Mathematics Lecturers' use of Technology in Teaching Circle Geometry at a selected Technical and Vocational Education and Training (TVET) College in KwaZulu-Natal

BY

REJOICE HLENGIWE MHLUNGU

(216072561)

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School of Education, College of Humanities, University of KwaZulu – Natal, Durban, South Africa

Supervisor: Dr. Lokesh Ramnath Maharajh

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SUPERVISOR'S STATEMENT

This thesis has been submitted with my approval.

[redacted]

DECLARATION

I, Rejoice Hlengiwe Mhlungu (student number 216072561), declare that:

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Rh Mhlungu **4 August 2022**

R. H. Mhlungu (216072561) **Date**

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ABSTRACT

This study explores the experiences of mathematics lecturers' use of technology in teaching circle geometry to level 4 at a selected TVET College. This qualitative study also aimed at exploring what, how, and why lecturers use that technology in a particular manner. An interpretive paradigm and case study were used on five participants to gain meaning in a real situation. For data generation needed to respond to the research questions in the study, the following instruments were utilized: open-ended questionnaires and individual semi-structured interviews. Purpose sampling was employed to acquire in-depth data. Data generated was guided by a TPACK theoretical framework for this study. The themes that emerged from data generation were Experiences and challenges regarding the use of technology, Students' performance, Content knowledge, mathematics teaching, and Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, Pedagogical Knowledge, Technological Knowledge, Technological Pedagogical and Content Knowledge and the use of technology in geometry teaching. The findings reveal insufficient relevant technologies to teach circle geometry level 4 at the TVET College. Mathematics lecturers encountered many challenges concerning the lack of relevant technology for specifically teaching circle geometry, and all mathematics lecturers were familiar with the concepts content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Most lecturers have sufficient knowledge of the teaching strategies, but the students lack a basic foundation in mathematics. Consequently, the teaching strategies that the mathematics lecturers use for circle geometry are specific to mathematics, and they experience difficulty teaching geometry. Lecturers can use technology for assessment, but available resources limit them for this study. Lastly, there is no opportunity for the lecturers to use technology for individual assessments for the students. There is a lack of insufficient resources limiting the teaching and learning of circle geometry at this TVET College. The DBE and DHET operate differently concerning curriculum development. Mathematics lecturers revealed that the FET phase mathematics' syllabus is different from NCV level 2 to 4, whereas it is equivalent according to DHET. There is evidence that inequality exists because some colleges use technology to teach geometry. Mathematics lecturers were confronted with many challenges concerning the lack of teaching and lecturing conditions due to security challenges on campuses to enable technology to teach circle geometry at level 4 in the TVET College. Although no technology is relevant to teaching circle geometry, mathematics lecturers are identified as incompetent in using technology in their circle geometry teaching activities. Mathematics lecturers do not hold technology knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge ((TPK), and technological, pedagogical, and content knowledge (TPACK) **relevant** for circle geometry. Mathematics lecturers are not competent in using circle geometry technology to teach level 4 in a TVET College. The study recommends that TVET Colleges provide mathematics lecturers with the required opportunity to teach level 4 circle geometry students using technology. Therefore, the findings of this study should be enlightening to the DHET and DBE ministers in South Africa for planning and designing the curriculum together through policies.

Keywords: content; technology; assessment; knowledge; pedagogy; circle geometry; mathematics

CHAPTER 1

INTRODUCTION TO THE STUDY

1.1. Introduction

This research study explored mathematics lecturers' use of technology in the teaching of circle geometry to level 4 at a selected Technical and Vocational Education and Training College in the Majuba District, KwaZulu-Natal, in South Africa. This research study is projected to determine 'what' technology lecturers use to unpack 'how' and 'why' lecturers use technology to teach circle geometry at a TVET College.

Mathematics teaching and performance in South Africa are complex. Chimuka (2017) has discovered that South Africa is faced with the poor performance of learners in mathematics. Many factors are affecting the teaching of mathematics in South African schools. Mathematics is measured by learners' achievement, of which the contextual factors may be teachers' practice, students, the nature of a school, classroom, language of teaching and learning, involvement of stakeholders, and curriculum issues. According to Mji and Makgato (2006), different teaching strategies used by different teachers add to the low performance in mathematics. Mulkeen (2005) states that rural areas get low-quality education since few teachers are qualified, lacking teaching resources compared to urban areas. Also, Arends, Winnaar, and Mosimege (2017) investigated how mathematics teachers' practice in the classroom affected learner performance. They discovered that various teacher classroom practices affect the learners' mathematics performance which shows that teacher classroom practices are crucial in learner performance in mathematics.

Reddy, Juan, Isdale, and Fongwa (2019) have discovered challenges of the inequality gaps between fee-paying schools and non-fee-paying schools from 1995 to 2015 to major achievements in mathematics and science. Consequently, to reduce low achievements, school climate pedagogical inputs and learning culture need to be addressed to improve learners' performance. They further clarified that there had been an improvement in learner performance in schools that have improved the availability of resources and learning conditions.

TVET lecturers and students use different types of technology in everyday life not for educational purposes but for socialising. Social networks are at high levels of usage.

Technology is used in learning and teaching and for school administration and management purposes. There is a big concern that teachers need to advance with technology use during teaching and learning situations. This advance may be known as transformation, labelled as the Fourth Industrial Revolution (4IR). Mathematics lecturers need to play a major role in the 4IR. During the pandemic (Covid -19), many TVET lecturers engaged with students via WhatsApp. The use of technology seems to be in demand in all higher education institutions, including universities and TVET Colleges. Internationally, technology use in teaching mathematics is increasing, with some governments making it compulsory for teachers to integrate technology in their teaching. Mailizar, Fan, and Education (2020) conducted a study in Indonesia where the aim was to investigate ICT to enhance the quality of education.

Euclidean Geometry in South Africa has negatively impacted learner performances (Bayaga, Mthethwa, Bossé, & Williams, 2019), including students in the TVET Colleges. Euclidean Geometry is one of the kinds of geometry that still exists and is recognized by mathematicians. TVET students start geometry only at level 4, the exit level, whereas at high schools, they start from grade 10. This late start of geometry by TVET students can bring about poor performance and a low pass rate in mathematics (Madhur, 2014). "Learning geometry is not easy, and some research found that several learners fail to develop an adequate understanding of Geometry concept" (Bhagat, Chang, & Education, 2015, p. 57). Mosia (2016) affirmed that underperforming learners in geometry are a product of a lack of understanding of the geometric language, concepts, theorems, and axioms and cause discouragement in learning, leading to failure in geometry.

Since the introduction of technology in geometry teaching, there has been a significant improvement in geometry performance when using technology for teaching and learning. For instance, Godebo (2018) found that using GeoGebra when teaching grade 11 geometry gave great improvement whereby it helped learners develop: 1. The visualisation that linked concepts and the development of mathematical ideas within computer based learning 2. creation of the independent constructivism learning and 3. Enhanced the conceptual understanding of geometry in learners. Govender (2016) also explored pre-services' views on the use of technology in the teaching of geometry where teachers were classified at the end of the study, which is knowing the essentials, knowledge of using technology in the teaching of geometry, and lastly using technology as a fast tracker to learning. This illustrates that technology improves learners' understanding of geometry concepts, thereby improving their performance in geometry.

The challenge with using technology in geometry teaching is that not all schools and TVET Colleges can afford the technology. This may give rise to inequalities in the education system if it is compulsory. During the pandemic era, inequality was observed whereby some schools and colleges were no longer affected especially private schools. Learning was not disrupted during the lockdown as they continued to use online learning up to the present moment. Another challenge is that some places still have no electricity for residential areas, which is also a challenge for some learners.

This research study then focused on using the available technology per the 4IR of the Vision 2030 in South Africa. This qualitative study was done with five mathematics lecturers who teach NCV level 4 mathematics, where geometry is studied at the exit level. By bearing in mind the purpose of this study, which is to explore lecturers' use of technology in teaching circle geometry at a TVET College, this research used two procedures for creating data, a questionnaire and a one-on-one semi-structured interview. This chapter discusses the background and focus of the study, the problem statement, the rationale, research objectives, and questions of the study and clarifies terms/concepts.

In the next section, I present a brief background of the study.

1.2. Background and focus

Since 2016, less than 50% of the matric final examination learners have written mathematics as a subject (Letsoalo, Masha, Maoto, & Development, 2019). Mathematics performance has been consistently lower than the other 11 main subjects offered at school. According to the Department of Basic Education, in 2018, only 21.7% of the mathematics learners achieved 50% and above. The results in mathematics have remained between 30% and 35%. The situation is not much better as far as mathematics literacy is concerned, an easier form of mathematics with more “practical” applications. From 2017 to 2018, the number of students taking the mathematics literacy examination has decreased, while the total number of students passing 30%, 40%, or higher has also declined. During this period, fewer students have taken and passed mathematics literacy at a level that shows basic competence.

During the twenty-seven years of my mathematics teaching in the Further Education and Training (FET) phase and at a TVET College, I have realised that geometry has not received the necessary attention and vigorous discussion by teachers and subject advisors, and departmental officials. When the National Curriculum Statement was introduced, geometry was downgraded to an optional paper 3 in mathematics in grades 10, 11, and 12 (Ma & Johnson, 2008). Making geometry optional gave rise to many teachers evading it. Teachers were limiting the learners' exposure to the reasoning associated with geometric understanding. However, CAPS geometry was returned as a compulsory module to the CAPS curriculum (Govender, 2016). Geometry is still a must, and it is also compulsory to teach it in grades 10, 11, and 12. The analysis of grade 12 results from the examiners' report found that the lowest average in that year for the second mathematics paper was found in Euclidean Geometry (Magidi, 2015). This suggests there may be a challenge in teaching and learning geometry.

Geometry in a TVET College is at level 4 (equivalent to grade 12) only, an exit level. The content in level 2 and level 3 has no geometry, possibly resulting in learners at a TVET College experiencing challenges in geometry. According to Ngoveni and Mofolo-Mbokane (2019), TVET learners perform poorly in geometry resulting in poor performance in mathematics at level 4. Geometry is a very important module and is the bedrock of engineering and technological development in our country. In 2017 the pass rate in level 4 mathematics by mechanical engineering students at two TVET Colleges was 15% and 19% (Ngwato, 2020).

Technology is the skillfulness, procedures, and techniques used to obtain objectives. Most people utilise technology to manufacture services or goods. When defining technology, Kasti (2018) mentioned that it is divided into visible 'hardware' devices like calculators, computers, laptops, smartphones, etc., and 'software'. Technology is used in learning and teaching and for school administration and management purposes. Educational technology is divided into traditional and modern technology (Vasquez, 2015). Das (2019) explored using technology in teaching mathematics by the teachers at the teacher-training colleges. The discoveries were that there are difficulties in using technology and mathematics software simultaneously because there are challenges in both mathematics content and technology use. Consequently, he mentioned more benefits of using technology than challenges.

Diagram 2.1 shows the benefits of using technology in education and learning (Das, 2019).

There is a concern that teachers need to advance with technology use during teaching and learning situations. This advance may be known as transformation, labelled as the 4IR. Mathematics lecturers need to play a major role in it. Lecturers need to be equipped with the necessary skills to teach and learn mathematics to be familiar with technology-based teaching strategies (Naidoo, 2019).

