897**			
TTF	0.669	0.762	0.463	0.483	0.532	**0.915**		
USAGE	0.838	0.691	0.504	0.527	0.616	0.687	**0.895**	
U_SAT	0.383	0.228	0.166	0.497	0.461	0.349	0.309	**0.889**

Generally, the indicator reliability, internal consistency reliability, convergent validity, and discriminant validity tests conducted on the measurement model were acceptable. Therefore, the measurement model showed the ample robustness needed to assess the structural model.

5.6 Structural Model

Section 5.5.1 provided insight into an assessment of the measurement model. After the superiority of the measurement model was sanctioned, the structural model was reviewed. The structural model helps the researcher determine how well empirical data support the theory. In this segment, the results of the structural model evaluation consequent to the five step-procedure of evaluating structural models recommended by Hair et al. (2017) are discussed, as illustrated in (4.7.2).

Step 1: Collinearity assessment

The multicollinearity of the structural model was assessed using the variance inflation factor (VIF) values. Multicollinearity exists when two or more independent variables are highly inter-correlated, and according to Hair et al. (2017), VIF values above 5.00 indicate the presence of multicollinearity. The results of the multicollinearity test are depicted in Table 8; all the VIF values were indeed less than 5.00 – indicating that collinearity among the predictors was not an issue within the structural model.

Table 8 : Multicollinearity Test

	ATT	PU	TTF	USAGE
ATT				2.452
COMP			1.640	2.907
PEOU	1.313	1.273	1.528	1.397
PU	1.345			1.667
QUIL			2.028	
TTF	1.492	1.273		2.679
USAGE				
U_SAT			1.284	

Step 2: Structural model path coefficients

The bootstrapping procedure was used to test hypotheses of the proposed research model as suggested by Hair et al.'s (2017) study that bootstrapping procedure of using 5000 subsamples should be utilised during hypotheses testing. The SmartPLS software divides data from the respondents into 5000 subsamples and analyses it. Each path on the model represents a proposed hypothesis. To assess each hypothesis, the beta sign, and statistical significance were used. The bigger the beta, the stronger the effect of the independent on the dependent construct. Moreover, due to the exploratory nature of the study, the critical values for the two-tailed t-tests were set to 1.65 (significance level 0.1) (Hair et al., 2014). Exploratory research is described as study conducted to learn more about a topic that is not well defined (Hair et al., 2017) and is carried out to advance a better knowledge of the topic at hand. The use of GeoGebra in Eswatini rural teachers' colleges is in its preliminary stage. Therefore, the factors that rural pre-service teachers consider important for GeoGebra acceptance are not well understood. Using the SmartPLS, the hypotheses were checked, and the outcomes are illustrated in

Table 9 and Table 10.

Table 9 : Hypotheses Tests for the Main Model

Path	Std Beta	Std Error	T - Statistics	P - Values	Decision
ATT -> USAGE	0.642	0.051	12.679	0.000	Accepted
COMP -> TTF	0.665	0.052	12.878	0.000	Accepted
COMP -> USAGE	0.102	0.075	1.361	0.174	Rejected
PEOU -> ATT	0.086	0.066	1.303	0.193	Rejected
PEOU -> PU	0.173	0.073	2.359	0.019	Accepted
PEOU -> TTF	0.080	0.055	1.460	0.145	Rejected
PEOU -> USAGE	0.125	0.058	2.145	0.032	Accepted
PU -> ATT	0.364	0.071	5.129	0.000	Accepted
PU -> USAGE	-0.031	0.044	0.688	0.492	Rejected
QUIL -> TTF	0.029	0.071	0.413	0.680	Rejected
TTF -> ATT	0.454	0.065	6.975	0.000	Accepted
TTF -> PU	0.403	0.071	5.679	0.000	Accepted
TTF -> USAGE	0.136	0.055	2.496	0.013	Accepted
U_SAT -> TTF	0.171	0.055	3.083	0.002	Accepted

Results from

Table 9 show that out of 14 hypotheses tested, five were rejected. The rejected hypotheses were having p-values greater than 0.05 and the paths were COMP to USAGE (β = 0.102, p > 0.05), PEOU to ATT (β = 0.086, p > 0.05), PU to USAGE (β = - 0.031, p > 0.05), PEOU to TTF (β = 0.080, p > 0.05), and QUIL to TTF (β = 0.029, p > 0.05). The nine paths which were supported by data were TTF to PU (β = 0.403, p < 0.05), TTF to USAGE (β = 0.136, p < 0.05), TTF to ATT (β = 0.454, p < 0.05), PU to ATT (β = 0.364, p < 0.05), COMP to TTF (β = 0.665, p < 0.05), PEOU to USAGE (β = 0.125, p < 0.05), PEOU to PU (β = 0.173, p < 0.05), U_SAT to TTF (β = 0.685, p < 0.05), and ATT to USAGE (β = 0.642, p < 0.05).

The paths which were rejected were removed from the model, and the bootstrapping was repeated to assess the indirect effect of TTF, PU, CP, and PI on USAT. Table 10 shows the results of indirect hypotheses testing.

Table 10 : Indirect Hypotheses Testing

Indirect path	Std Beta	Std Error	T-Statistics	P-Values	Decision
PEOU -> ATT -> USAGE	0.055	0.043	1.297	0.195	Rejected
PEOU -> PU -> ATT -> USAGE	0.040	0.021	1.940	0.053	Rejected
COMP -> TTF -> PU -> ATT -> USAGE	0.064	0.017	3.748	0.000	Accepted
PEOU -> TTF -> PU -> ATT -> USAGE	0.008	0.006	1.486	0.138	Rejected
PU -> ATT -> USAGE	0.233	0.051	4.552	0.000	Accepted
TTF -> PU -> ATT -> USAGE	0.094	0.025	3.719	0.000	Accepted
U_SAT -> TTF -> PU -> ATT -> USAGE	0.017	0.007	2.519	0.012	Accepted
COMP -> TTF -> ATT -> USAGE	0.197	0.035	5.610	0.000	Accepted
PEOU -> TTF -> ATT -> USAGE	0.026	0.016	1.635	0.103	Rejected
TTF -> ATT -> USAGE	0.291	0.047	6.140	0.000	Accepted
U_SAT -> TTF -> ATT -> USAGE	0.053	0.019	2.823	0.005	Accepted
PEOU -> PU -> USAGE	-0.005	0.008	0.636	0.525	Rejected
COMP -> TTF -> PU -> USAGE	-0.008	0.012	0.694	0.488	Rejected
PEOU -> TTF -> PU -> USAGE	-0.001	0.002	0.514	0.608	Rejected
TTF -> PU -> USAGE	-0.012	0.018	0.689	0.491	Rejected
U_SAT -> TTF -> PU -> USAGE	-0.002	0.004	0.601	0.548	Rejected
COMP -> TTF -> USAGE	0.092	0.038	2.425	0.016	Accepted
PEOU -> TTF -> USAGE	0.012	0.008	1.494	0.136	Rejected
U_SAT -> TTF -> USAGE	0.025	0.012	2.001	0.046	Accepted

The results showed that PEOU had no indirect effect on USAGE. All the six indirect paths between PEOU and USAGE were not significant at 0.05 level. COMP encompassed a considerable implied impact on USAGE. Out of three indirect paths tested between COMP and USAGE, only one was not statistically significant. The other three paths were significant with TTF, PU, and ATT – playing a mediating role between COMP and USAGE. The PU had an indirect effect on USAGE through ATT. Three indirect paths between TTF and USAGE were tested, and two were significant at 0.05 level. The results showed that TTF had indirect effects on USAGE. Henceforth, the variables PU and ATT played a mediating role between TTF and USAGE. Four indirect relationships between U_SAT and USAGE were tested, and of the four relationships tested, only one was not significant. Results showed that U_SAT had indirect effects on USAGE. The TTF, ATT, and PU mediated the relationship between U_SAT and USAGE.

In a nutshell, results showed that factors affecting rural-based Eswatini pre-service teachers' acceptance of GeoGebra as adaptive technology in the cognition of Circle Theorems were ATT, PEOU, TTF, COMP, PU, and U_SAT. Table 9 indicates that ATT, TTF and PEOU were the only factors that showed a candid impact on USAGE. Table 10 shows that TTF, U_SAT, PU, and COMP had a significant indirect effect on USAGE.

Table 11 shows the results of four hypotheses which were tested to determine factors that affect TTF constructs on rural-based Eswatini pre-service teachers' acceptance of GeoGebra adaptive technology in the cognition of circle theorems.

Table 11 : Results of TTF Hypotheses Testing

Path	Std Beta	Std Error	T - Statistics	P - Values	Decision
COMP -> TTF	0.665	0.052	12.878	0.000	Accepted
PEOU -> TTF	0.080	0.055	1.460	0.145	Rejected
QUIL -> TTF	0.029	0.071	0.413	0.680	Rejected
U_SAT -> TTF	0.171	0.055	3.083	0.002	Accepted

Out of the four hypotheses, only two were significant. The paths which were significant were COMP to TTF ($\beta = 0.665$, $p < 0.05$) and U_SAT to TTF ($\beta = 0.171$, $p < 0.05$). This implies that COMP and U_SAT are the only factors that affect TTF constructs on rural-based Eswatini pre-service teachers' acceptance of GeoGebra adaptive technology in the cognition of circle theorems. The paths which were not supported by the data are PEOU to TTF ($\beta = 0.080$, $p > 0.05$) and QUIL to TTF ($\beta = 0.029$, $p > 0.05$).

Step 3 Coefficient of determination (R-squared)

The coefficient of determination values shows the total amount of variance in the endogenous variable that is being explained by the exogenous variables. The higher the coefficient of determination, the higher the predictive power of the structural model (Falk & Miller, 1992).

According to Chin (1998), a model having an R-squared of 0.67, 0.33, and 0.19 is considered substantial, moderate, and weak, respectively. Figure 14 and Figure 15 show the coefficient of determination. Figure 14 is composed of 10 constructs. The TTF is directly predicted by three constructs namely QUIL, U_SAT, PEOU, and COMP. The TTF predicts ATT, USAGE, and PU. The USAGE is predicted by COMP, ATT, PU, and PEOU.

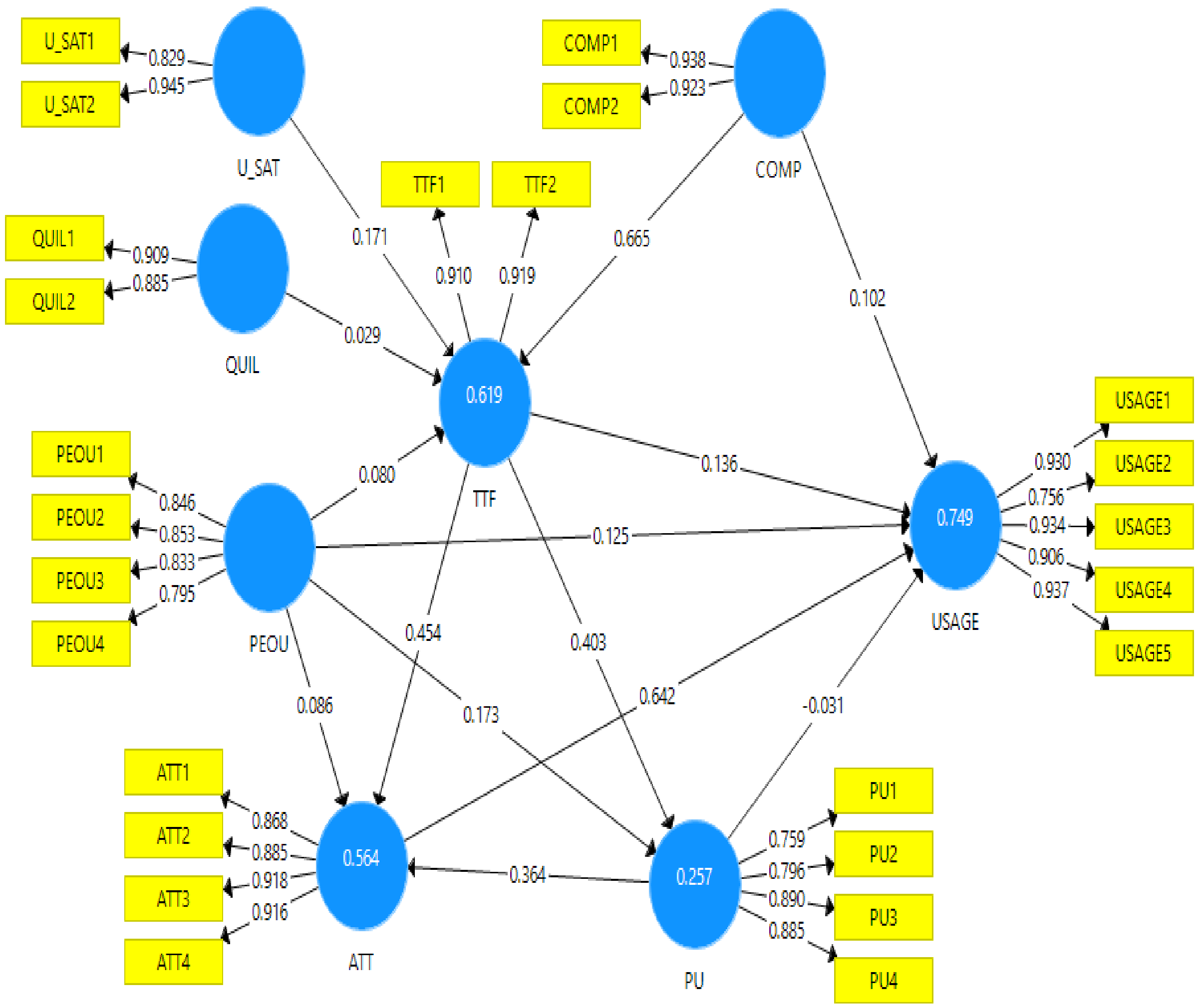

Figure 14 : Structural Model, Source: Researcher

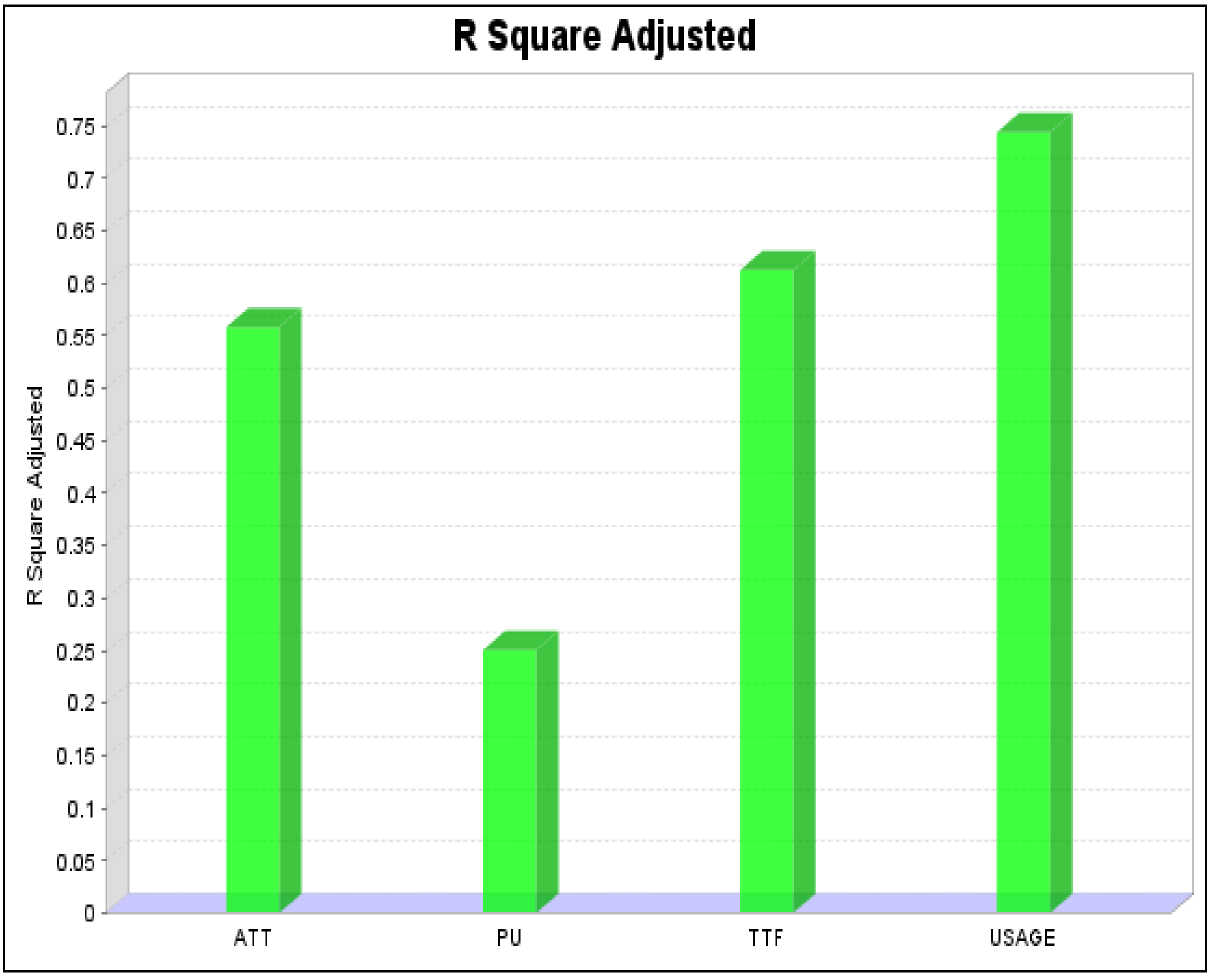

Figure 15 : R-squared Values, Source: Researcher

The results also showed that the coefficient of determination for PU was 0.257, that the total contribution of TTF and PEOU, on the explained variance of PU, is (25.7%). Thus, the coefficient of determination for PU is considered weak (Chin, 1998). Moreover, it can be gathered from Figure 5 that the coefficient of determination for TTF was 0.619. These results mean that the total contribution of QUIL, U_SAT, COMP and PEOU on the explained variance of TTF was (61.9%), and the coefficient of determination for ATT was 0.564. Hence, the total contribution of PEOU, PU, and TTF on the explained variance of ATT was (56.4%). These coefficient of determination values for ATT and TTF are considered moderate (Chin, 1998). Additionally, the model shows that the coefficient of determination USAGE was 0.749, and this coefficient of determination is considered substantial (Chin, 1998). Ultimately, the coefficient of determination implies that the total contribution of ATT, PEOU, PU, TTF, QUIL, COMP and U_SAT on the explained variance of USAGE was (74.9%).

Step 4: Effect size (f-squared)

The f-squared estimate for exogenous latent variables across the model is shown in Table 12.

Table 12 : The f-squared

	ATT	PU	TTF	USAGE
ATT				0.671
COMP			0.708	0.014
PEOU	0.013	0.031	0.011	0.045
PU	0.225			0.002
QUIL			0.001	
TTF	0.316	0.172		0.028
USAGE				
U_SAT			0.059	

The f-squared values of 0.02, 0.15, and 0.35 are considered small, medium, and large, respectively (Chin, 1998). Results from Table 12 show that the effect sizes of ATT to USAT and COMP to TTF were considered large which means that these two exogenous variables (ATT and COMP) contribute a substantial amount in the variance of their endogenous variables (USAT and TTF). Also, TTF had a medium effect size on ATT, PEOU, and PU, as depicted by Table 12. The effect of PU on ATT is also considered medium, whereas, QUIL has a small effect size on TTF. The effect of PEOU to ATT, QUIL to TTF, PU to USAGE, PEOU to TTF, and U_SAT to TTF, was less than 0.02. Therefore, results as indicated by Table 12 show that the exogenous variables did not have a big effect on their endogenous variables.

Step 5: Blindfolding and Predictive Relevance Q-squared

The Q-squared coefficient is a non-parametric Stone-Geisser test whose value is used in evaluating predictive validity of the hypothetical model. In SmartPLS, the Q-squared values are calculated using construct cross-validated redundancy values, which in turn are calculated using the blindfolding algorithm (Hair et al., 2014). The algorithm is assessed by systematically assuming that every 7th case was missing from the responses, and these model parameters were then estimated and used to predict the missing values (Hair et al., 2014). Results of the construct cross-validated redundancy are shown in Table 13, and they revealed that all the Q-squared values were bigger than zero (Hair et al., 2017). This signals that the hypothesised model can be used to predict the phenomena under study; rural-based Eswatini pre-service teachers' acceptance of GeoGebra adaptive technology in the cognition of circle theorems.

Table 13 : Q-squared

	SSO	SSE	Q^2 (=1-SSE/SSO)
ATT	1000.000	552.142	0.448
COMP	500.000	500.000	
PEOU	1000.000	1000.000	
PU	1000.000	827.130	0.173
QUIL	500.000	500.000	
TTF	500.000	248.429	0.503
USAGE	1250.000	508.244	0.593
U_SAT	500.000	500.000	

5.7 Multigroup Analysis

To assess if there was a significant difference between the path coefficients of males' and females' structural models multigroup analysis was used, and the outcomes are illustrated in Table 14. From the results, conclusions can be drawn that male's path coefficients were bigger than females on the following paths: ATT to USAGE, PEOU to TTF, PU to ATT, QUIL to TTF, U_SAT to TTF, PEOU to USAGE and TTF to PU. However, males' path coefficients were less than female's path coefficients on these paths: COMP to TTF, COMP to USAGE, PEOU to ATT, PEOU to PU, and PU to USAGE.