A robot teacher was introduced in India to replace the teachers. "This robot was praised on the 5th October 2019 during the World Teachers' Day for successfully teaching more than 300 learners to master subject content" (Mpungose, Khoza, & Learning, 2020, p. 4). A study was conducted at a particular University of Technology by Msomi and Bansilal (2019) to investigate the challenges of implementing e-learning practices faced by the lecturers in that sector. The findings indicate that lecturers show different enthusiasm towards integrating technology into education. Some lack confidence, while others lack access to resources and poor infrastructure. This suggests that even at the University of Technology, there is still inadequate integration of technology in the teaching and learning situation. Internationally, technology use in teaching mathematics is increasing, with some governments making it compulsory for teachers to integrate technology in their teaching. Lecturers need to be equipped with the necessary skills to teach and learn mathematics to be familiar with technology-based teaching strategies (Naidoo, 2019). Most students and lecturers do not use these for educational purposes. Rather they use these digital technologies face-to-face in the classroom (Mpungose et al., 2020). Most TVET lecturers have started to use WhatsApp to communicate with students during this Covid-19 pandemic. The question is, how many students are on this platform of social media? Most do not have access to the internet, data, or Wi-Fi. Circle geometry seems to be a difficult module for lecturers to teach and students to learn because it consists of difficult geometry language, drawings with angles, and thinking (Luneta, 2015). "The research on the effects of technology in the classroom is increasing very rapidly, but there seems to be much debate on whether or not technology has been making a significant impact on student achievement".

The South African Department of Education shows inequality concerning technology use between state and private schools. During the pandemic, only private schools did not experience difficulties for learning during the lockdown. Teaching continued with the help of online learning in private schools, while in state schools, learners stayed at home without learning for a longer timer than expected because of the shortage of technology to use for online learning. The lack of access to technology in TVET Colleges has affected learning during lockdown because students must stay at home. Although students were provided with laptops by DHET, not all students have access to WIFI or the internet. There is an urgent need for technology to be used in teaching and learning.

1.3. The rationale of the study

I have taught mathematics at a secondary school for twenty years, and over the last seven years, I have been teaching mathematics at a TVET College. During this time, I observed that teachers experienced difficulties teaching geometry. The quality of teaching and learning in South Africa is of great concern for educators, parents, education officials, and ordinary citizens (McConkey, 2014). Many researchers, too, have expressed concerns about the poor performance in mathematics, especially in geometry (Armah, Kissi, & Education, 2019). From a personal perspective, I have found that in the classroom context, most learners tend to struggle when completing tasks that involve calculations, proofs, and interpretation in circle geometry. They even attain low marks in the tests and examinations. Nonetheless, learners showed more interest when I supported my teaching with technology such as an overhead projector (OHP) or PowerPoint presentation in my lesson. They seemed to take more caution of the steps to be followed when doing calculations and proofs.

We have experienced several technological developments in the twenty-first century (Mdlongwa, 2012). Information and Communication (ICT) technology has become an unavoidable aspect of life. We encounter ICT at universities, schools, sports fields (e.g., Video Assisted Referee – VAR), and personal (WhatsApp, Facebook, etc.). According to Theunissen and Siebörger (2019), ICT could address the crisis in South African education and has the potential to improve education. Therefore, it may be wise to include ICT in the teaching of circle geometry at TVET Colleges. The Department of Basic Education (2016) has also made a call for ICT to improve learner performance. The use of ICT by mathematics teachers in the teaching and learning of mathematics results in various economic, educational, and socio-political gains (Adelabu, Makgato, & Ramaligela, 2019; Cesaria & Herman, 2019; Mailizar et al., 2020).

1.4. Problem statement

Geometry in a TVET College is at level 4 (equivalent to grade 12) only, an exit level. The content in level 2 and level 3 has no geometry, possibly resulting in learners at a TVET College experiencing challenges in geometry. According to Jojo (2019), TVET learners perform poorly in geometry resulting in poor performance in mathematics at level 4. Geometry is a very important module and is the bedrock of engineering and technological development in our country. In 2017, mechanical engineering students' pass rate in level 4 mathematics at two TVET Colleges was 15% and 19% (Mzini, 2019). There is a promise for more mobile learning tools to be created because they motivate students to make mathematics content more enjoyable and interactive than ordinary lessons. However, there is a lack of research done in TVET Colleges as the above findings were either from the data of secondary or primary schools.

1.5. Significance of the study

The technological advancements made globally make it critical for South Africa to include technology in teaching school subjects, particularly mathematics. Mathematics teachers must use ICT to communicate among themselves and teach the subject in their classrooms to generate skills necessary to address Sustainable Development Goals (SDG's) (Mondal, Van Belle, & health, 2018). The use of ICT can raise the level of interest in learners while preparing them for the ever-demanding new phase of the 4IR. The 4IR refers to disruptive technologies and trends such as the internet, virtual reality, and artificial intelligence that change our lives and work. This study will add value to the current knowledge concerning ICT in mathematics teaching and learning. This research aims to teach circle geometry using digital technology. This study further proposes that policy-makers and other education practitioners will benefit from the insight gained in aiding policy development and application.

1.6. Objectives of the study

Main objective:

To explore the experiences of mathematics lecturers' use of technology in the teaching of circle geometry to level 4 students at a selected TVET College.

1.7. Research questions

This study explored the lecturers' use of technology in circle geometry in a TVET College. Its purpose was to discover the use of technology in teaching and learning circle geometry.

The main research question was:

> ***What are mathematics lecturers' experiences using technology to teach circle geometry to level 4 students at a selected TVET College?***

The sub research questions were:

1. What technology do mathematics lecturers teach circle geometry to level 4 students in a TVET College?
2. How do mathematics lecturers teach circle geometry using technology in a TVET College?
3. Why do mathematics lecturers teach circle geometry in the way they do?
4. What do mathematics lecturers do to enhance the effective teaching of circle geometry using technology?

5. What implications does technology have for the teaching and learning mathematics in TVET Colleges in South Africa?

1.8. Clarification of key terms

The concepts below are illustrated in the study, and their detailed explanation will help the reader reach a better understanding of the research study. These concepts are lecturers' use; technology; circle geometry; National Certificate Vocation (NCV) Programmes; Technical and Vocational Education and Training (TVET) College; NCV Mathematics; CAPS and Curriculum.

a) Lecturers: According to this study, lecturers are the people who give mathematics and circle geometry lectures in a TVET College.

b) Use: According to the Oxford Dictionary, use is to hold, take or deploy something due to achieving or undertaking, or completing something.

c) Technology: The term technology may mean educational technology and digital technology. Educational technology is divided into traditional and modern technology (Vasquez, 2015). Technology is the skill, procedures, and techniques used to obtain objectives and is used in learning and teaching and for school administration and management purposes. Most people utilise technology to manufacture services or goods. TVET lecturers and students use different types of technology in everyday life not for educational purposes but for socialising. Social networks are at high levels of usage.

d) Geometry: Geometry is a Greek word originating from 'geo,' which means the universe and 'meter', whose meaning is to measure (Jones, 2002). The National Council for Teachers of Mathematics (NCTM) approved geometry as one of the main sub-topics that need to be incorporated in the mathematics curriculum outline (Al-Shehri, Al-Zoubi, & Bani Abdel Rahman, 2011). Meanwhile, Tabak (2004) states that Euclidean Geometry originated from the ancient Greeks and was named after Euclid of Alexandria (300 - 400 BC), a famous Greek mathematics genius. He further mentioned that Euclid is one of the top mathematicians in the whole history of mathematics.

e) National Certificate Vocation (NCV) Programmes: National Certificate Vocational (NCV) is a three-year training programme that admits students from grade 9 and is at National Qualification Framework (NQF) level 4 and consists of 21 subjects in all.

This NCV programme was designed to give students some skills through theory and practice, which is done in a real workplace for a specific given period (Shu, Brunton, & Fiala, 2003). The students do seven subjects: fundamentals (English, mathematics or mathematical literacy, and life orientation), while the remaining four are vocational subjects. Fundamentals are compulsory subjects irrespective of any programme that the students do. This suggests that all students are doing fundamentals.

f) Technical and Vocational Education and Training (TVET) College: TVET Colleges were previously knowns as the FET (Further Education and Training) Colleges. They offer two types of curriculum, either Report 191 or NCV curriculum. There is a total of only fifty TVET Colleges in South Africa.

g) NCV Mathematics: NCV Mathematics is the type of mathematics done within the NCV programme. It is studied by the students who do finance and IT as a programme within business studies and engineering programmes at this TVET College. Mathematics is a way of communicating that mainly uses symbols and notations to tell numerical, geometric, and graphic relations (Shu et al., 2003). It also includes three detecting, representing and investigating patterns and qualitative relationships between physical and social phenomena and mathematical objects. Mathematics helps build creative thinking in real-life situations where people can make decisions. For learners to achieve the learning as mentioned above, they need to have the resources: basic calculators, rulers, measuring tapes, textbooks, and a file for Portfolio of Evidence (POE) for each student. However, an argument can be raised about how NCV Mathematics level 4 is equivalent to mathematics grade 12, as Powell (2013) mentioned because they have different learning outcomes.

The following table (table 1.1) shows NCV mathematics level 4 learning outcomes in NCV curriculum versus mathematics grade 12 learning outcomes:

Topic	**Level 4 mathematics**	**Grade 12 mathematics**
1.	Numbers	Patterns, Sequences, and Series
2.	Functions and algebra	Functions and Inverse Functions
3.	Space, Shape, and Measurement	Exponential and Logarithmic Functions
4.	Data Handling	Finance, Growth, and Decay
5.	Financial mathematics	Trigonometry

6.	---------	Polynomials
7.	---------	Differential Calculus
8.	---------	Analytical Geometry
9.	---------	Euclidean Geometry
10.	---------	Statistics
11.	---------	Counting Principles and Probability

h) Curriculum: The curriculum can be defined as dispensing the learners' experiences. This means to use Stenhouse (1975) when a teacher is developing a curriculum in a classroom setting by starting a lesson by considering learners' experiences or using the students' context. It is a system for dealing with people, which refers to human interaction during teaching and learning. Teachers are required to always consider diversity when presenting the curriculum. NCV students are in a classroom setting with their peers, which allows a lecturer to consider inequality amongst learners. This means that curriculum is not just what is learnt but the syllabus, subjects, resources, lesson plans, assessment of students, and timetables.

i) CAPS: This is the South African Basic Education curriculum, the Curriculum and Assessment Policy Statement.

j) The Department of Higher Education and Training (DHET): The Department of Education has two departments which are the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET). DHET is the department founded in 2009 with Minister Dr. Blade Nzimande as the head (2009 to date) and deals with post-school education. It also has a mission to develop skilled, capable, and well-educated citizens who can compete worldwide in a knowledge-intensive for meeting the goals which develop South Africa. It consists of the TVET Colleges, universities, and Community Education and Training (CET).

1.9. Limitations of study

The limitation of this research study involves the lecturers who taught level 4 mathematics because of the study scope of geometry which is only done at the exit level. This will influence the generalisation of the study in other areas. A qualitative study was used to apply a case study with one-on-one interviews and an open-ended questionnaire. Observations were not done since they may take too long to complete, considering the pandemic era where Covid-19 limits the number of people in the classrooms. I disclosed the purpose of the study.

I observed ethics strategies before, during, and after this qualitative study. Before conducting the study, I wrote a gatekeeper application to the Department of Higher Education and Training and the college rector to conduct this qualitative study in three different campuses of the TVET College located in the Majuba district. Permission to conduct the study was granted. I also wrote consent letters to mathematics lecturers who teach level 4 (participants) requesting them to be engaged in the study. Each participant had a consent letter addressed to them where they were made aware that they had a right to consent to the letter by signing or to refuse to be part of the study. All participants who consented were called to the lecture theatre to inform them of the study, the phenomenon, purpose, and objectives. They were also informed that they had a right to withdraw during the study.

The participants' anonymity and confidentiality rights were taken into consideration. All participants were provided with my contact details and individual appointments to meet the privacy criteria. I also asked permission to conduct a study from the Research Office of the University of KwaZulu-Natal, where ethical clearance was approved.
During the study, I observed all ethics issues by avoiding mistreatment of the participants regarding age, religion, family background, culture, gender, and race. During data collection, confidentiality and anonymity of the participants were done using (lecturer A, lecturer B, lecturer C, lecturer D, and lecturer E) respectively, not using their real identification. I also disclosed to the lecturers that the study had no remuneration and was voluntary. The clear, appropriate, and straightforward language was used. Sharing data with other researchers and other participants was avoided. Participants were informed that copies of the data would be sent to them. Confidentiality for this study was taken into consideration. Participants were informed that data would be kept for five years in a safe cabinet at the university.

1.10. Context of the study

The participants for this study were selected from five campuses of the TVET College in KwaZulu-Natal, Amajuba District. The district was chosen based on my geographical and socio-economic background and position as a mathematics lecturer in the named district. - Figure 1.1 below shows the map of the whole of KwaZulu- Natal and districts within it:

Figure 1.1: The map above displaying all the districts in the KwaZulu -Natal Province (2016).svg

Figure 1.2: The map above displays the Majuba district in KwaZulu- Natal Province towns. (2016).svg

Amajuba district is one of eleven district municipalities in KwaZulu -Natal, as shown in figure 1.1 above. It is the district where the study took place. It lies in Free State Province, Mpumalanga Province, and Limpopo. Amajuba District has three local municipalities: Danhauser, Newcastle, and Emadlangeni, and consists of Charlestown, Utrecht, Newcastle, Hattingspruit, and Danhauser towns district. Before 1994, Newcastle was the capital of the Northern Natal cluster. For over three decades, the Chinese and Taiwanese communities have contributed to the economy of Newcastle. Newcastle also relied heavily on ArcelorMittal, Karbochem, Venco, NPC, and the textile factories. In August 1996, South Africa signed an international trade agreement, which affected the socio-economy of Newcastle. Most companies are still closing at present. Most factories employ illegal immigrants from the surrounding countries without work permits. They are cheap labour, which hinders most Newcastle residents from getting employment. Some factories are still shutting down as textile factories because China is busy with cheap trades to our country, affecting the Majuba District economy. The high unemployment rate leads to a high crime rate in this area and the surrounding towns. Only four main sectors contribute most to the Amajuba district's economy: Business services 15,2 %; Community services 22,2%; Trade 8,6%; lastly, manufacturing 35%.

The Amajuba district has formal schooling, which takes place in many high schools and primary schools and seven campuses of the TVET College but with no university in the area. This TVET College, as a site of research, has eight campuses in all. The first three campuses are at Newcastle, with two being the business studies campus, and the last one is for engineering studies. One is located at Dundee, which has both engineering and business studies. The remaining campus is the big training centre, and the last three campuses are at Madadeni Township, which is for the engineering, occupational programmes unit.

The students who attend the college are previously disadvantaged, most of whom are black from rural areas where most of them stay as far as Ngwavuma and Jozini. Therefore, during their study period, they stay in private accommodation on their own as tenants because the college does not provide for them. Some struggle to pay rent as they were raised by their grandparents, who depend on social grants, while others head their households because they have no parents. While they are heading their households, they also have children. Female students are the majority at this TVET College.

The college has built strong structures because it was previously a teachers' college of education, including campuses funded by the DHET. The college is well resourced and has a well-resourced media centre. Two years ago, the TVET College acquired computers with the internet, situated in the staff room. As of now, there are only a few computers in good working condition. There is no internet, and those computers are infected with viruses. There are tarred roads to the township campuses. In Madadeni Township, only the main streets have tar.

1.11. A brief outline of the chapters

Chapter one comprises a South African current curriculum set and the status of the present geometry and mathematics status quo at the Majuba District TVET Colleges. The full details, reasons, and the importance of conducting this study were stated. Firstly, the clarification of terms, ratio, purpose, and focus of the study, research problem, key research questions, the significance of the study, limitations of the study, location of the study are also discussed in this chapter one for insight and outline of the study.

Chapter two offers the literature review on the lecturer's use of technology in teaching geometry to improve the learners' performance in geometry and mathematics as a subject. It starts with reviewing the perspective on the nature of mathematics in the South African curriculum and technology as a context for teaching TVET geometry.

Chapter three, a theoretical framework, unpacks the importance of the theory used to generate data. The ideas that influence the phenomenon of the study are specified by the theoretical framework, which provides logic and applied foundations of the research study (Creswell, 2014).

Chapter four demonstrates a qualitative study's research method and design, including the population and sample selection and size, further discussing the interpretive paradigm and data collection process and deliberating how they were created. The data generating method and plan were constructively described, including the conformation of ethical issues such as trustworthiness and authenticity. The limitation of the study was also properly explained.

Chapter five offers the research design and methodology. The purpose of the study was to explore the lecturers' use of technology in the teaching of circle geometry level 4 at the TVET College. The data produced was addressing the following questions:

1. What technology do lecturers use to teach circle geometry to level 4 students?
2. How do mathematics lecturers teach circle geometry using technology in a TVET College?
3. Why do mathematics lecturers teach circle geometry how do they use technology in a TVET College?

This chapter represents the research study's findings, using ten themes and categories tabled created through two research methods (one-on-one semi-structured interviews and the open-ended questionnaire). The direct quotations cite the presented evidence from the participants.

Chapter six: conclusions and recommendations. This chapter represents the summary and conclusions of the findings during data collection, the study's significance and limitations, and recommendations and suggestions for further study.

CHAPTER 2

Review of Literature

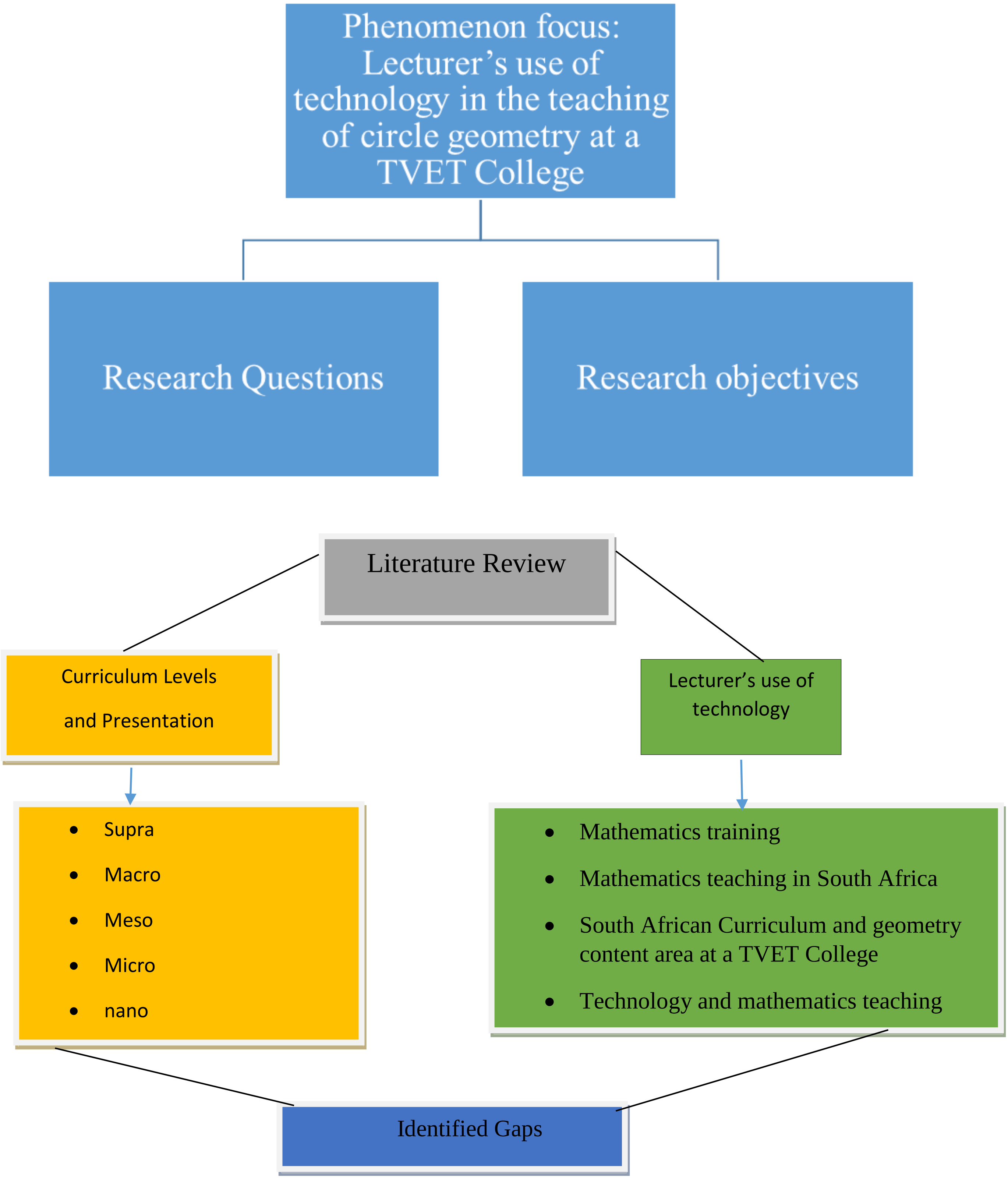
2.1. Introduction

The literature review uses the facts and proofs to back the specific skill used for the particular theme, selection of the technique, and the validation that the study will provide the new data/ findings to the current body of knowledge (Hart, 2018, p. 31). It gives a framework for creating the significance of the study and the level for measuring the data collected from the other studies (Creswell & Creswell, 2017). In chapter 1, the background of the research problem and introduction has been outlined. This chapter reviews the lecturers' use of technology in teaching geometry to improve the learners' performance in geometry and mathematics. It starts with reviewing the participants' perspective on mathematics in the South African curriculum and technology as a context for teaching TVET geometry. Therefore, the chapter concentrates on research based on the lecturers' use of technology in the teaching of geometry at a TVET College, the preparedness of lecturers to integrate geometry and technology approaches in geometry teaching, their views, and challenges on of these approaches in teaching.