Table 14 : Multigroup

Path	Std Beta	P-Value
ATT -> USAGE	-0.057	0.604
COMP -> TTF	0.163	0.149
COMP -> USAGE	0.017	0.911
PEOU -> ATT	0.048	0.739
PEOU -> PU	0.158	0.307
PEOU -> TTF	-0.179	0.101
PEOU -> USAGE	-0.132	0.280
PU -> ATT	-0.225	0.107
PU -> USAGE	0.118	0.243
QUIL -> TTF	-0.056	0.674
TTF -> ATT	0.285	0.044
TTF -> PU	-0.226	0.138
TTF -> USAGE	0.031	0.787
U_SAT -> TTF	-0.002	0.971

The results in Table 13 also showed that only one path TTF to ATT was significant at 0.05 level. This means that male and female pre-service teachers' models differ significantly. However, this path was significant for each group – indicating that the same model can be used to predict factors that affect both male and female rural-based Eswatini pre-service teachers' acceptance of GeoGebra as adaptive technology in the cognition of circle theorems.

5.8 Paired-samples t-test.

To find out if GeoGebra enhances rural-based Eswatini pre-service teachers' cognition of circle theorems, the paired-samples t-test was used to assess if there is a significant difference between pre-service teachers' pretest-posttest marks. The results of the t-test are shown in Table 15, Table 16, and Table 17.

Table 15 : Paired-sample Statistics

		Mean	N	Std Deviation	Std. Error Mean
Pair 1	Pre-test	4.82	182	1.960	0.124
	Post-test	6.29	182	1.758	0.111

Table 16 : Paired Sample Correlation

	N	Correlation	Sig.
Pair 1 pre-test & post-test	182	0.899	0.000

Table 17 : Paired Sample Test

	Paired difference					t	df	Sig. (2-tailed)
	Mean	Std Deviation	Std Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 Pre-test – Post-test	-1.472	0.86	0.054	-1.579	-1.365	-27.053	181	0.000

The pair-samples t-test was conducted to evaluate the impact of GeoGebra on rural-based Eswatini pre-service teachers' cognition of circle theorems, and there was a statistical difference in pre-test (M = 4.82, SD = 1.96) to post-test (M = 6.29, SD = 1.758), t (181) = -27.053, p < 0.001 (two-tailed). The mean decreases in pre-service teachers' marks by -1.472 with a confidence interval ranging from -1.579 to -1.365.

Utilising the following formula, the effect size statistics was physically computed:

Eta squared $=\frac{t^2}{t^2\ (N-1)}$

Eta squared $= \frac{-27.053^2}{-27.053^2\ (182-1)}$

Eta squared = 0.8.

According to Cohen (1988), an eta squared value of 0.2 (small effect), 0.5 (medium effect), and 0.8 (large effect) size. The results showed an eta squared value of 0.8. This eta squared value is considered a large-size effect (Cohen, 1988). The results imply that there was a large effect, with a substantial difference in the scores that pre-service teachers had before and after using the GeoGebra.

5.9 Summary

The chapter described how data were initially prepared before being analysed. The Statistical Package for Social Sciences was used to edit the gathered data (SPSS). Data screening was carried out by looking for missing data, outliers, and normality checks. SmartPLS 3 was utilised to do data analysis after data preparation was completed. This analysis was carried out in two steps. The measurement models were evaluated in the first stage based on indicator reliability, internal consistency, reliability convergent validity, and discriminant validity. With acceptable results for reliability and validity, the analysis of the structural models was done to test the model hypotheses of this study and to determine the explanatory power of the proposed learners' model. The results of paired-samples t-test were also presented in this study.

CHAPTER SIX
DISCUSSION OF RESULTS

6.1 Introduction

The central focus of the previous chapter was to run an examination of the study's findings. Furthermore, the chapter empirically investigated the acceptance of GeoGebra by pre-service teachers in Rural Eswatini, as well as establishment of GeoGebra's potential predictors of acceptance for circle theorems by Rural Eswatini pre-service teachers. As a result, the Rural Eswatini pre-service teachers' acceptance of GeoGebra model was evaluated. The purpose of this chapter is to discuss potential justifications for the significance of the relationships proposed in the conceptual model, in accordance with the findings of chapter 5.

Furthermore, this chapter analyzes the research findings considering prior literature and reports on the consistency, or inconsistency, of the research findings with prior studies. Following the introduction, sections 6.2 to 6.5, discuss findings on the acceptance of the GeoGebra for circle theorem learning by rural Eswatini pre-service teachers, which in turn address the research questions. The questions aimed at how do predictors: compatibility (COMP), system quality (QUIL), user satisfaction (USAT), Task-Technology Fit (TTF), perceived ease of use (PEOU), perceived attitude towards (ATT) and perceived usefulness (PU) influence the actual use of GeoGebra for circle theorem-learning by rural Eswatini pre-service teachers.

Data analysis was presented under the following objectives of the study, which were to:

- Determine the effects of rural Eswatini pre-service teachers' system quality, system compatibility, and user satisfaction on their Technology Task Fit of GeoGebra for circle theorems' cognition.
- Find the factors that rural Eswatini pre-service teachers consider important when accepting GeoGebra.
- Investigate the effects of gender on the acceptance of GeoGebra by Eswatini pre-service teachers.
- Find the effects of GeoGebra on pre-services teachers' cognition of circle theorems.

Section 6.2 reports on the effects of rural Eswatini pre-service teachers' system quality, system compatibility, and user satisfaction on their GeoGebra Technology Task Fit for circle theorems' cognition. The results of the effect of rural Eswatini pre-service teachers' system quality, system compatibility, and user satisfaction on their Technology Task Fit of GeoGebra for circle theorems' cognition were discussed in section 6.3. Section 6.4 deliberated on the effects of gender on Eswatini pre-service teachers' acceptance of GeoGebra. The results of GeoGebra's effects on pre-service teachers' cognition of circle theorems were presented in Section 6.5 and finally, in Section 6.6, the chapter's summary is presented.

6.2 The Effects of Rural Eswatini Pre-service Teachers' System Quality, System Compatibility, and User Satisfaction on their Technology Task Fit of GeoGebra for Circle Theorems' Cognition

The first objective investigated the effects of system quality, system compatibility, and user satisfaction on rural Eswatini pre-service teachers' Technology Task Fit of GeoGebra for circle theorems' cognition. The PLS-SEM was used to evaluate the hypotheses based on the rural Eswatini pre-service teachers' acceptance of the GeoGebra model proposed in chapter 3. The acceptance of the GeoGebra structural model by rural Eswatini pre-service teachers, as shown in Figure 5, was evaluated using the R-squared value (variance explained); structural paths (path coefficient); size of the effect (f-squared); and relevance prediction (Q-squared). However, because the question's goal was to identify predictors of rural Eswatini pre-service teachers' Technology Task Fit to use GeoGebra for learning circle theorems, only significant paths were discussed in this section.

Results indicate that the proposed model adequately explains the variance in rural Eswatini pre-service teachers' Technology Task Fit of GeoGebra to teach circle theorems. The shared variance explained by COMP, PEOU, QUIL, and U_SAT on TTF was 0.619. The R-squared values of 0.19, 0.33 and 0.67 are weak, moderate and substantial, respectively (Chin, 998). This R-squared value of TTF is considered moderate (Chin, 1998). The results imply that the combined effect of exogenous variables: COMP, PEOU, QUIL, and U_SAT in explaining rural Eswatini pre-service teachers' Technology Task Fit of GeoGebra to teach circle theorems was (61.9%).

The Q-squared value of TTF was 0.503, whereas the Q-squared value was above zero, showing that the prototype has extrapolative relevance (Garson, 2016; Hair et al., 2017). This implies that the predictors COMP, PEOU, QUIL, and U_SAT can be used to predict the Technology Task Fit of GeoGebra to teach circle theorems amongst rural Eswatini pre-service teachers. In other words, the factors COMP, PEOU, QUIL, and U_SAT influence rural Eswatini pre-service teachers' Technology Task Fit of GeoGebra to teach circle theorems positively.

The COMP, PEOU, QUIL, and U SAT f-squared values on TTF were 0.708, 0.011, 0.001, and 0.059, respectively. The f-squared of QUIL and PEOU were less than the cut off value of 0.02 (Chin, 1998), implying that removing these constructs from the model has no effect on the explained variance of TTF. The COMP and U SAT, on the other hand, had f-squared values been greater than the threshold value of 0.02, implies that removing one of these two constructs will significantly affect the explained variance of TTF (Chin, 1998).

Table 11 in chapter 5 summarises the results of the four TTF hypotheses tested, as illustrated that two of the four hypotheses tested were supported by the data, while the other two were not. The QUIL to TTF and PEOU to TTF were the two unsupported hypotheses, as data only supported the paths COMP to TTF and U SAT to TTF. According to these findings, TTF is only influenced by U SAT and COMP.

6.2.1 System Quality

System quality was described by Isaac et al. (2019) as the extent to which a person feels that systems are straightforward to use, understand, and fix, as well as pleasurable to operate. Eswatini pre-service teachers were asked two questions in the survey to determine the extent to which they feel that GeoGebra was straightforward to use, understand, and fix, as well as pleasurable to operate when learning circle theorems. The QUIL1 had a mean of 5.880 with a standard deviation of 1.264, and QUIL2 had a mean of 5.790 with a standard deviation of 1.192. All the means were greater than 4, indicating that rural Eswatini pre-service teachers felt that GeoGebra was easy to operate, connect, and learn, as well as enjoyable to use to learn circle theorems.

Hypothesis 12 proposed that system quality influenced technology task fit positively. The path coefficient results show that the hypothesis was rejected because its beta coefficient ($\beta = 0.029$, $p > .05$) was not significant. This finding implies that the system quality of rural Eswatini pre-service teachers has no effect on their Technology Task Fit.

The study found no evidence of a positive relationship between system quality and GeoGebra's Technology Task Fit for learning circle theorems. The findings contradict those of Aldholay et al. (2018) and Isaac et al. (2019) who found that system quality had a positive effect on Technology Task Fit. The findings could imply that even though rural Eswatini pre-service teachers agreed that GeoGebra is straightforward to use, understand, and fix, as well as pleasurable to operate when teaching and learning circle theorems, they still believe that the quality of the system was not good enough. This supports the suggestion of Ali and Younes (2013) who noted that systems quality is a multidimensional process focusing on different aspects of the system. A possible reason for this finding might be linked to the number of questions (two) concerning system quality that were asked in this study. Only two questions were asked to explain a multidimensional latent variable, which might have not captured all the aspects of system quality. Future studies could relook at this relationship and cover all the aspects of system quality which include, quality aspects and other facets relating to technical issues.

6.2.2 Perceived Ease of Use

Perceived ease of use was demarcated as a person's opinion that utilising a modern innovation will be effort-free (Davis et al., 1989). Hypothesis 6 projected that perceived ease of use impacted Technology Task Fit in a constructive manner. The path coefficient outcomes suggest that the hypothesis was rejected because its beta coefficient ($\beta = 0.080$, $p > .05$) was not significant. This finding implies that perceived ease of use has no bearing on the Technology Task Fit of rural Eswatini pre-service teachers.