It has been a challenge doing the literature review for this study on the use of technology by the lecturers in teaching geometry at a TVET College due to the scarcity of research (Bush & Oduro, 2006). Most researchers in Zambia, Kenya, Zimbabwe, Nigeria, Ghana, South Africa, China, and the UK and have been conducting studies based only on four areas: the teaching strategies for mathematics in primary schools, high schools, and universities, investigating the factors contributing to the poor performance in mathematics in secondary schools, comparing US and Chinese students' problem-solving skills in geometry. There is limited research on technology in geometry teaching at TVET Colleges.

This literature review chapter presentation is in line with the phenomenon lecturers' use of technology in the teaching of geometry, impact on curriculum, curriculum presentation and levels and thereby lecturers' readiness as well as the Department of Higher Education on the use of the 4IR as per the government's 2030 vision.

Figure 2.1 below stipulates a flow chart that outlines the structure of this chapter.



2.2. What is the curriculum?

This Ph.D. study is located in the field of curriculum studies. While most academics are not united on curriculum, it is appropriate to begin this literature review with a brief discussion. The curriculum is the foundation of learning and teaching. It is an inscribed design combining the time, the procedure allied to the assessment and standards, content, management, and staff development. The curriculum constitutes a list of everything the education departments want teachers to teach our students. This means that curriculum is not just what is learnt but the syllabus, subjects, resources, lesson plans, assessment of students, teaching strategies, and timetables.

The word 'Curriculum' originates from the Latin word 'currere', which means 'to run a course' (as athletes or horses run a course) Hoadley and Jansen (2013, p. 31). Koehler and Mishra (2011) describe the term curriculum as a purposeful plan for teaching and learning that needs the sequencing, purposefulness, and practical organization and the management of the connections among the educators, learners, and the content knowledge needed to be acquired by the educators' learners. A very simple definition is mentioned by The Association for Supervision and Curriculum Development (McTighe & Wiggins, 2013), which states that curriculum is the knowledge and skills that the learners need to learn.

However, the clarification of the term curriculum has many meanings from different authors (Marsh, 2009), including the curriculum documents from the National Department of Education and textbooks from different authors. The South African Qualification Authority (SAQA) states that curriculum is a practice of learning while discerning the beliefs and values of a particular society. SAQA believes that the curriculum must be more intensified than a course outline because it comprises all the teaching and learning experiences based on the objectives and aims of the higher education system. Alternatively, Budiman (2012) specifies the five fundamental definitions of the curriculum.

Firstly, the curriculum is a ground plan for conquering goals. Goals arise from the objectives, aims, and outcomes mentioned by Kennedy, Hyland, Ryan, and Tools (2009). Aims originate from the teachers' viewpoint to stipulate the content that needs to be done. These are outlined from the Subject Guideline and the Assessment Guidelines as per the Department of Education and Training. At the same time, objectives are the common specific declarations that suggest the teachers' expertise to be covered from the content knowledge required to be studied (Kennedy et al., 2009; Kennedy, 2006). Finally, outcomes pertain to content to be known by the students at the end of the lesson as per subject guidelines.

Secondly, the curriculum can also be defined as dispensing the learners' experiences. This means to use Stenhouse (1975) when a teacher is developing the curriculum in a classroom setting by starting a lesson by considering learners' experiences or using the students' context.

Thirdly, a curriculum is a system for dealing with people. This refers to human interaction during the teaching and learning situation. Teachers are required to always consider diversity when presenting the curriculum. NCV students are in a classroom setting with their peers, which allows a lecturer to consider inequality amongst learners.

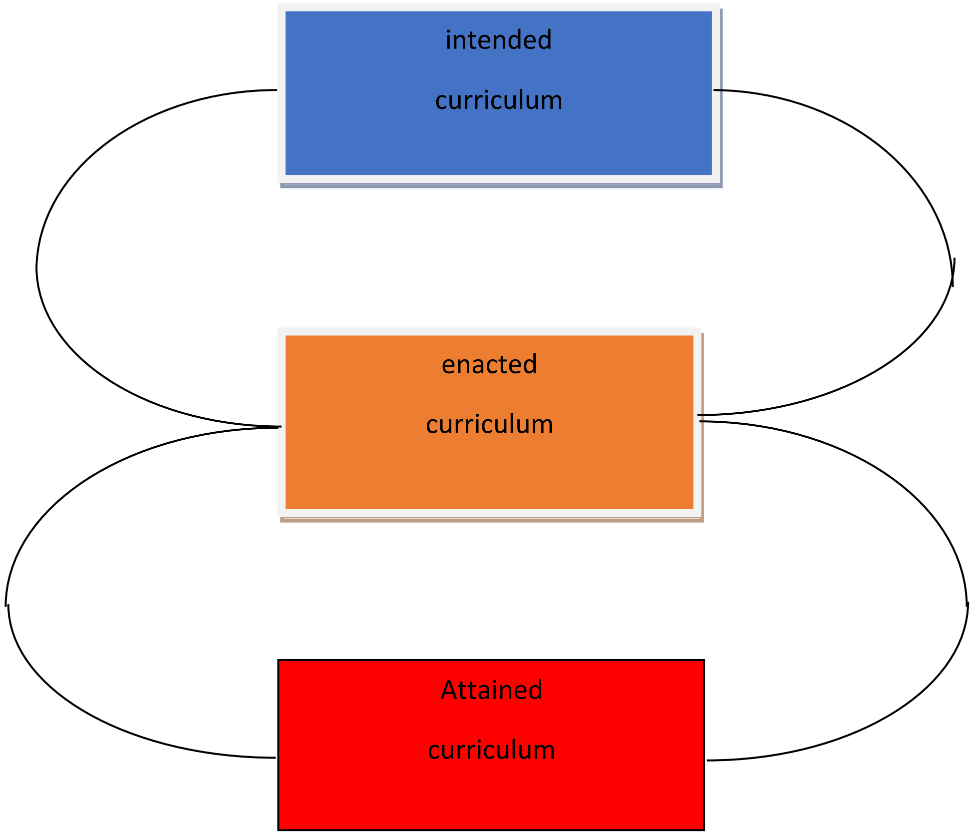
Fourthly, the curriculum can be defined as a field of study with foundations, knowledge domains, research, theory, principles, and specialists. It means that the national level of NCV curriculum is arranged by the DHET, which is to be implemented by the TVET lecturers in the classrooms during the teaching and learning situation when they are expected to integrate theory into practice. In terms of subject matter, curriculum means what is to be 'learnt', outlined in the curriculum document as the 'skills, attitudes, knowledge and values to be taught'. This is content to be taught as per assessment and subject guidelines. Lastly, the way curriculum is presented shows the approach as Thijs and van den Akker (2009) state that there are five levels on which curriculum is developed which are supra (international /comparative), macro (system, society, national, and state), meso (school and institution), micro (classroom) and nano (individual and learner).

Figure 2.2 below indicates curriculum levels (Van den Akker, 2010).

In figure 2.2, The supra level is where the curriculum is planned at a national level. Dr. Blade Nzimande shares a curriculum committee as a Minister of Higher Education and Training. The macro-level is the level where the government utilises the curriculum structures.

The next level is meso, where education policies and code of conduct are designed. The micro-level is the one that has teaching and learning activities which are followed by the last level, the nano-level, which shows the teaching strategies to be used when learning (Van den Akker, 2010). Furthermore, Khoza (2015) believes that besides the existence of these levels, the curriculum can be symbolised in the primary stages of the intended, planned, or prescribed curriculum, implemented, enacted, practiced, and assessed or attained curriculum.

Figure 2.3 below indicates the curriculum representations by Van den Akker (2010) and Hoadley and Jansen (2013) levels.



2.2.1 Prescribed curriculum

The planned, intended, prescribed, or formal curriculum connects to the objectives and goals of the curriculum (Marsh, 2009). Further clarification is on different practices that the planned curriculum might have, which are: “an official syllabus document or learning guide, a teachers’ teaching plan from one school, a textbook and a broad curriculum framework (or broad policy)”, (Hoadley & Jansen, 2013, p. 31). Furthermore, Mpungose (2020) adds that a formal curriculum is a policy document with ideas that provide educational aims and objectives for learning and teaching. Liu (2016, p. 7) has clarified that the intended curriculum is seen as the one that consists of both the basic philosophy and the formal curriculum, which influences the curriculum developers and the policymakers in their different roles. Fomunyam (2014, p. 14) is of the idea that curriculum is the anticipation that "the planned or intended curriculum is interrelated to the personal, social and political dimensions of schooling and it is only through individualistic theorizing that the new trends, realities, and solutions can be treated to improve the learning and two-way teaching process." This shows that the attained, enacted, and intended curriculum is about the curriculum's aims, objectives, and goals. NCV is stipulated from the top structure (DHET) and down to the bottom structure (students) where an essential document known as Assessment Guideline (AG) can help with guidance on what direction to follow when implementing the mathematics curriculum using the prescribed documents that can show the specific areas that need to be covered in geometry. These documents (AG and SG) provide a clear direction on the 'what and how' curriculum about geometry that should be implemented and assessed by the mathematics lecturers.

2.2.2 Enacted curriculum

Marsh (2009) mentions that the enacted curriculum is the how-to process where educators are expected to translate and execute the curriculum, whereas Hoadley and Jansen (2013) view the enacted curriculum as the procedure for lecturers and students should do the curriculum. Understanding the idea of the enacted is very significant because of these two reasons, "it creates the possibility for explaining why students always learn miscellaneous things when a lecturer teaches them and also stresses that the lecturer's role as an interpreter of the curriculum". (Hoadley & Jansen, 2013, p. 37) suggest that in NCV, the enacted curriculum is how lecturers should understand and interpret the NCV Curriculum during the teaching and learning process, especially how geometry is understood and interpreted during the facilitation process while using the technology. Students become motivated when the lesson becomes practical and procedural, passing the subject. Lecturers need to have the correct conceptual knowledge and the simple pedagogy to understand the content easily. They are perceived as the mediators or facilitators of the learning process in the classroom, as suggested by (Hoadley 2015). The curriculum guides on which aspects to cover and allows for flexibility for the lecturers as proposed in the curriculum document.

2.2.3 Attained curriculum

Van den Akker (2010) states that the attained curriculum embodies the students' learning experiences and the learning outcomes. Whereas Liu (2016, p. 7) mentions that the attained curriculum "comprises the experiential curriculum (learning experiences from students' perspective) and the learned curriculum (resulting learner outcomes), relating to students." On the other hand, Hoadley and Jansen (2013) agree that the attained curriculum is the most significant level because it gives a holistic view of the learning and teaching process by providing the students' achievement based on the assessment conducted in the classroom environment. This suggests that the curriculum experiences of the NCV mathematics' students are observed through learning by their performances that show the outcome, which is either fail or pass of a student in a subject.