Unlike DeLone and McLean (2016), this investigation uncovered that perceived ease of use has no connection with Technology Task Fit. The findings suggest that rural pre-service teachers' perceptions of the effort required to learn and be skilled in GeoGebra usage circle theorems instruction have no bearing on their Technology Task Fit. Since rural pre-service teachers are members of the digital generation who are proficient computer users, so, they found it easy to use GeoGebra. Consequently, their effort to learn GeoGebra had no effect on their Technology Task Fit. Another probable justification for this conclusion is that the data were collected when the rural trainees had already been subjected to the use of GeoGebra to learn circle theorems. Mutambara and Bayaga (2020a) noted that the power and influence of perceived ease of use on technology model acceptance diminishes with experience and prior exposure to the model. According to Mutambara and Bayaga (2020), since the data was collected when rural Eswatini pre-service teachers were already experienced users of GeoGebra for learning circle theorems, the effect on their Technology Task Fit had already diminished.

6.2.3 System Compatibility

The degree to which a system is technically logical, multipurpose, and elegant was defined as system quality (Adeniji et al., 2018). Two survey questions were developed to test key aspects of system compatibility, most notably how rural Eswatini pre-service teachers perceived GeoGebra's system compatibility for learning circle theorems. Rural Eswatini pre-service teachers almost unanimously agreed in their survey responses that GeoGebra is technically sound for learning circle theorems. The mean for COMP1 was 4.460, with a standard deviation of 2.232, and the mean for COMP2 was 4.990, with a standard deviation of 1.875.

The system compatibility of rural pre-service teachers has appreciable power on their technology task fit. Conclusions insinuate that the path coefficient is ($\beta = .665$, $p < .05$), indicating that hypothesis H11 is supported. This result implies that rural Eswatini pre-service teachers' Technology Task Fit will increase by 0.665 units if their system compatibility increases by one unit. The f-squared for this path was 0.708. This result implies that removing system compatibility from the model will significantly affect the explained variance of Technology Task Fit.

The conclusions drawn from this investigation are in harmony with those of Isaac et al. (2019), who established that university students' system compatibility has a tangible constructive influence on their technology task fit. However, these findings contradict the ones for Islam and Azad (2015), who uncovered that system compatibility has no bearing on Technology Task Fit. This finding suggests that rural Eswatini pre-service teachers perceive GeoGebra to be in line with their current needs, values, and prior experiences of learning circle theorems. It is because GeoGebra is aligned with the learning of circle theorems that they perceive GeoGebra as a technology suitable for learning Geometry. This is agreeable with the suggestion of Alamri et al. (2020), who reckon that if cyber instructional technologies resonate students' philosophies, standards, and routines, then students are more likely to regard it as a technology that fits the task at hand.

6.2.4 User Satisfaction

The User satisfaction was expressed as the degree to which users deem a system expedient and desirable for utility (DeLone & McLean, 2016). Eswatini pre-service teachers were asked two questions in the survey to determine the extent to which they regard GeoGebra as convenient and desirable for utility in learning circle theorems. U_SAT1 had a mean of 5.810 with a standard deviation of 1.492 and U_SAT 2 had a mean of 5.840 with a standard deviation of 1.224. All the means were greater than 4, indicating that rural Eswatini pre-service teachers perceive GeoGebra as useful and desirable for reuse in the learning of circle theorems.

Thus, it was concluded that rural Eswatini pre-service teachers' user satisfaction positively influences their Technology Task Fit. The results show the path coefficient ($\beta = .171$, $p < .05$), indicating that hypothesis H13 is supported. The implication is therefore that rural Eswatini pre-service teachers' Technology Task Fit will increase by 0.171 units if their user satisfaction increases by one unit.

This finding synchronizes with that of Alamri et al. (2020) and Isaac et al. (2019), who noted that user satisfaction has a progressive influence on Technology Task Fit. One possible reason for this finding is that rural Eswatini pre-service teachers belong to the digital generation who finds computer-aided learning easy and useful. In essence, rural-based teacher trainees were pleased to note that GeoGebra is easy to use, and it can enhance their circle theorems' cognition. That is, the ease of use and utility of GeoGebra in learning circle theorems improve pre-service teachers' user satisfaction, which in turn stimulates their technology task fit.

The results for this objective are summarized in Figure 14, and results in Table 11 (See section 5.5.2) show that rural Eswatini pre-service teachers' Technology Task Fit was influenced by system compatibility and user satisfaction. Rural Eswatini pre-service teachers' perceived ease of use and system quality do not influence their Technology Task Fit. Figure 16 shows the predictors of the TTF.

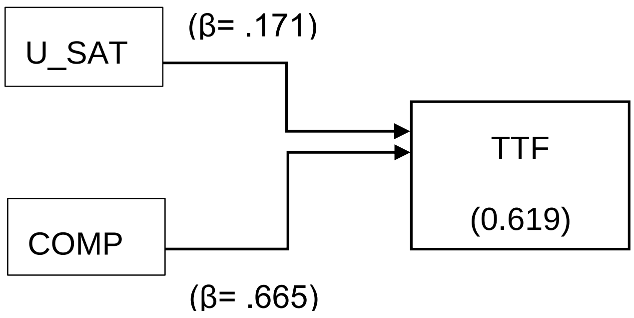

Figure 16 : Predictors of TTF, Source: Researcher

6.3 Factors that Rural Eswatini Pre-service Teachers Consider Important When Using GeoGebra

This objective aimed to investigate the factors that rural Eswatini pre-service teachers consider important when accepting GeoGebra. Based on the Rural Eswatini Pre-service teachers' acceptance of the GeoGebra model proposed in chapter 3, the hypotheses were tested in chapter 5 section 5.5.2. This section discusses the results.

The conclusions drawn alluded to the fact that the R-squared of PU was 0.257, which is a low R-squared (Chin, 1998). This means that the combined contribution of TTF and PEOU to the explained variance of PU was (25.7%). The ATT, on the other hand, has a moderate R-squared of 0.564. (Chin, 1998). The TTF, PEOU, and PU explained 56.4% of the variance in rural Eswatini pre-service teachers' perceptions of using GeoGebra for circle theorem learning. The USAGE had an R-squared value of 0.749. According to Chin (1998), this R-squared value of USAGE is substantial. This R-squared value indicates that the model constructs TTF, PU, PEOU, QUIL, U SAT, ATT, and COMP account for 74.9% in rural Eswatini pre-service teachers' actual use of GeoGebra for learning circle theorems.

The ATT, PU, TTF, and USAGE had Q-squared values of 0.448, 0.173, 0.503, and 0.593, respectively. All the Q-squared values were greater than zero, signifying that the model encompasses extrapolative significance (Garson, 2016; Hair et al., 2017). This means that the predictors COMP, PEOU, PU, ATT, PEOU, QUIL, and U SAT can be used to forecast the use of GeoGebra to teach circle theorems in rural Eswatini pre-service teachers.

6.3.1 Perceived Attitude Towards

In the background of technology acceptance enquiry, Venkatesh et al. (2003) distinguished perceived attitude towards as somebody's sentimental impression of the use of an innovation. Eswatini pre-service teachers were asked four questions in the survey to determine the extent to which they respond to and are inclined to use GeoGebra for learning circle theorems. The ATT1 had a mean of 5.020 with a standard deviation of 1.883, the ATT2 had a mean of 4.900 with a standard deviation of 2.050, the ATT3 had a mean of 4.740 with a standard deviation of 1.905, and the ATT4 had a mean of 4.680 with a standard deviation of 1.966. All the means were greater than 4, indicating that Eswatini pre-service teachers had a positive attitude toward using GeoGebra to learn circle theorems. This factor was the most significant factor (see Table 11 in section 5.5.2) in explaining variances in Eswatini pre-service teachers' usage of GeoGebra for learning circle theorems.

Perceived attitude towards the use of GeoGebra influences their actual usage of GeoGebra. The results show that the path coefficient is ($\beta = .642$, $p < .05$), indicating that hypothesis H1 is supported. This result implies that rural Eswatini pre-service teachers' actual use will increase by 0.642 units if their perceived attitude towards GeoGebra increases by one unit. The f-squared for this path was 0.671. This f-squared is considered large (Chin, 1998). This means that removing perceived attitude towards GeoGebra on rural Eswatini pre-service teachers' acceptance of GeoGebra model, will greatly affect the explained variance of USAGE.

In line with prior studies (Aman et al., 2020; Eksail & Afari, 2019; Teo et al., 2008), this enquiry established that rural Eswatini pre-service teachers' perceived attitude towards GeoGebra for learning circle theorems influences their actual use. This lends support to Mutambara and Bayaga's (2020) contention that improving instructors' opinions toward the use of technology in learning improves its actual usage. One possible explanation for this result is that Eswatini pre-service teachers discovered that GeoGebra can improve their performance in circle theorems and GeoGebra's utility reinforces rural Eswatini pre-service teachers' positive attitude toward the GeoGebra adaptive technology.

6.3.2 Perceived Ease of Use

Perceived ease of use is user's perception that the utility of an information system will be free of mental strain (Davis et al., 1989). In this study, Eswatini pre-service teachers were asked five questions to determine the extent to which they perceived the effort needed for GeoGebra usage in the learning of circle theorems. The PEOU1 had a mean of 5.090 with a standard deviation of 1.968, PEOU2 had a mean of 4.900 with a standard deviation of 2.050, PEOU3 had a mean of 4.880 with a standard deviation of 1.969, PEOU4 had a mean of 5.260 with a standard deviation of 1.786, and PEOU5 had a mean of 4.630 with a standard deviation of 1.976. All the means were greater than 4, indicating that the majority of Eswatini pre-service teachers perceived GeoGebra to be easy to learn, and simple to use, during instruction of circle theorems.

The results showed that Eswatini pre-service teachers' perceived ease of use influenced their perceived usefulness and actual usage, but not their perceived attitude and Technology Task Fit. These results supported H4 ($\beta = .173, p < .05$) and H14 ($\beta = .125, p < .05$). However, the results did not support H5 ($\beta = .086, p > .05$), and H6 ($\beta = .080, p > .05$), and the implication is that rural Eswatini pre-service teachers' actual use and perceived usefulness will increase by 0.125 and 0.173 units, respectively if their perceived ease of use of GeoGebra increases by one unit.

The findings are inconsistent with those of Sánchez-Prieto et al. (2019), who found that perceived ease of use has no bearing on perceived usefulness. This implies that the effort required to learn GeoGebra usage in circle theorems' instruction has control on its usefulness. In this investigation, the mean of all the questions about perceived ease of use was greater than 4, indicating that Eswatini pre-service teachers thought GeoGebra was simple to learn. This implies that learning circle theorems with GeoGebra was not difficult for them. Rural Eswatini pre-service teachers think GeoGebra is useful for learning circle theorems because it requires little effort to learn.

In contrast to the findings of Sánchez-Prieto et al. (2019), this study discovered that the perceived ease of use of Eswatini pre-service teachers influences their actual use of GeoGebra for learning circle theorems. According to Pittalis (2020), using technology for learning generally requires additional effort in terms of learning the technology. This study discovered that rural Eswatini pre-service teachers found GeoGebra to be simple to use when learning circle theorems. Because of the ease of use of GeoGebra, rural Eswatini pre-service teachers do not consider learning to use GeoGebra to be requiring extra effort. The ease of use of GeoGebra has a positive impact on their actual use of it for learning circle theorems.