A curriculum can be defined as a field of study with its foundation, knowledge domains, research, theory, principles, and specialists. TVET Colleges have Report 191 and NCV as only two types of curriculum. Both these curricula use the OBE approach like CAPS in Basic Education. The main difference is that Report 191 is done by students who have passed matric, while NCV is for those without matric, and the entry-level is grade 9. Report 191 starts from N1 to N6, while NCV starts from level 2 to 4. These curricula are planned at the National level by the Department of Higher Education (DHET). They are to be implemented at a local level at a TVET college by the curriculum workers (lecturers) during the learning process. They are supposed to link theory into practice and interrelate with the curriculum. This study explores the lecturers' use of technology in teaching geometry at a TVET College. The NCV curriculum will be used because the level 4 students will be utilised since geometry is mainly done in exit level 4.

To get an NCV certificate, they must complete three levels: level 2, level 3, and level 4. All the levels have fundamentals and vocational subjects, and in fundamentals, mathematics is a compulsory subject. However, NCV policy also specifies that level 4 allows students to obtain the required knowledge, practical skills, applied competence, and understanding needed for employment in a specific occupation, trade, or entrance in higher education. Nevertheless, most students tend to fail mathematics, especially the geometry part of mathematics.

TVET Colleges were formed to address the skills shortages in South Africa (Wedekind, 2016), where the NCV program through the NCV Curriculum is mainly used for skills upliftment that started in 2007. There is still a huge challenge that faces our country: a high unemployment rate and a skills shortage, especially in engineering, science, and technology. The careers mentioned earlier use mathematics as one of the requirements to qualify. A wide gap needs to be addressed between the education sector and the industries that require the TVET curriculum to align with what the workplace requires.

During this Corona Virus outbreak, the National Treasury projections in South Africa show that more than seven million people in South Africa will lose their jobs, and economic depression will be rife (Şenol & ZEREN, 2020). This shows that the education system in our country has not done justice for the citizens as the skills have been delivered inadequately to secure the economy for the country. The South African job market requires specialised skills that the curriculum for enough an affordable system of skill delivery is to be addressed through the education programs in the TVET sector for the security of the country. China and South Africa have an ongoing China-South Africa education relationship to transfer the skills that can uplift South Africa's skills shortage. Most TVET Colleges take their artisans to China for further training. When the Chinese curriculum is designed, the research is used from the industries to give the policymakers to address the skills required by the country, and the educators are involved in designing the curriculum for the country. This is evident as Li (2010) conducted a study to inform policymakers about expanding enrolments. Findings help curriculum design and find that access was not granted to many industries. The findings of the study suggest the redesign of the curriculum in Chinese is needed. Ehizuelen (2018) also conducted a study that suggests that the skills done in China need not only be for the workforce but also to change the way the employees and help for practical skills that need to be transferred and for which the students are trained. He further mentioned a need for curriculum reform that supports science, engineering, mathematics, and technology. Hu (2005) concurs that curriculum restructuring is important to Chinese educators' professional development. It makes them great participators in the nation's curriculum development as they are also involved in the schools' curriculum development. This suggests that there is also an outcry of mathematics in China. Even though Chinese educators are involved in curriculum designing, development, and implementation, there is still a need for addressing mathematics for upgrading science and technology in the country.

Meanwhile, teachers become qualified in Finland after acquiring a master's degree pass (Kansanen, 2014). The education system allows them to design the curriculum and write their textbooks where their system gets a support model of peer-group mentoring to facilitate the profession. In South Africa, there is no evidence that educators are included in the curriculum development from the national level (Carl, 2009). This suggests that educators must use the CAPS document as-is and the textbooks that educators do not write. Educators must interpret the work suggested by the curriculum document and decide on which resources to use, irrespective of the environment.

2.3 View of mathematics

Mathematics has become a very important subject throughout South Africa. Most high salary paying jobs need mathematics as a compulsory subject to qualify for university or college entry. This has led to every parent encouraging their child to do mathematics as a subject in high school. Some parents force their children to opt for mathematics even if they do not have enough potential and interest in a subject. Vaidya and Kumar (2006) state that many fields and disciplines such as computer science, engineering, natural sciences, medical science, economics, and accounting worldwide require mathematics to qualify. This suggests that mathematics is a subject that controls many careers. The day cannot pass by without mathematics, e.g., budgeting, driving when judging distance, time management, doing groceries, cooking, etc. Regarding potential in doing mathematics, Mji and Makgato (2006) view that learners experience difficulty learning mathematics due to lack of motivation, resulting in low self-esteem and confidence in the subject.

Hemmi (2010) believes that theorems, methods, and axioms are very useful for the knowledge of mathematics. This has created the image that all mathematicians are critical and independent thinkers and the greatest problem solvers. Meanwhile, Ernest (1998) also suggests that axioms, theories of mathematics, and theorems are valuable and significant to present science as a basis of truthfulness and belief. The idea is similar to the above: mathematics is also used for problem-solving situations like many philosophers and mathematicians who spent their lives proving certain theorems such as Pythagoras, Wallis, Proclus, and Euclid (Chen, 2021; Govender, 2016). This suggests that teachers and learners use deductive reasoning to form knowledge. Also, whatever problem they need to solve has to be proven scientifically and mathematically. Naidoo (2011); Shoba (2020) concur by saying mathematics is the skill of patterns whereby mathematicians use investigation patterns found in space, numbers, science, and computers. Patterns are prodded with the impulse of devising new assumptions and inaugurating the truth by exact deduction from the selected definitions and axioms. Hence, the patterns are seen as a principle of mathematics and the basic language to express the mathematical ideas throughout the universe (Sampson, 2007).

In the NCV curriculum, a student has to either do mathematics or mathematical literacy (Wedekind, 2016). For this study, geometry is a section of mathematics done by the TVET students studying engineering studies or business studies. There is an outcry for declining students who study mathematics in South African TVET Colleges. This is affirmed by Reddy, Wildschut, Luescher, Petersen, and Rust (2018), who mention a drastic reduction of South African TVET students due to a high failure rate in mathematics as a fundamental subject. This is also similar in developing countries like India, Pakistan, China, Kenya, and Ethiopia (Wang, 2012), where dropout rates remain high due to a high failure rate of mathematics as a subject in secondary schools. This is evident because De Witte, Rogge, and Education (2014) mentioned a shortage of students to further their careers in mathematics. As a result, this created many vacancies in these fields which is hard to fill by the required academics.

Basic education previously had pressure to launch many projects like the Dinaledi in 2001 and the Masifunde project in 2002 to help with the increase of the number of learners studying mathematics and science in grades 10 to 12. The main goal of these projects was to help improve a quality pass in mathematics and science and increase learners' enrolment in mathematics, science, and technology (Kennedy & Odell, 2014; Scott & Research, 2012).

2.4 Mathematics training in South Africa

South Africa has been a democracy since 1994. Non- racial, educational policies that aim to resolve the past wrongdoings have replaced the apartheid–era educational policies (Venkat & Spaull, 2015). During the previous apartheid era, there were 18 education departments, 32 universities and technikons, and 105 colleges of education, which differed regarding the quality of education (OOSTHUIZEN, 2009; Reddy, 2004). All the colleges of education were shut down, and the universities took over to train teachers in South Africa. Many scholars have tried to explore and investigate the level of content knowledge that the South African teachers have in mathematics and geometry as a subtopic for mathematics. For example, Venkat and Nic Spaull (2015) conducted a study to test grade 6 teachers' content knowledge. It was found that 79 % of the teachers could not score an average mark of 60 % on a range of grade 6 and 7 level items. This suggests a great problem with mathematics teachers in South African Primary schools. This has led to the introduction of a diploma program that will provide lecturers in the TVET sector with professional lecturers' qualifications.

Another challenge affecting mathematics teaching in post-apartheid South Africa has been the numerous curriculum changes ranging from OBE to CAPS. From 2008 to 2013, geometry was optional and written as a 3rd paper in the National Senior Certificate examinations. As geometry was optional, universities complained. However, there seemed to be little to no research done in this area. According to Van Putten, HOWiE, and Stols (2010), the reason for geometry being optional was that teachers in South Africa are not familiar with the content.
While the two studies referred to above relate to teachers and their content knowledge, a study conducted by Van Putten et al. (2010) explored the level of understanding of pre-service mathematics education (PME) students. They further mentioned that the students majoring in mathematics teaching lacked an in-depth understanding of geometric concepts. The study found that PME students were at level 3 of Van Hiele geometric thinking. These PME students could not obtain even 50% on level 1 of the Van Hiele geometric thinking pre-test. More than half the PME students were at level 0. These PME students were then taught geometry as part of the study. After that intervention, the results showed that only 6 out of 32 students were on level 3. What surprised the researchers is that these students are supposed to be at level 4 of van Hiele geometry teaching, raising concerns about teaching their learners at different schools.

Another study proves that high school teachers do not have enough knowledge about geometry to impart sufficient knowledge to learners. The study was conducted by Dhlamini (2012), which aimed to investigate grade 12 mathematics teachers' understanding of Euclidean Geometry. The participants were given a written test and a task-based interview. The researchers used Bloom's Taxonomy learning and van Hiele's theory of levels of thinking because they wanted to find out the content knowledge for educators. The findings demonstrated a lack of deep understanding of geometric concepts. This shows a requirement for the reskilling of teachers in the capacity development of geometry teaching and understanding and how they should teach geometry in the classroom.

Also, a South African study done by Malatjie, Machaba, and Education (2019) examines teachers' and facilitators' (subject advisors') views on mathematics and mathematics pedagogical practices. The framework used is from the sociology of education used for Bernstein (1996), which constructed recognition and realisation rules. There are two contributions of this paper in the literature:

- Teachers and subject advisors view mathematics and mathematical literacy pedagogical practices to better understand this possible tension around whether the teaching approach for the two domains should be different or similar.
- If mathematical literacy is considered 'separate', mathematics and mathematical literacy teachers should not conflict.

The findings revealed that learners and teachers are the same. Mathematics and mathematical literacy teachers use the same teaching strategies, while there is a big difference between the two. Mathematics gives learners procedures while mathematics literacy is for reasoning and problem solving, which Bernstein refers to as a competency-based curriculum. This means that the subject advisors and teachers have not yet developed the required pedagogy for teaching mathematics. There seems to be a lack of or no development on teacher training about pedagogical skills, thus leading to teachers not being developed in teaching the subject. This shows that lecturers were not developed and taught a subject and geometry as part of mathematics subject.

2.5 Mathematics teaching in South Africa

Mathematics teaching and performance in South Africa are complex. For example, there is a difference in mathematics teaching and performance between urban and rural areas. This difference may result from the different social contexts that result in learners not getting similar school knowledge as teachers contextualise the lessons per curriculum requirement (Beyer & Davis, 2012; Hoadley, 2017). According to Mji and Makgato (2006), different teaching strategies used by different teachers add to the low performance in mathematics. Giertz (2016) states that rural areas get low-quality education since few teachers are qualified and lack teaching resources compared to urban areas.

Mathematics teaching at TVET Colleges is also a complex issue. TVET lectures have different categories in their teaching qualifications. Some lecturers have education qualifications with very limited skills, and some are from the industries and have skills but lack the appropriate education qualification. Other lecturers have Nated (Report 191) qualifications from TVET colleges but no skill or education qualification (Witten & Makole, 2015). This suggests that the lecturers may have content knowledge but fail to teach students using the required strategies. There is no direct qualification for the TVET lecturer required to qualify for a TVET lecturing job. Lecturers are supposed to use different roles in their teaching to accommodate the diversity of learners' needs. The teachers' role is when the teacher interacts with pupils in leading the lesson (Mercer, Sams, & Education, 2006).

Language in all academic teaching and learning spheres is fundamental to comprehending instructions and providing required and appropriate responses. Mathematics is no exception. In South Africa, only 11 languages have been recognized in the Education Policy System since 1997, but only two languages are used for teaching and learning: English and Afrikaans. English and mathematics are key to entering a tertiary-level South Africa institution. All the remaining languages are used at home, but irrespective of what other language they use at home, the learners and parents have no choice for teaching and learning purposes. They must choose what a school offers, either English or Afrikaans, for teaching and learning mathematics.

Phakeng (2018) states that South African schools are faced with a high failure rate in mathematics because of multilingual classrooms. He categorized the bearer of language in teaching and learning of mathematics like for instance:

- A problem of code-switching in rural classrooms where learners are immigrants and learners are taught only at low cognitive levels. At the end of the year, learners write a common paper in mathematics that covers low and high cognitive levels and fail a subject.
- Classrooms in urban areas are crowded with immigrant learners, and teachers favored learning mathematics even in French and taught the high cognitive level mathematics in that language. When examinations come, their performance is low because they struggle as the mathematics paper is only in English.

- Township schools with immigrant learners are shy to be stigmatized as foreigners also fail because of language.
- Township classrooms where South African learners only are taught by an immigrant educator where code-switching is not done and learners are scared to reveal themselves have misunderstood a subject and underperform in mathematics because of language.

Phakeng (2018) further suggests using multi-language in mathematics where translating tasks using many languages in the classroom can make learners more active, gain interest in the subject, and lead them to higher performance. He further mentioned a disconnection between a policy and a practice because while learners have different languages for use, only English is mainly used in mathematics teaching.

Most TVET Colleges also use English in the teaching and learning of mathematics. While this study is based on technology usage in the teaching of geometry as a module in mathematics, there is a great concern for learners with disabilities on how they have accommodated English and technology usage in mathematics learning. Geometry is a module in mathematics with many unique concepts, terminology, axioms, riders, and theorems. This suggests a great challenge of bringing together English and mathematics during learning. Teachers must address that code-switching to a home language while using the real-life situation and teaching the high cognitive demand tasks of mathematics might be the solution (Phakeng, 2018). Because students at the TVET College where a study will take place are from different socio-economic backgrounds, I think lecturers are required to reconsider code-switching when teaching mathematics. Thus, language may be categorized as a teaching and learning mathematics resource.

On the other hand, Westaway and Graven (2017) conducted the study to explore grade 3 teachers' resistance to 'take' up advanced mathematics teaching roles and found that educators are resistant to change as per curriculum requirements. According to the South African Education Band, grade three is an exit grade at the foundation band. Their findings revealed that the way teachers present the new curriculum where lessons are supposed to be learner-centered as per OBE requirement shows that educators still believe learners need to be passive listeners. Educators become active presenters of a lesson, making lessons educator-centered and making students and teachers believe mathematics is difficult for all. If learners fail mathematics in lower grades, a negative attitude towards the subject is created, leading to poor performance. This suggests that educators in lower grades still need teacher development to create the new classroom practice for leading the subject as per the subject policy requirement, improving the educators to present higher cognitive mathematics tasks, thereby improving the pass percentage in a subject.

While the scholars mentioned that the problem might arise from the educators' pedagogy, another study conducted by Machaba (2019) showed that grade 3 learners' origins through ethnic group and socio-economic factors are seen as the greatest educational barriers and lead to mathematics high failure rate. This shows that if learners fail in lower grades, they can pass a subject in higher grades. Learners who fail mathematics in junior classes tend to develop a lack or no self-esteem, thus becoming failures in mathematics because of a lack of self–confidence (Malatjie et al., 2019). Therefore, remedial programs are essential for supporting learners in mathematical learning and development.

A study by Makamure and Jita (2019) aims to examine the importance and contribution of the teaching practice to the development of pre-service teachers' knowledge of teaching mathematics to learn to teach in Zimbabwe. The study also mentioned a dismal fail in mathematics, which may be caused by the educators' insufficient teaching skills in mathematics due to insufficient educator training before their teacher's graduation. The study's findings show that the effectiveness of mathematics teaching does not rely only on the content knowledge of an educator. It relies on combining content knowledge and presenting the subject (pedagogy).

Makamure and Jita (2019) recommend the adequate monitoring of educators regarding mathematics content and pedagogy teaching expertise and re-training those who do not meet the required standards. This suggests that mathematics' high failure rate is a global trend, and everyone blames the system for the poor training of educators in pedagogy and content knowledge. There should be an ongoing process of capacity development and skilling of educators concerning pedagogical skills of mathematics. This will also help the DHET with the ongoing development of TVET lecturers in mathematics pedagogy to uplift the high performance in mathematics and a high pass rate in a subject. Some TVET lecturers did not do education as a profession as they were recruited from industries.

This can affect how they present a subject to students (Makole, 2015). Arends et al. (2017) share a similar view as their study also aimed at investigating mathematics educators' mathematics teaching practices concerning mathematics performance in South African schools. The findings show that various teacher classroom practices affect learner performance in mathematics. They also recommend identifying the classroom practices to support these mechanisms to give educators ongoing support concerning classroom practices.

ZWELANDILE did another study (2016) to explore designing, developing, and implementing the South African education system curriculum, only in the Eastern Cape province in South Africa. The study's findings showed a lack of infrastructure and resources and poor quality in teacher training with a lack of teacher and parental participation in the designing and development of the curriculum and teachers, do not get any support from various stakeholders. Stakeholders include teachers, learners, parents, government, curriculum managers, administrators, and professional organizations (Bandur, 2012). The parents' involvement may be a challenge at the TVET College because most students are on their own at rented private accommodation, and only a few stays with their parents. This shows that there is insufficient parental involvement in the learning of mathematics for the students where this study is conducted.

For effective learning to occur, teachers need to ensure learners' well-being before learning can occur. For the effectiveness of the lecturers' use of technology in geometry study, students' needs must be considered like gender, age, mental and emotional development, physical, cultural background, personal goals, and aspirations. This is also mentioned by Tiangson (2013) by saying learners are the reason a curriculum is developed and implemented, which suggests that learners are the greatest component for successful implementation of the curriculum and is measured through subject passing.

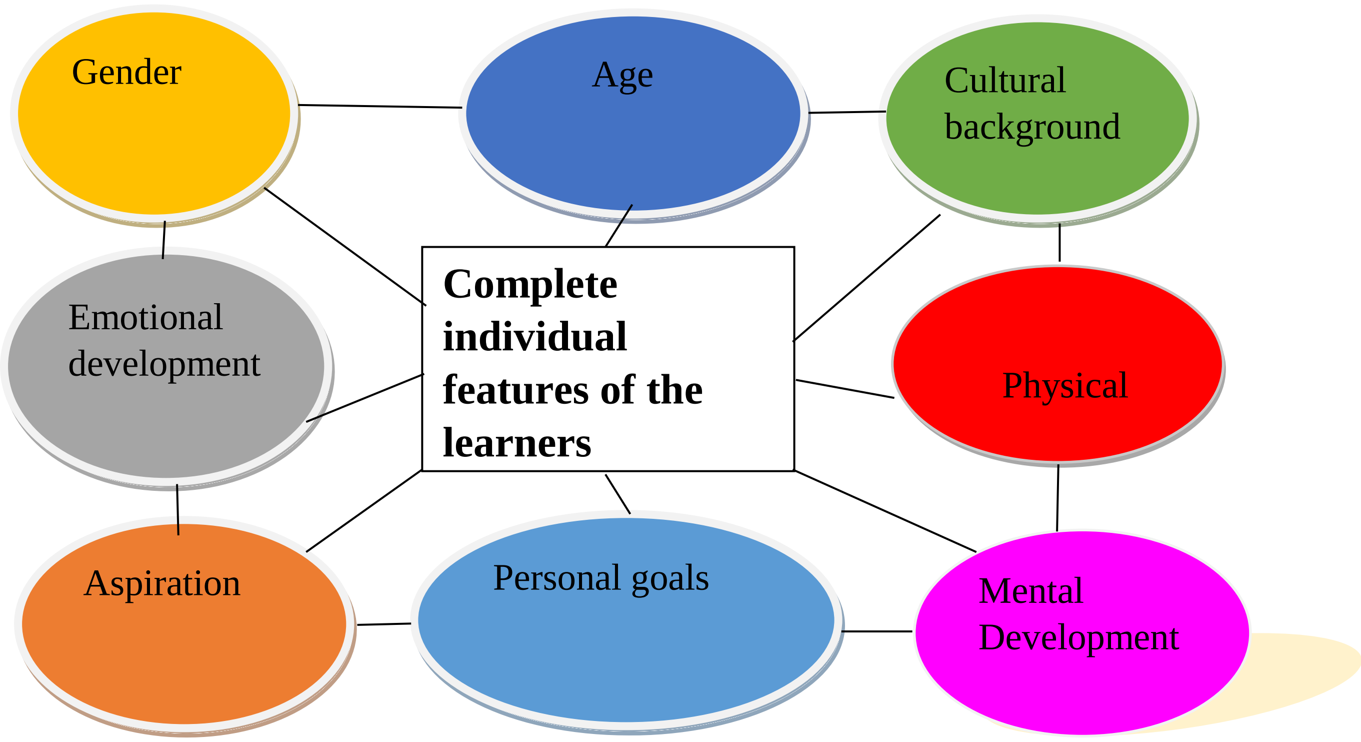


Figure 2.4 shows the role of the learners during the development and implementation of the curriculum as adapted from Murphy (2013).

2.6 The South African curriculum and geometry as a content area in mathematics at a TVET College

Mathematics for level 4 has the following content areas in the curriculum guideline: Complex Numbers (10%); Functions and Algebra (40%); Space, Shape, and Measurement (25%); Data Handling and Probability Models (15%) and Finance (10%). The percentages following content areas represent the stipulated specific weighting and compulsory time allocation for each module in mathematics (Matshoba & Burroughs, 2013). This study is mainly on geometry which researchers define in different ways.

Geometry is a Greek word originating from 'geo', which means the universe, and 'meter' means to measure (Barnes-Svarney & Svarney, 2012). Meanwhile, the National Council for Teachers of Mathematics (NCTM) approved geometry as one of the main sub-topics in the mathematics curriculum outline (Al-Shehri et al., 2011). This suggests that with little or no knowledge of measurements and the understanding of the universe, one will battle in the learning process of geometry as it consists of theorems and axioms that require proof and application of real-life problems.

Tabak (2004) states that Euclidean Geometry originated from the ancient Greeks and was named after Euclid of Alexandria (300 - 400 BC), a famous Greek mathematics genius. He further mentioned that Euclid is one of the top mathematicians in the whole history of mathematics. Euclidean geometry is one of the kinds of geometry that still exists and is also recognized by mathematicians. Even the Egyptians used geometry when they were building their pyramids.