The perceived ease of use of GeoGebra for circle theorems' instruction did not influence "the perceived attitude towards" of rural Eswatini pre-service teachers. This finding is surprising given the body of knowledge's widespread belief that perceived ease of use influences perceived attitude (Mutambara & Bayaga, 2020b; Sánchez-Prieto et al., 2019; Teo et al., 2015). These results were also in contradiction with those of Kalogiannakis and Papadakis (2019), who discovered that pre-service teachers' perceived ease of use influences their perceived attitude toward the use of ICT in education. Two possible explanations for these findings are the timing of data collection for this study. The survey was conducted after the pre-service teachers completed their post-test. This suggests that the pre-service teachers were accustomed to the use of GeoGebra in the learning of circle theorems. With practice, the effect of perceived ease of use diminishes (Mutambara & Bayaga, 2020c). The survey was conducted when the pre-service teachers had already been subjected to and were familiar with GeoGebra. Additionally, rural Eswatini pre-service teachers perceived the use of GeoGebra as simple for learning circle theorems. These are the two reasons why rural

Eswatini pre-service teachers' perceived attitudes toward the use of GeoGebra were unaffected by their perceived ease of use.

The study also discovered that the perceived ease of use of rural Eswatini pre-service teachers does not influence their Technology Task Fit. This finding implies that the effort required to learn to use GeoGebra has no effect on rural Eswatini pre-service teachers' perceptions of GeoGebra's ability to improve cognition of circle theorems. The findings revealed that rural Eswatini pre-service teachers unanimously agreed that GeoGebra was simple to use, as evidenced by a mean score of 4, or higher on all questions concerning perceived ease of use in this study. However, the fact that it takes less effort to learn to use GeoGebra in learning circle theorems has no effect on rural Eswatini pre-service teachers' perceptions of GeoGebra's ability to improve cognition of circle theorems.

6.3.3 Technology Task Fit

Technology Task Fit, as defined by Goodhue and Thompson (1995), is a most important aspect in explicating job performance levels. Technology Task Fit is a question of how the proficiencies of the information system complement the undertakings that the user must accomplish. Two survey questions were created to test key aspects of Technology Task Fit, specifically how rural Eswatini pre-service teachers perceived GeoGebra's ability to improve cognition of learning circle theorems. In their survey responses, rural Eswatini pre-service teachers almost unanimously agreed that GeoGebra can improve cognition of circle theorems. The TTF1 had a mean of 4.710 and a standard deviation of 1.884, while TTF2 had a mean of 5.000 and a standard deviation of 1.900. The mean of all the survey questions was greater than 4, indicating that the majority of rural Eswatini pre-service teachers agreed that GeoGebra can improve circle theorems' cognition.

According to the findings, Technology Task Fit had a positive effect on the TAM variables, perceived usefulness, perceived attitude toward use, and actual use. These findings supported H7 (β=.454, $p<.05$), H8 (β=.136, $p<.05$), and H9 (β=.403, $p<.05$). These outcomes entail that for every one-unit improvement in rural Eswatini pre-service teachers' Technology Task Fit, their perceived usefulness, perceived attitude toward use, and actual use will increase by 0.454, 0.136, and 0.403, respectively. These findings indicate that rural Eswatini pre-service teachers' beliefs about GeoGebra's ability to improve circle theorem cognition influence their attitudes toward it, perceived usefulness, and actual use.

The outcomes of this study are coordinated with findings of Wu and Chen (2017), who found that Technology Task Fit influences perceived usefulness. In this study, rural Eswatini pre-service teachers used GeoGebra for learning circle theorems and have recognized that it can improve their cognition, as their mean scores for the pre-test were significantly less than their mean scores for the post-test. It is this belief that GeoGebra is useful to improve their cognition of circle theorems, which makes rural Eswatini pre-service fit for learning circle theorems.

The findings show that the Technology Task Fit of rural Eswatini pre-service teachers influences their perceived attitude toward the use of GeoGebra for learning circle theorems. These findings are consistent with findings from (Alamri et al., 2020; Gan, Li, & Liu, 2017) during which it was concluded that the suitability of GeoGebra for teaching circle theorems influences rural Eswatini pre-service teachers' attitudes toward GeoGebra. GeoGebra's ability to experiment with circles to improve cognition in circle theorems influences the attitude of rural Eswatini pre-service teachers toward GeoGebra.

In this study, pre-service teachers from rural Eswatini used GeoGebra to learn circle theorems and in so doing, they realized that it is GeoGebra's capabilities that allow it to match the task (learning circle theorems). That is, GeoGebra's ability to improve cognition in circle theorems is what causes rural Eswatini trainees to comprise an irrefutable opinion towards GeoGebra.

The application of GeoGebra on circle theorems' learning was found to be influenced by Technology Task Fit. These outcomes are coherent with those of Glowalla and Sunyaev (2014) and Isaac et al. (2019), who found that university students' Technology Task Fit influences their use of online learning. The findings suggest that the ability of GeoGebra to fit and enhance cognition in circle theorems influenced rural Eswatini pre-service teachers' decision to use GeoGebra for learning circle theorems. According to Goodhue and Thompson (1995), Technology Task Fit is a major factor in explaining job performance levels. Rural Eswatini pre-service teachers realized that GeoGebra can improve their performance in circle theorems, which increases their decision to use it.

Technology Task Fit also plays a considerable function in mediating the affiliation between user satisfaction and actual use of GeoGebra for learning circle theorems. Table 6 (see section 5.5.2) shows the path coefficient as (β =.025, $p < 0.05$). This result infers that if their user satisfaction with GeoGebra increases by one-unit, rural Eswatini pre-service teachers' actual use will increase by 0.025 units. User satisfaction was demarcated as an individual's emotional mindset toward an exact computer package expressed by a person who directly uses the application (Doll & Torkzadeh, 1988). In this study, rural Eswatini pre-service teachers used GeoGebra for learning circle theorems, and they were satisfied that it can be used to enhance their cognition of circle theorems. It is this belief that developed an affective attitude of the pre-service teachers towards GeoGebra-based circle theorems' instruction that influences them to use GeoGebra.

6.3.4 Perceived Usefulness

In the educational context, perceived usefulness was defined as a person's confidence that using ICT will escalate his/her teaching and learning (Mutambara & Bayaga, 2020b). Five questions were designed for the survey to test key aspects of perceived usefulness, most notably how rural Eswatini pre-service teachers perceived the usefulness of GeoGebra for learning circle theorems. In their responses to all five survey questions, rural Eswatini teacher-trainees were almost unanimous and agreed that GeoGebra was useful in learning circle theorems. The PU1 had a mean of 4.960 with a standard deviation of 1.978, PU2 had a mean of 4.820, with a standard deviation of 1.906, PU3 had a mean of 4.810, with a standard of 1.993, PU4 had a mean of 4.900, with a standard deviation of 2.049, and PU5 had a mean of 5.260, with a standard deviation of 1.786.

The results revealed that perceived usefulness influenced perceived attitude towards the use, but not actual use. These results supported H3 ($\beta = .364$, $p < .05$), but not H2 ($\beta = -.031$, $p > .05$), and they implied that rural Eswatini pre-service teachers' perceived attitude towards will increase by 0.364 units if their perceived usefulness increases by one unit.

Congruent to the findings of Kalogiannakis and Papadakis (2019) and Joo et al. (2018), this study discovered that the perceived usefulness of GeoGebra for learning circle theorems had a positive impact on the perceived attitude of rural Eswatini pre-service teachers. The findings are also incompatible with those of Bhattarai and Maharjan (2020), who discovered that pre-service teachers' intention to use technology in class is influenced by their belief that it improves their teaching performance. The rural-based pre-service teachers completed pre- and post-tests for this study, and post-test scores of the majority were higher than those of the pre-test. Hence, an inference can be drawn that the use of GeoGebra necessitated an improvement in their performance. This belief that using GeoGebra will improve their performance in circle theorems influences their attitudes toward GeoGebra. Rural Eswatini pre-service teachers discovered that they can easily manipulate objects inside circles after using GeoGebra to learn circle theorems. This improved their comprehension of the circle theorems. Hence, GeoGebra's ability to improve rural Eswatini pre-service teachers' circle theorem cognition improves their attitude toward it.

According to findings of this study, Eswatini pre-service teachers' actual use of GeoGebra for circle theorems is unaffected by their perceived usefulness. These findings contradict those of Lin and Huang (2008) and Yang (2007), who disclosed that the utility of an invention influences its use by pre-service teachers. Outcomes of this study were not a surprise, given that the rural Eswatini trainees had previously used GeoGebra, and found it useful for learning circle theorems. One would expect GeoGebra's utility to have an impact on its actual use.

Although perceived usefulness had no direct influence on actual use, it did have an indirect effect through the mediation of perceived attitude toward using GeoGebra for learning circle theorems. The path has a coefficient ($\beta = .233$, $p > .05$), as illustrated by the outcomes in Table 10 (see section 5.5.2). This judgment hints that the usefulness of GeoGebra in the learning of circle theorems for rural Eswatini pre-service teachers influences actual use through their attitudes toward it. Perceived attitudes of rural pre-service teachers toward GeoGebra plays an important role in its actual use. The utility of GeoGebra for circle theorems reinforces the attitudes of rural Eswatini pre-service teachers toward its use, which influences its actual use.

6.3.5 System Compatibility

The findings revealed that system compatibility has no effect on actual use. The H11 was not supported by the data (β = .102, p > .05). The results contradict the findings of Alamri et al. (2020), Islam and Azad (2015), and Isaac et al. (2019), who discovered that system compatibility influences university pre-service teachers' use of online learning applications. This finding implies that rural Eswatini pre-service teachers perceive GeoGebra to be incompatible with their values and prior experiences with learning circle theorems. This misalignment is what causes rural Eswatini pre-service teachers' actual use of GeoGebra for learning circle theorems to be unaffected by their GeoGebra's system compatibility.

According to the findings in Table 10, system compatibility had an implied control over actual use via the mediation of perceived attitude, and perceived usefulness. This finding implies that the degree to which GeoGebra is professed to resound with the modern requirements, standards, and previous occurrences of rural Eswatini pre-service teachers is not strong enough to directly influence GeoGebra's use, but it does contribute through perceived usefulness and perceived attitude toward the use.

The results of objective 2 are summarized in Figure 17 where it is illustrated that perceived attitude towards, perceived ease of use, and Technology Task Fit had direct influence on actual use. Perceived usefulness had an indirect effect on actual use through perceived attitude. Technology Task Fit mediates the effect of system compatibility and user satisfactory on actual use, and then perceived usefulness is influenced by perceived ease of use and Technology Task Fit.