Comparing the CAPS geometry scope with the TVET geometry scope may also clarify some mathematics challenges in a TVET sector. This confirms that TVET students start geometry only at level 4, the exit level, whereas at high schools, they start from grade 10. This late start of geometry by TVET students can bring about poor performance and a low pass rate in mathematics (Hassan, 2020).

Below in table 2.1 are the differences for the journey of geometry at school and TVET according to CAPS and NCV adapted from (Richardson, Wu, & Judge, 2016).

GEOMETRY GRADE 10-12	**GEOMETRY LEVEL 4 ONLY**
Midpoint theorem	Midpoint theorem
Circle geometry	Circle geometry
Quadrilaterals	Cyclic Quads
Classifying 3D objects	
Congruency	
Similarity	
Pythagorean Theorem	

According to Jones (2002), geometry is a fundamental part of life that some careers need to master as architecture design, art, building, naming a few because it is linked to aesthetic visual and intuitive human facilities. Plumbers, builders, car designers, etc., cannot master their productions with little or no knowledge of geometry which suggests that geometry is applied in everyday life for economic development. There are aims and skills for geometry to be learnt/taught.

Table 2.2 showing Jones (2002) summarised the objectives for teaching and learning geometry:

To give wide- ranging geometric experiences in two and three dimensions
To inspire the improvement of the use of estimations, deductive reasoning and proof of the theorems
To create comprehension of the geometrical characteristics, axioms, and theorems as well as their application
To arouse a positive attitude towards mathematics and science
To apply geometry in everyday real life situations
To develop the awareness of the cultural and historical heritage of geometry in the whole society

As this study is mainly based on geometry learning and teaching using technology, the objectives mentioned above for teaching and learning geometry are very important. This suggests that when conducting this study, the guidelines will be observed whether any of the above aims are attained. It is worth highlighting that the visual images invite students to perceive and conjecture generalisations during the lesson. When students work with practical visual images, it is very easy for them to understand the content, arousing interest in conceptual understanding, leading to a better performance in geometry and a high pass rate in mathematics. Geometry is one of those modules in mathematics where curiosity needs to be stimulated during teaching and learning that can make learners develop self-confidence, understanding, and solve problems easily. The students can make connections to the drawings of geometry. This means that all learners need to be part of a learning experience where learning happens through contextualisation, as suggested by (Stenhouse 1975). CAPS requires learners to be active participants of a lesson through communication skills development (Nompula, 2012). Solving geometry riders requires practical geometric expertise with visualization and a deep understanding of the theorems.

2.7 Technology

2.7.1What is it?

Technology is the skilfulness, procedures, and techniques used to obtain objectives. Most people utilise technology to manufacture services or goods. TVET lecturers and students use different types of technology in everyday life not for educational purposes but for socialising. Social networks are at high levels of usage. Technology is used in learning and teaching and for school administration and management purposes. The term technology may mean educational technology and digital technology. Educational technology is divided into traditional and modern technology (Sáez-López, Sevillano-García, Vazquez-Cano, & Development, 2019). Davies and Hughes (2014) state that technology helps during teaching and learning by arranging educational resources meaningfully.

2.7.2 Technology and mathematics teaching

While there is a shortage of literature on the use of technology in teaching mathematics at TVET Colleges and schools in South Africa, there was a study done by Osakwe (2020) in South Africa which set out to explore the integration of technology into teaching at a mathematics department at a South African university. This study took ten years (2003 - 2013). The aim was to determine the attitude and beliefs towards using technology for teaching mathematics by students and staff at the university. Findings indicate that the participants still use the chalkboard for teaching, not technology. One of the reasons mentioned by the participants for not using modern technology or why they prefer the use of chalkboards is that there is a lack of training regarding the use of technology in the teaching of mathematics. They also discovered that more males than females are teaching the subject. The subject culture also seems stronger than those with higher academic qualifications and those not teaching. This study will help identify whether the TVET lecturers are well equipped with technology usage skills in geometry.

Drigas and Pappas (2015) examined online and mobile application tools for mathematics to show how this could impact teaching and learning. The use of smartphones, tablets, and laptops is very important to teachers and students worldwide. Their study shared that in Japanese Primary schools, mobile tutoring systems helped improve arithmetic skills and aroused mathematical concepts knowledge using learning theories, mobile learning approach, education medium, and a games development approach. This proved to be a fun way for children to practice basic mathematical operations. The researchers discovered that the games were very useful for students who had just started mathematics.

Technology use in mathematics teaching can be beneficial and enjoyable for learners and students. Shao (2014), inspired by the Nokia Mobile Learning for mathematics project (which used networking for teenagers' mathematics homework), designed MobileMath for secondary schools. It was found that students who used MobileMath enjoyed learning activities, especially games. Reardon and Tangney (2014) created an angle tool in mobile mathematics with trigonometry and geometry teaching objectives. This tool helped collaborate learning experiences, organizing groups in which students communicated in finding the correct solutions. GeoGebra was created in 2012 by (Kramarenko, Pylypenko, & Muzyka, 2020). This tool improved the spatial skills of the students. This application motivated my interest in mathematics to make it easily understood and hope for mathematics students to do much better in mathematics independently.

There is a concern that teachers need to advance with technology use during teaching and learning situations. This advance may be known as transformation, labelled as the 4IR, in which mathematics lecturers need to play a role. Lecturers need to be equipped with the necessary skills to teach and learn mathematics to be familiar with technology-based teaching strategies (Naidoo, 2019).

During this era of the Covid -19 pandemic attack in South Africa, the whole country is in lockdown. With the changing environment, the Department of Higher Education and Training planned to resume academic activities for the universities and the TVET Colleges from the 20th April 2020. Academic support would be done online where the online transition is created as the only solution as it is unknown whether the virus will end soon. The problem with TVET Colleges lecturers, especially where I am stationed, is that there was no training with e-learning. Covid-19 seems to push South Africa towards transformative constitutions. The problem only lies with the capacity building and training of TVET lecturers over technology in the teaching and learning for online access. Most citizens have complained that our country is falling behind 4IR as some learners and students cannot access learning on top of these. Some students feel this creates education exclusion since most environments may not have the network in their respective homes or conducive environments for learning.

City Press (2020-04-19) states that the South African Union of Students (SAUS) has pleaded to the Higher Education, Science, and Innovation Task team for the tertiary students who fail dismally, not to be expelled but rather be given another chance next year (2021). This shows that there may be a gap identified by this union, which may be the lack of training of lecturers for the integration of technology in teaching and learning since learning will only be online until this pandemic is eradicated. Many digital technologies can be used for teaching and learning purposes, for example, Moodle, zoom, WhatsApp, Skype, Facebook, Twitter, etc. However, most students and lecturers do not use these for educational purposes. Rather they use these digital technologies face-to-face in the classroom (Khoza, Biyela, & Technologies, 2020).

A robot teacher was introduced in India to replace the teachers. "This robot was praised on the 5th October 2019 during the World Teachers' Day for successfully teaching more than 300 learners to master subject content" (Khoza et al., 2020, p. 4). These teachers may seem to praise this robot as seen as the best because it has covered the content to many students at once. On another note, how can students get feedback if they experienced a pedagogical problem when the presentation was unclear and easily presented? Educators contextualize and re-contextualize the lesson and experience difficulties until learning becomes meaningful to learners (Stenhouse & development, 1975). When teachers use digital technology, it is recommended that they reflect on, in, and for their doings to address the professional, societal, and philosophical questions of education for the professional use of 4IR (Khoza, 2018). This also means that putting a robot teacher to replace a teacher will not solve a high failure rate in mathematics as it is much better when a teacher can explain the content.

Meanwhile, a study was conducted at a particular University of Technology by Msomi and Bansilal (2019) to investigate the challenges of implementing e-learning practices faced by the lecturers in that sector. The findings indicate that lecturers show different enthusiasm towards integrating technology into education. Some lack confidence, while others lack access to resources and poor infrastructure. This suggests that even at the University of Technology, there is still inadequate integration of technology in the teaching and learning situation.

Internationally, technology use in teaching mathematics is increasing, with some governments making it compulsory for teachers to integrate technology in their teaching. Mailizar et al. (2020) conducted a study in Indonesia where the aim was to investigate ICT to enhance the quality of education. This is evident because Mailizar (2018) also revealed that 35% of Indonesian secondary mathematics teachers had never participated in any ICT-related training course. This is alarming since a curriculum policy in Indonesia was introduced in 1984, which forces teachers to integrate modern technologies into mathematics classrooms. Studies by Boris et al. (2013) in Australia, Stoilescu (2015) in Canada, and Agyei, Voogt, and technologies (2011) in Ghana reveal that mathematics teachers do not have sufficient knowledge about ICT and the knowledge of using ICT in teaching.

The study was done in the United States middle and high school teachers by (Hill & Uribe-Florez, 2020) and explores how mathematics educators integrate technology in their mathematics classrooms. A mixed-method was used to collect data quantitatively through a survey and a qualitative approach. The results of the quantitative data stated that these teachers used for the study are most confident in their content knowledge but with lower content knowledge in geometry than algebra. The themes that emerged for technology integration reflected conceptual understanding, teaching strategies, time, and student engagement (Hill & Uribe-Florez, 2020). Conclusively, high confidence in pedagogical knowledge is reflected in how teachers integrate technology in mathematics teaching.
Meanwhile, a similar study was conducted in Indonesia at the TVET conference. The purpose of the study was to obtain an overview of knowledge of learning technology and identify factors that influence the use of technology in teaching and learning (Malik, Rohendi, Widiaty, & Research, 2018). This study intended to use the papers and analyse data from those papers to determine the intended ability, including mastery of teacher-related technology, pedagogy, and subject content as explained in the TPACK framework.

These researchers indicated that technology in learning shows the relationship between the teachers' three basic knowledge: technological knowledge, pedagogy, and content. The methodology used for this paper is the literature review extracted from 120 papers for the ten-year studies, i.e. (2008 to 2018). The results indicated that teachers do not all have good skills related to technology as they only follow developments. However, they have knowledge of technology integration in teaching materials which is sufficient with an average value. The lowest value is technology integration with teaching material and technological knowledge. This suggests that many teachers do not know how to integrate technology in teaching, even in TVET Colleges in Indonesia. However, teachers are familiar with technology usage in everyday life because they are most interested in ICT. Still, the problem is that it should be integrated within education through several pedagogical methods.

A study was done in Spain to analyse 37 contributions published between 2014 and 2017 that used the TPACK framework (Rodríguez Moreno, Agreda Montoro, & Ortiz Colón, 2019). It has four criteria: public, topic, main results, and methodological results. The seven domains of teacher knowledge, including the distinguished context of training using the TPACK framework, were used for this study which is defined by (Mishra & Koehler, 2006). The researchers argued that these dimensions could not be conceived separately. Regarding the investigations carried out in primary and higher education, they confirm the advances in technology in primary education classrooms in the future are due to the teachers' acquisitions of the technological, pedagogical and content competence during their initial training. Regarding the studies analysed, there is a lack of showing the teachers' actions when applying technology in their daily practice and a lack of studies in pre-and secondary schools. My study aims to get an overview of knowledge of learning technology and identify factors that influence the use of technology in learning. The aforementioned suggests a promise for more mobile learning tools to be created because its motivated students to make mathematics content more enjoyable and interactive than ordinary lessons. However, there is a lack of research done in TVET colleges as the above findings were either from the data from secondary schools or the primary schools.