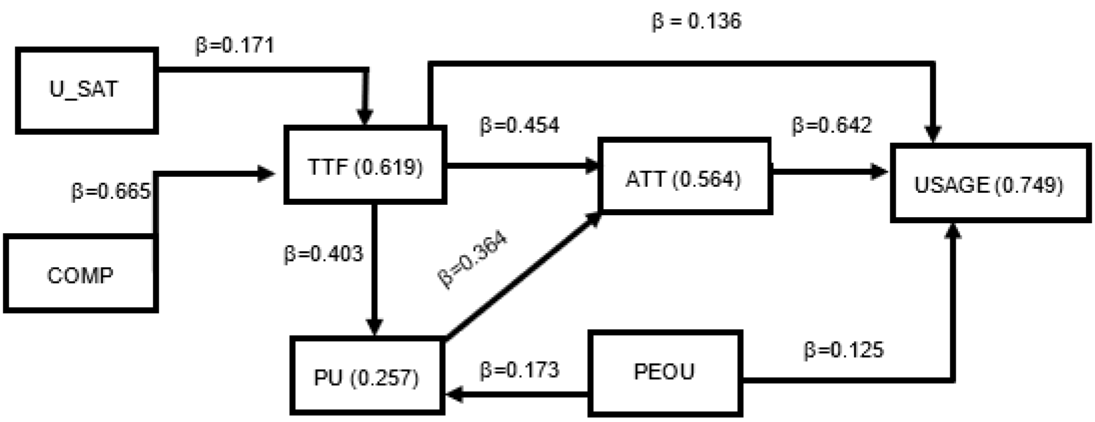

Figure 17 : Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra Model, Source: Researcher

6.4 The Effects of Gender on the Acceptance of GeoGebra

Multigroup analysis was used in this study to examine the effects of gender on rural Eswatini pre-service teachers' actual use of GeoGebra in the learning of circle theorems. Table 14 (see section 5.5.2) displays the results and shows that only one of the nine paths tested (TTF to ATT) was significant. At the 0.05 level, the other seven paths were insignificant.

According to the findings of this study, the path: TTF to ATT ($\beta = 0.258$, p 0.04) was significant. This result indicates that there is a tangible distinction in the path coefficients of male and female rural Eswatini pre-service teachers on the path TTF to ATT. However, the path was significant for both subgroups (males and females), indicating that both males and females agreed that their Technology Task Fit influences their perceived attitude toward using GeoGebra in learning circle theorems.

This discovery is inconsistent with Teo and Milutinovic (2015) findings that gender had no influence on Serbian pre-service teachers' intention to use technology. However, the finding is harmonious with the findings of Belgheis and Kamalludeen (2018) and Admiraal et al. (2017), who likewise found that pre-service teachers' intention to use GeoGebra is unaffected by their gender.

The results also show that there was no arithmetically substantial demarcation in male and female path coefficient values on the following paths: ATT to USAGE, COMP to TTF, PEOU to PU, PEOU to USAGE, PU to ATT, TTF to USAGE, TTF to PU, and U SAT to TTF. These breakthroughs are in accordance with those of Teo et al. (2015), Admiraal et al. (2017), and Belgheis and Kamalludeen (2018), who discovered that pre-service teachers' use of GeoGebra in class is not influenced by their gender. It can therefore be concluded, according to these findings, that male and female rural Eswatini pre-service teachers’ values when using GeoGebra to learn circle theorems are the same. In other words, gender has no effects on rural Eswatini pre-service teachers' use of GeoGebra for learning circle theorems. One possible explanation for these discoveries is that both male and female rural Eswatini trainees who partook in this enquiry were of the same age, and they had majored in the same subjects. The participants were also from a similar age bracket, they had a parallel fluency regarding computer use, and they were studying the same subject majors. This means even though students have different capabilities in circle theorems, these differences were not based on gender; thus, gender could not moderate their actual use of GeoGebra in learning circle theorems.

The results of this study contradict those of Teo and Noyes (2014) which revealed that gender moderates the acceptance of technology use in the classroom by pre-service teachers. In their study, Teo and Noyes (2014), revealed that the force and influence of the central factors of the UTAUT may function diversely when effected on different genders. Contrary to the finding of Teo and Noyes (2014), this study established that the same model (Rural Eswatini Pre-service teachers' acceptance of GeoGebra model) can be earmarked for the explanation of actual use of GeoGebra in learning circle theorems, both for male and female rural Eswatini pre-service teachers.

6.5 The Effects of GeoGebra on Pre-Services Teachers' Cognition of Circle Theorems

The paired-samples t-test was used to establish whether GeoGebra improves the cognition of circle theorems in rural Eswatini pre-service teachers, and the results are shown in Table 15 (section 5.5.2) in which it can be concluded that there was a numerically prominent variation between pre-test ($M = 4.82$, $SD = 1.96$) and post-test ($M = 6.29$, $SD = 1.758$), $t(249) = -27.053$, p 0.001. (two-tailed). The mean increase in pre-service teachers' marks in rural Eswatini was 1.47, with a confidence interval ranging from -1.579 to -1.365. The results showed that post-test scores for rural Eswatini pre-service teachers were higher than pre-test scores, and the difference was statistically significant. The results show that GeoGebra's ability to give rural Eswatini pre-service teachers' the opportunity to experiment and interact with circles enhances their cognition on circle theorems. This purports that using GeoGebra to learn circle theorems improves the cognition of rural Eswatini pre-service teachers.

GeoGebra usage was found to be directly and statistically related to rural Eswatini pre-service teachers' achievement in circle theorems. These findings are consistent with those of Salifu (2020b) and Ganesan and Eu (2020), who discovered that GeoGebra improves pre-service teachers' geometry cognition. One possible explanation for this conclusion is that by using GeoGebra to learn circle theorems, rural Eswatini pre-service teachers were able to manipulate and comprehend circle properties, thereby improving their cognition.

This discovery is significant in Eswatini colleges because it provides empirical evidence that GeoGebra can be used to enhance geometry cognition. The finding is also significant to the Department of Education as it provides evidence that using technology in the classroom can improve students' performance in mathematics. Furthermore, research has shown that when technology is used, a higher level of learner enthusiasm, subject knowledge acquisition, and effective teaching can all be easily achieved (Belgheis & Kamalludeen, 2018), than when technology is not incorporated.

6.6 Summary

Findings of this study were the central discussion and dominant reflection of this chapter. To begin with, factors influencing rural Eswatini pre-service teachers' Technology Task Fit were reviewed. It was concluded that user satisfaction and system compatibility are the determinants of rural Eswatini pre-service teachers' Technology Task Fit. Findings also revealed that perceived ease of use and system quality are good predictors of Technology Task Fit in rural Eswatini pre-service teachers.

This chapter also examined factors that rural Eswatini pre-service teachers consider important when learning circle theorems using GeoGebra. Findings revealed that perceived attitude toward use, perceived ease of use, and Technology Task Fit, all have a direct impact on actual use of GeoGebra for learning circle theorems. Perceived usefulness was found to be directly related to perceived ease of use and Technology Task Fit. In turn, perceived usefulness was discovered to have no direct effect on actual use of GeoGebra to learn circle theorems. Through the mediation of perceived attitude toward, and perceived usefulness, they were found to have an implied bearing on actual use. Through the mediating effect of Technology Task Fit, it was discovered that user satisfaction and system compatibility have inferred control over actual use.

Findings on the effects of gender on actual use of GeoGebra in the learning of circle theorems were also discussed in this chapter. The findings corroborated that gender does not possess any bearing on the use of GeoGebra for learning circle theorems. These findings imply that both male and female rural Eswatini pre-service teachers consider the same factors when learning circle theorems using GeoGebra. It can thus be concluded that rural Eswatini pre-service teachers' acceptance of the GeoGebra model can be used to explain the use of GeoGebra in the learning of circle theorems for both male and female rural pre-service teachers.

Furthermore, pre- and post-test scores for rural Eswatini pre-service teachers differed significantly. This discovery supports the contention that GeoGebra can be used to improve circle theorems' cognition. Recommendations that address these issues are outlined in the next chapter. Contained in the chapter that follows, is also the theoretical contribution, practical contribution, methodological implications of the study, limitations, and propositions for future research.

CHAPTER SEVEN

SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter looked at the implications of the study's findings, both in terms of the study's limitations and what it means for understanding the acceptance of GeoGebra for learning circle theorems by rural Eswatini pre-service teachers. Recommendations on what Eswatini pre-service teacher training institutions could do to ensure the successful implementation of GeoGebra for learning circle theorems were suggested. Finally, suggestions for future research on aspects of the subject in Eswatini and other African countries are made. The next discussion is the summary of each chapter in this study.

7.2 Summary of Each Chapter

Chapter 1 presented the background of the study and highlighted the problem to be investigated. Research questions and objectives were also presented in chapter 1. The significance of this study, and the possible contributions were also highlighted in the first chapter which ended by describing the structure of the thesis.

Chapter 2 provided a detailed review of past studies that are related to the study. This chapter presented the findings of other researchers who sought to find the acceptance of GeoGebra by pre-service teachers. The chapter also presented the results of other scholars on the effects of gender on the acceptance of GeoGebra. The effects of GeoGebra on students' performance was also discussed in chapter 2.

Chapter 3 discussed the theoretical underpinnings of this study and presented the TAM and the TTF as the theories underpinning the study. Each theory (the TAM and the TTF) was discussed and the justifications for use of the two theories were also presented. The chapter also presented the conceptual framework of the study and ended by presenting the model hypotheses.

Chapter 4 highlighted the philosophical position of the researcher and presented the research methods used in this study. The chapter also presented the two types of structural equation modelling, and the criteria used to select the partial least squares as the data analysis method of this study. Ultimately, a detailed presentation on how data was going to be analysed was given in this chapter.

Chapters 5 and 6 presented the results of the study. Moreover, in chapter 6, the results of this study were compared to results of the other scholars who conducted similar studies.

Ultimately, *Chapter 7* summarised the findings of this study.

7.3 Contributions of the Study

This study sought to debunk elements that rural pre-service teachers deem crucial when using GeoGebra to enhance circle theorems cognition. The study has made a significant input to the knowledge databank. The contributions made by this study to the exiting literature on the use of GeoGebra can be divided into theoretical and practical contributions.

7.3.1 Theoretical Contribution

This study has added to theory-building in the sector of technology acceptance, particularly in a higher educational context, by proposing and empirically testing rural Eswatini pre-service teachers' acceptance of the GeoGebra Model. The study focused on external factors that influence pre-service teachers' Technology Task Fit, thereby combining the Technology Acceptance Model and Technology Task Fit to prove factors that can predict pre-service teachers' actual use of GeoGebra for learning circle theorems in Eswatini. The study sheds some light on the causal relationships between the Technology Task Fit and the Technology Acceptance Model. The acceptance of the GeoGebra Model by rural Eswatini pre-service teachers is detailed as follows.

Contribution 1: This study developed, and empirically tested the Rural Eswatini Pre-service Teachers' Acceptance of GeoGebra Model to create a model that can be used to forecast rural Eswatini pre-service teachers' acceptance of GeoGebra for learning circle theorems. Factors that can be used to predict Technology Task Fit in rural Eswatini pre-service teachers were included in this model. System Compatibility and User Satisfaction influenced the Technology Task Fit of rural Eswatini pre-service teachers. The degree to which pre-service teachers in rural Eswatini perceived GeoGebra's ability to improve cognition of learning circle theorems was influenced by their perception of its usefulness and desire to reuse it. Furthermore, the degree to which a system is technically sound, flexible, and sophisticated influenced rural Eswatini pre-service teachers' perceptions of GeoGebra's ability to improve cognition in circle theorems.

Contribution 2: The Rural Eswatini Pre-service Teachers' Acceptance of the GeoGebra Model was also evaluated to identify the factors that control rural Eswatini pre-service teachers' actual use of GeoGebra for learning circle theorems. The study showed that perceived attitude toward, perceived ease of use, and Technology Task Fit, all have a direct influence on actual use. Through perceived attitude, perceived usefulness had an indirect effect on actual use. The effect of system compatibility and user satisfaction on actual use is mediated by Technology Task Fit. Perceived ease of use and Technology Task Fit both influence perceived usefulness.

Contribution 3: The original Technology Acceptance Model has been expanded by including Technology Task Fit. The factors: System Compatibility and User Satisfaction have an indirect impact on rural Eswatini pre-service teachers' use of GeoGebra to improve cognition of circle theorems. This study also revealed the Technology Task Fit Influences TAM's perceived usefulness and perceived attitude towards. The discovery suggests that GeoGebra's ability to improve rural Eswatini pre-service teachers' cognition of learning circle theorems influence its usefulness and their attitudes toward it. This study also revealed that context-related external variables can be used to improve the prognostic power of the initial TAM. This is useful for creating other conceptual frameworks for investigating technology adoption in educational settings.

Contribution 4: According to the investigations' outcomes, perceived attitude toward the use of GeoGebra for learning circle theorems was the strongest direct predictor of actual use by rural Eswatini pre-service teachers. This implies that the attitudes of rural teacher-trainees toward GeoGebra have a principal bearing in its actual use to improve cognition of circle theorems.

7.3.2 Practical Contribution

In practice, this research has contributed to a better understanding of the factors that can help or hinder the successful implementation of GeoGebra for learning circle theorems in Eswatini. These factors can assist Eswatini teacher training institutions, researchers, and educational learning platform-developers in creating mathematical educational learning platforms that are successful. This is especially true in the setting of African countries and other countries with a growing economy where the situation in teacher education institutions is like that of Eswatini. Individual contributions are described in detail.

Contribution 6: This study discovered that user satisfaction and system compatibility are good predictors of Technology Task Fit and through this finding, it can be inferred that an educational learning platform should be technically sound, flexible, and sophisticated for users to want to reuse it. This discovery assists educational learning platform developers in inventing mathematical educational learning platforms that are technically sound, flexible, and sophisticated, as this will improve their actual use.

Contribution 7: On the one hand, perceived attitude toward actual GeoGebra use was discovered to be the best predictor of actual use. On the other hand, perceived attitude toward use was discovered to play a critical mediating role between perceived usefulness and actual use. This finding implies that, for educational learning platforms to be successfully implemented in Eswatini teacher training institutions, pre-service teachers' mind-set on technology incorporation in education ought to be optimistic. This discovery assists Eswatini teacher training institutions and researchers in determining factors that influence pre-service teachers' perceived attitude toward technology integration in education. According to the findings of this study, perceived usefulness and Technology Task Fit accounts for (56.4 %) in perceived attitude towards the use. It is critical for researchers to isolate additional elements that impact teacher-trainees' opinions toward technology integration, as this plays a significant role in its actual use.

Contribution 8: The original Technology Acceptance Model and Technology Task Fit Models have been applied in an educational context, and it has been demonstrated that the two models can be combined to explain the actual use of technology in an educational context. This is useful for other researchers who are interested in developing conceptual frameworks for investigating the acceptance and use of e-learning technology in their own educational contexts.

Contribution 9: This study also shows that incorporating GeoGebra adaptive technology can improve cognition of circle theorems. This discovery provides undeniable evidence to education ministries in developing countries that technology integration improves teaching and learning.

Contribution 10: GeoGebra usage by pre-service teachers was also examined in this study. Successful implementation requires an understanding of the factors that influence students' acceptance of, and use of, technology for learning. Institutions must consider students' technology acceptance factors before investing in technology integration projects. Before students can use an information system, they must firstly accept it. To avoid the squandering of funds, by institutions, the technology acceptance agenda must be prioritised and made a prerequisite. In this study, User Satisfaction and System Compatibility had a straight impact on Technology Task Fit, which in turn influenced the actual use. Perceived attitude towards and perceived ease of use had a direct effect on actual use. Perceived usefulness had an implied influence on actual use through the mediating effect of perceived attitude towards.

7.4 Limitations of the Study

The results of the research need to be contemplated considering its limitations as enlisted thus:

- The study was limited to a rural teacher training institution. To get a clearer picture of the actual use, both rural and urban areas of Eswatini should be considered.
- Only pre-service teachers were the participants in this study. Generalising the outcomes of this investigation across all universities and colleges must be prudently instigated.
- The study focused on one teacher training institution; thus, generalisation of these results to other teacher training institutions should be cautiously undertaken.
- For the same reasons, it was a snapshot of the situation in rural Eswatini teacher training institutions. One can expect a study like this to capture the current situation as accurately as

possible, but it is essential to remember that time does not stand still, and the human world, and everything in it is constantly changing. Perceived Usefulness and Perceived Ease of Use are two core constructs that have been shown to change over time in other studies (Mutambara & Bayaga, 2021). There is a good chance that many of the phenomena discovered in this study, such as the fact that there is no appreciable discrepancy between both genders' acceptance of GeoGebra as a tool for learning circle theorems, will change over time.

7.5 Conclusion

This research established that rural Eswatini pre-service teachers' Technology Task Fit is influenced by User Satisfaction and System Compatibility. Perceived ease of use and System Quality were found not to be good predictors of rural Eswatini pre-service teachers' Technology Task Fit. The study revealed that User Satisfaction and System Compatibility explained (61.9%) of variance in rural Eswatini's Technology Task Fit. The study also established that GeoGebra can improve rural Eswatini pre-service teachers' circle theorems' cognition.

The research also highlighted that perceived attitude towards the use, perceived ease of use, and Technology Task Fit, had a direct effect on the actual use of GeoGebra for learning circle theorems. Perceived usefulness was found to have an insignificant direct effect on actual use, however, and had an indirect effect through the mediating effect of perceived attitude towards the use. Technology Task Fit mediated the effect of User Satisfaction and System Compatibility on actual use. The model explained (74.9%) of variance in rural pre-service teachers' actual use of GeoGebra for learning circle theorems.

The study also indicated an indifferent outcome between male and female rural Eswatini pre-service teachers' actual use of GeoGebra for learning circle theorems. This finding implies that gender was not a moderator of rural Eswatini pre-service teachers' actual use of GeoGebra for learning circle theorems. This means that Rural Eswatini Pre-service Teachers' Acceptance of the GeoGebra Model can be used for both male and female pre-service teachers to explain the actual use of GeoGebra for circle theorems' cognition.

7.6 Recommendations

Research on technology acceptance and use is an ongoing scholastic agenda, particularly in developing countries, and more investigation is required to advance our understanding. There are several options for expanding on this research. The following are some ideas for future research on GeoGebra.

- Future studies could focus similar research on other learning platforms and compare the results. This study only focuses on GeoGebra, so repeating the study with different learning platforms would enhance understanding.
- Future studies could conduct a similar study in urban teacher training institutions and compare the results with those of this rural-based investigation. This study only focused on rural pre-service teachers, therefore repeating the same study in urban areas would give a clear picture of the acceptance and use of GeoGebra by pre-service teachers in Eswatini.
- The Rural Eswatini pre-service teachers' acceptance of the GeoGebra Model explained (74.9%) of variance in rural Eswatini pre-service teachers' actual use of GeoGebra. It would be interesting to find other factors other than the ones evaluated in this study that influence the actual use of GeoGebra in Eswatini.
- Moreover, the study focused on one teacher training institution; future research could repeat the same study with students from other faculties other than education. This would enhance identifying the elements that impact Technology Task Fit and the actual use of GeoGebra in Eswatini.

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APPENDIX A - QUESTIONNAIRE

User satisfactory (U_SAT)	Sources
Overall, I am satisfied with GeoGebra adaptive technology enhancing my cognition of circle theorems	(Gharbawi & Bassam, 2016b)
GeoGebra proves circle theorems satisfactorily and enhances	
Attitude towards (ATT)	
I believe it is beneficial to use GeoGebra for learning circle theorem	(Mutambara & Bayaga, 2020a; Mutambara & Bayaga, 2020c)
I would like to use GeoGebra to learn other geometry concepts	
I feel positive about using GeoGebra for learning circle theorem	
My experience with GeoGebra to learn learning circle will be good	
Task-Technology Fit (TTF)	
The GeoGebra technology has all the necessary buttons with relevant functionality to learn all geometry circle theorems	(Gharbawi & Bassam, 2016b)
I solve circle theorem problems easily because all of the tools I need to draw and measure angles, draw circles, points, lines, tangents to a circle, chords, cyclic quadrilaterals, triangles, and bisectors are available	
Solving circle problems using GeoGebra made me excited, enthusiastic and motivated	
Learning ambience was changed and my attention was improved during circle theorems in which GeoGebra was used to enhance cognition	
Quality (QUAL)	(Gharbawi & Bassam, 2016
the interactive geometrical property of GeoGebra enhances conceptual understanding	
GeoGebra improves visualisation of concepts and establishes a link between different related concepts	
GeoGebra makes learning, an abstract concept, much more meaningful.	
Compatibility (COMP)	
GeoGebra is compatible with my operating system	(Mutambara & Bayaga, 2020a; Mutambara & Bayaga, 2020c)
GeoGebra is compatible with my computer hardware device	
Perceived Ease of Use (PEOU)	
Learning how to use the basic GeoGebra geometry tools is simple	
I find it easy to get GeoGebra adaptive technology to do any geometrical constructions I want.	
My interaction with the GeoGebra adaptive technology during my mathematics lessons is clear and understandable	
I find GeoGebra adaptive technology during circle theorem lessons flexible to interact with	
It is easy for me to become skilful at using GeoGebra adaptive technology during circle theorem lessons	

I find GeoGebra adaptive technology easy to use	
Perceived usefulness (PU)	
Using GeoGebra in class will improved my work efficiency in learning circle theorems	(Mutambara & Bayaga, 2020a; Mutambara & Bayaga, 2020c)
Using GeoGebra to learn circle theorems will enhance the quality of my learning	
Using GeoGebra to learn circle theorems would increase my productivity	
Using GeoGebra would enhance my effects in learning circle theorems	
Using GeoGebra would make it easier for me to learn circle theorems	
I would find GeoGebra useful in learning circle theorems.	
Actual usage (USAGE)	
I intent to continue to use GeoGebra	(Gharbawi & Bassam, 2016
I intent to use GeoGebra for learning circle theorems	
I intent to continue use GeoGebra for learning geometry	
I intent to use GeoGebra in my future studies	
I intent to use GeoGebra in my teaching carrier	

APPENDIX B – CONSENT LETTER FROM COLLEGE PRINCIPAL

ANNEXURE B: Permission to conduct research in a teachers' college

University of Zululand

Private Bag X1001

KwaDlangezwa

3886

Tel 035 902 6220

Email:

realboytwo@gmail.com

11 February 2020

The Principal

Ngwane Teachers College

Nhlangano

S400

Eswatini

Dear Sir/Madam

A REQUEST FOR PERMISSION TO CONDUCT RESEARCH WITH PRE-SERVICE TEACHERS

I am a student conducting research for Doctoral Education degree in the faculty of Education at the University of Zululand. I write this letter to request for permission to conduct research with pre-service teachers at your college. My research focus is on enhanced cognition of circle theorems via adaptive technology in rural-based Eswatini: PRE-SERVICE teachers' usage and acceptance of GeoGebra.

The aims of my study are:

1. To explore rural-based Eswatini pre-service teachers' awareness of GeoGebra usage in the cognition of circle theorems.

2. To investigate the degree to which rural-based Eswatini pre-service teachers use adaptive technology (GeoGebra) to solve circle geometry theorem problems.
3. To determine factors affecting rural-based Eswatini pre-service teachers' usage of GeoGebra as adaptive technology in the cognition of circle theorems.
4. To determine factors affecting rural-based Eswatini pre-service teachers' acceptance of GeoGebra as an adaptive technology that enhances cognition of circle theorems.
5. To find out if GeoGebra enhances rural-based Eswatini pre-service teachers' cognition of circle theorems.

Your consideration of this letter and granting of permission to conduct the research will be appreciated.

Yours sincerely

Mfanasibili P. Nxumalo

SUPERVISOR

Prof. A. Bayaga. Email: BayagaA@unizulu.ac.za

RESPONSE

I do/~~do not~~ give permission to the student to conduct research in...Ngwane Teachers.......College

Vice PRINCIPAL

(...Ngwane Teachers...College)

NGWANE
P.O. BOX 474
20 FEB 2020
4
NHLANGANO
TEACHERS COLLEGE

APPENDIX C – CONSENT LETTER FROM THE DEPARTMENT OF ESWATINI EDUCATION

ANNEXURE A: Permission to conduct research in a teachers' college

University of Zululand

Private Bag X1001

KwaDlangezwa

3886

Tel 035 902 6220

Email:

realboytwo@gmail.com

11 February 2020

Ministry of Education

P.O. Box 39

Mbabane

H100

Eswatini

Dear Sir/Madam

A REQUEST FOR PERMISSION TO CONDUCT RESEARCH WITH PRE-SERVICE TEACHERS

I am a student conducting research for Doctoral Education degree in the Faculty of Education at the University of Zululand. I write this letter to request for permission to conduct research with a teachers' college in the Shiselweni Region. My research focus is on enhanced cognition of circle theorems via adaptive technology in rural-based Eswatini: PRE-SERVICE teachers' usage and acceptance of GeoGebra.

The aims of my study are:

1. To explore rural-based Eswatini pre-service teachers' awareness of GeoGebra usage in the cognition of circle theorems.

2. To investigate the degree to which rural-based Eswatini pre-service teachers use adaptive technology (GeoGebra) to solve circle geometry theorem problems.
3. To determine factors affecting rural-based Eswatini pre-service teachers' usage of GeoGebra as adaptive technology in circle theorems cognition.
4. To determine factors affecting rural-based Eswatini pre-service teachers' acceptance of GeoGebra as adaptive technology that enhances cognition of circle theorems.
5. To find out if GeoGebra enhances rural-based Eswatini pre-service teachers' cognition of circle theorems.

Your consideration of this letter and granting of permission to conduct the research will be appreciated.

Yours sincerely

Mfanasibili P. Nxumalo

SUPERVISOR

Prof. A. Bayaga. Email: BayagaA@unizulu.ac.za

RESPONSE

I do/~~do not~~ give permission to the student to conduct research at the teachers college.

REGIONAL EDUCATION OFFICE
R.E.O
21 FEB 2020
P.O.BOX 112 NHLANGANO S400
SWAZILAND

____
REGIONAL EDUCATION OFFICER

Date 21/2/20

APPENDIX D – ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF ZULULAND
RESEARCH ETHICS COMMITTEE
(Reg No: UZREC 171110-030)

RESEARCH & INNOVATION
Website: http://www.unizulu.ac.za
Private Bag X1001
KwaDlangezwa 3886
Tel: 035 902 6731
Fax: 035 902 6222
Email: LundallN@unizulu.ac.za

ETHICAL CLEARANCE CERTIFICATE

Certificate Number	**UZREC 171110-030 PGD 2019/48**						
Project Title	**Enhancing cognition of circle theorems via adaptive technology in rural-based eSwatini: Preservice teachers usage and acceptance of Geogebra**						
Principal Researcher/ Investigator	MP Nxumalo						
Supervisor and Co-supervisor	Prof A Bayaga						
Department	Maths, Science and Technology Education						
Faculty	Education						
Type of Risk	Medium Risk – Data collection – from people						
Nature of Project	Honours/4th Year		Master's		**Doctoral**	x	Departmental

The University of Zululand's Research Ethics Committee (UZREC) hereby gives ethical approval in respect of the undertakings contained in the above-mentioned project. The Researcher may therefore commence with data collection as from the date of this Certificate, using the certificate number indicated above.

Special conditions:

(1) This certificate is valid for 1 year from the date of issue.
(2) Principal researcher must provide an annual report to the UZREC in the prescribed format [due date-13 December 2020]
(3) Principal researcher must submit a report at the end of project in respect of ethical compliance.
(4) The UZREC must be informed immediately of any material change in the conditions or undertakings mentioned in the documents that were presented to the meeting.

The UZREC wishes the researcher well in conducting research.

Professor Gideon De Wet
Chairperson: University Research Ethics Committee
Deputy Vice-Chancellor: Research & Innovation

13 December 2019

CHAIRPERSON
UNIVERSITY OF ZULULAND RESEARCH ETHICS COMMITTEE (UZREC)
REG NO: UZREC 171110-030
13-12-2019
RESEARCH & INNOVATION OFFICE

APPENDIX E – ETHICAL CLEARANCE EXTENSION

UNIVERSITY OF ZULULAND
RESEARCH ETHICS COMMITTEE
(Reg No. UZREC 171110-030)

RESEARCH & INNOVATION
Website: http://www.unizulu.ac.za
Private Bag X1001
KwaDlangezwa 3886
Tel: 035 902 6324/6374
Email: MangeleS@unizulu.ac.za/

ETHICAL CLEARANCE CERTIFICATE

Certificate Number	UZREC 171110-030 PGD 2019/48							
Project Title	Enhancing cognition of circle theorems via adaptive technology in rural-based eSwatini: Preservice teachers usage and acceptance of Geogebra							
Principal Researcher/ Investigator	MP Nxumalo							
Supervisor and Co-supervisor	Prof MS Mabusela				Mr A Chibisa			
Department	Maths, Science and Technology Education							
Faculty	Education							
Type of Risk	Medium Risk- Data collection from people							
Nature of Project	Honours/4th Year		Master's		Doctoral	x	Departmental	

The University of Zululand's Research Ethics Committee (UZREC) hereby gives ethical renewal approval in respect of the undertakings contained in the above-mentioned project. This approval is extended for another 1 year. The Researcher may therefore continue with data collection as from the date of this Certificate, using the certificate number indicated above.

SPECIAL CONDITIONS: (1) This certificate is valid for 1 Year from the date of issue.

(2) Principal researcher must provide an annual report to the UZREC in the prescribed format [due date- 10 January 2023]

(3) The UZREC must be informed immediately of any material change in the conditions or undertakings mentioned in the documents that were presented to the meeting.

(4) Under the Protection of Personal Information Act, 04 of 2013 ("POPIA"), researchers have a general legal duty to protect information they process. They must ensure the security and protection of any personal information processed through the research and provide a compliant and consistent approach to data protection. The information collected via interviews must be for research purposes only. No personal information such as opinions, views and academic background may be linked to the respondents' identity or shared with anyone for marketing purposes or otherwise.

The UZREC wishes the researcher well in conducting research.

Prof. Nokuthula Kunene
Chairperson: University Research Ethics Committee
Deputy Vice-Chancellor: Research & Innovation
10 January 2022

CHAIRPERSON
UNIVERSITY OF ZULULAND RESEARCH ETHICS COMMITTEE (UZREC)
REG NO: UZREC 171110-30
10 -01- 2022
RESEARCH & INNOVATION OFFICE

APPENDIX F – INFORMED CONSENT LETTER FOR PARTICIPANTS

Technology Education, Faculty of Education,

University of Zululand
Private Bag X1041
RICHARDS BAY
3900
11 February 2020

Dear Participant

INFORMED CONSENT LETTER

My name is Mfanasibili Philemon Nxumalo; I am a Technology Education PhD candidate studying at the University of Zululand, Kwadlangezwa Campus, South Africa. I am interested in exploring "Enhancing Cognition of Circle Theorems Via Adaptive Technology In Rural-Based Eswatini: Pre-Service Teachers Usage and Acceptance of GeoGebra" in Eswatini

To gather the information, I am interested in conducting mathematics lessons (on circle theorems) that will incorporate the use adaptive technology called GeoGebra in your class. I will also ask you write a pre-test/post-test and require you to complete a questionnaire.
Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person but reported only as a population member opinion.
- The lessons will last up to a period of 4 weeks and will fall within the teaching hours of your normal school timetable.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such an action.
  The research aims to:

  1. Determine the effect of rural Eswatini pre-service teachers' system quality, system compatibility, and user satisfaction on their Technology Task Fit of GeoGebra for circle theorems cognition.
  2. Find the factors that rural Eswatini pre-service teachers consider important when accepting GeoGebra.
  3. Investigate the effects of gender on the acceptance of GeoGebra by Eswatini pre-service teachers.
  4. Find the effects of GeoGebra on pre-services teachers' cognition of circle theorems.

- Your involvement is purely for academic purposes only, and there are no financial benefits/losses involved.
- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	willing	Not willing
Audio equipment		

Photographic equipment		
Video equipment		

I can be contacted at:
Email: realboytwo@gmail.com
Cell: +26876217899.

My supervisors are Professor M.S. Mabusela and Mr. A, Chibisa who are located at the Department of Education, Faculty of Science, Mathematics, and Technology Education Kwadlangezwa Campus – University of Zululand. Contact details: emails: MabuselaM@unizulu.ac.za, ChibisaA@unizulu.ac.za

APPENDIX G – LANGUAGE EDITOR'S CERTIFICATE

Angela Bryan & Associates

6 Martin Crescent
Westville

Date: 24 January 2022

To whom it may concern

This is to certify that the Thesis: Enhancing Cognition of Circle Theorems via Adaptive Technology in Rural -Based Eswatini: Pre-service Teachers' Usage and Acceptance of GeoGebra written by Mfanasbili P. Nxumalo has been edited by me for language.

Please contact me should you require any further information.

Kind Regards

Angela Bryan

angelakirbybryan@gmail.com

0832983312