2.8 Conclusion

Using technology in the teaching and learning process is very important, especially in teaching geometry, to advance the skills needed by the country. In this chapter, the researcher has reviewed academic work from different scholars across all specialties based on the lecturers' use of technology in geometry at the TVET College. Students and lecturers are the central part of teaching and learning, and lecturers' voices in using technology and curriculum design have been ignored. There are several research studies on primary school teachers, high school teachers, and university use of technology like WhatsApp, GeoGebra, etc., in the teaching and learning of geometry and mathematics as a subject in the current years. There is also common research on teachers' content knowledge of mathematics and the teaching strategies used by mathematics teachers and geometry. However, there is no substantial body of study that focuses on the lecturers' use of technology in the teaching of geometry. This is what this study intended to pursue. This study largely relates to lecturers' use of technology, and the following chapter represents the framework used for the study.

CHAPTER 3
THEORETICAL FRAMEWORK

3.1. Introduction

The preceding chapter presented the literature on lecturers' use of technology in geometry teaching. Chapter 3, a theoretical framework, unpacks the importance of the theory used to generate data. The ideas that influence the phenomenon of the study are specified by the theoretical framework, which provides logic and applied foundations of the research study (Creswell, 2014). Meanwhile, Henning and van Rensburg (2004) view that a theoretical framework helps complete thinking on how the world is viewed, thereby clearing the interlocks of how things are related in the whole world.

TPACK stands for Technological Pedagogical Content Knowledge. It is an applicable theory for this study because it is framed by the prominent gestures of the technological (lecturers' use of technology), the pedagogical (teaching using technology), and content knowledge (circle geometry content). These gestures are significant and specifically tackle the phenomenon of lecturers' use of technology in the teaching of geometry.

The chapter unfolds in the following manner: the history and explanation of the TPACK theory are presented, followed by the benefits of the theory. Lastly is the demonstration of the use of the TPACK in numerous backgrounds.

3.2. The history and explanation of the TPACK framework

TPACK framework was first offered as Technological Pedagogical Content Knowledge (TPCK), which extends the discoveries of Shulman (1986) Content and Pedagogy (CPK) through learning and teaching. In 2006, this framework was upgraded to Technological, Pedagogical, and Content Knowledge (TPACK) (Mishra & Koehler, 2006), which was constructed over sequences of theories which were based on realising the development of teachers' integration of technology in teaching and learning (Hill & Uribe-Florez, 2020). Koehler, Mishra, and Cain (2013) further mentioned that this TPACK theory gives a framework that aids teachers in understanding adaptable knowledge based on three areas and how that knowledge can effectively be used to integrate technology during teaching and learning in the classroom.

TPACK theory is the best framework for understanding the content that uses technological tools. The TPACK stresses the interrelationship among the curriculum content, the technology, and the pedagogical approach. In addition, there is the belief that this theory is also specific and appropriate to apply as it demonstrates how teachers understand the interrelation between technology, content, and pedagogy how it can be applied for effective teaching and learning while achieving the learning outcomes with educational technology.

An educator needs to have the knowledge required to use technology successfully in the teaching and learning to deliver the curriculum, as suggested by the TPACK framework. The study of Edwards (2019) confirms the work of Koehler, Mishra, and education (2009) on the TPACK framework. Edwards (2019) shows the seven elements of knowledge needed when teaching mathematics. The first three of these elements are important; 1. Content knowledge, 2. Pedagogical knowledge, and 3. Technological knowledge. as shown in the simple diagram 3.1 below:

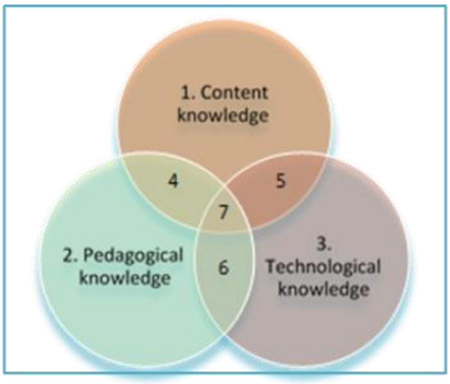


Figure 3.1: Three first elements that are intersecting for the TPACK framework

When successfully integrating technology into the curriculum, teachers need to have the following three types of knowledge concerning figure 3.1, which has three intersecting circles, which is the actual representation of:

- Content knowledge is the kind of knowledge that is very important, which an educator needs to master, and the knowledge of the subject matter that needs to be delivered to learners. An educator needs to be an expert or a specialist for teaching a subject (Koehler et al., 2009)

- Pedagogical knowledge: This knowledge is the 'how' part during the teaching process. It is concerned with how educators are delivering the subject curriculum to attain the learning outcomes in the classroom (Koehler et al., 2009)
- Technological knowledge is the technical skill and knowledge an educator must possess in the classroom and how an educator thinks concerning technology. It involves the broad information of knowledge applied. An educator can differentiate on what technology to use and how to use it to attain the curriculum goals through ongoing adaptation to technology changes (Koehler et al., 2009).

This suggests that the three above-discussed types of knowledge are necessary for teaching circle geometry using technology effectively. They are a basic part of knowledge, and it seems it is a multifaceted interaction kind of knowledge for curriculum implementation using the TPACK framework. The qualifications of lecturers and experience in teaching will determine the quality of use of technology in the teaching of geometry. Teachers' knowledge and technology form the foundation for developing learners' learning. Therefore, educators must know how and why learners learn and how the lessons need to be taught using technology (Bulut, Işıksal, & Teaching, 2019).

In addition to the components mentioned above of knowledge, the other last-four makes the TPACK framework, as shown in figure 3.2. below. These are as they appear in the following figure 3.2 below: Pedagogical Content Knowledge (PCK); Technological Content Knowledge (TCK); Technological Pedagogical Knowledge (TPK) and the last one known as Technological, Pedagogical and Content Knowledge (TPACK).

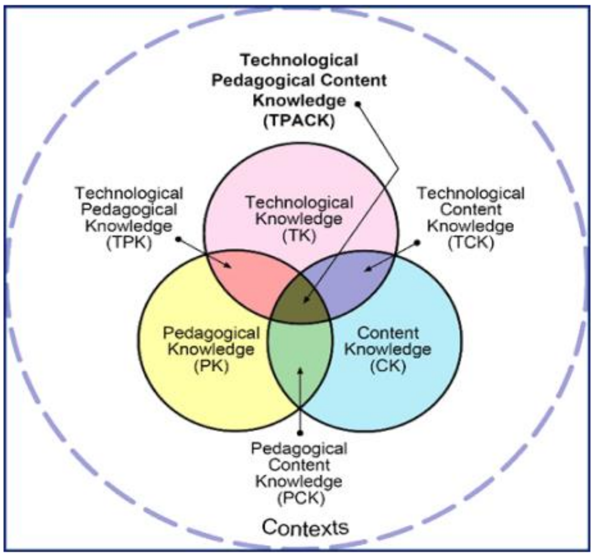


Figure 3.2: TPACK and its constituents of knowledge (http://tpack.org, 2012, reproduced by permission of the publisher).

- Pedagogical Content Knowledge (PCK) is about how educators implement the curriculum in class (Koehler et al., 2009). This is about the interpretation of the curriculum document (Shulman, 1986). What do lecturers do if students do not understand a lesson? Do they use the context for the students, or do they not contextualise? In other, words which teaching and learning strategies do the mathematics lecturers use to teach circle geometry?
- Technological Content Knowledge (TCK) is about understanding how technology may influence the content being taught in a class. In other words, educators need to be aware and skilled on which technology to use for specific content (Koehler et al., 2009). This suggests that not every available technology can be used. The mathematics lecturers need to be highly skilled in choosing the technology to use in circle geometry.
- Technological Pedagogical Knowledge (TPK) is about understanding using the technology in teaching with the required skills for a particular subject while integrating with learning theories like behaviorism, cognitivism, constructivism, humanism, and connectivism (Koehler et al., 2009). This suggests that mathematics lecturers need to integrate technology with the learning theories when teaching circle geometry using educational technology.
- Technological, Pedagogical, and Content Knowledge (TPACK) is the last constituent of the TPACK theory. This requires the educators to have the necessary skills and effective use of technology for effective teaching and to learn the subject matter, comprehending the first three overlapping teachers' knowledge discussed earlier. Using this framework, learners will link the previous knowledge and the environment to make learning more meaningful while using technology in the classroom (Koehler et al., 2009). This suggests that mathematics lecturers need to use the context and link the present lesson with the previous learning for effective learning when teaching circle geometry using technology. Learning will be more meaningful. In other words, mathematics lecturers need to lead the lesson to the expected learning outcomes, with the students being active participants in the class. When looking at the educators' role during the 21st century, it is observable that educators contribute the most to the development of humans, especially with the use of technology during the learning process (Malik, Rohendi, & Widiaty, 2019).

3.3. Benefits of the TPACK framework

A survey was conducted by Alrwaished, Alkandari, Alhashem, and Education (2017) at the schools in Kuwait while using 90 pre-service and 154 in-service mathematics and science high school educators as participants of the study. The first data collected showed that in-service educators required more development in the use of technology during curriculum implementation in the classroom. Further steps were taken to enroll 57 in-service mathematics and science educators for training using the TPACK framework. The results showed that the educators registered for training in TPACK agreed it was meaningful in both mathematics and science and showed great improvement.

The study revealed some challenges when educators used TPACK to develop curriculum in the classroom; therefore, the TPACK framework effectively addresses professional development in technology usage in the curriculum. The study concludes that there are some challenges when teachers use technology in the curriculum; therefore, TPACK technology effectively addresses the misconceptions created by insufficient knowledge of using technology in the classroom, thus, creating more confusion in learning. This also suggests that the TPACK framework will be more effective in using this study in mathematics lecturers' use of technology in the teaching of geometry.

Subsequently, another benefit of using TPACK as a framework for effective learning and teaching showed that it helped educators understand the skill to know and use the available technology in the teaching and learning process (Govender & Khoza, 2017).

Furthermore, there is also the study conducted by Mailizar et al. (2020) in Indonesia at secondary schools. The objective of the study was to investigate the secondary mathematics educators' knowledge and use of ICT in teaching. Three hundred and forty-one mathematics educators were used as the participants with the employment of the TPACK framework through the survey. The study results revealed that secondary mathematics educators from Indonesia had insufficient knowledge of ICT and inadequate knowledge of using ICT in the curriculum during the teaching and learning process.

The conclusion of the study suggests that professional development needs to be addressed in Indonesia concerning the use of technology in the curriculum. This study revealed the benefits of the TPACK framework are based on understanding the content, technology, and pedagogy used for technology by finding out the shortage of knowledge of ICT in mathematics teachers. The Government in Indonesia needs to provide ICT training for all mathematics educators concerning the technological, content, and pedagogical knowledge of ICT usage in the classroom.

Kirikcilar and Yildiz (2019) studied Turkey's mathematics, science, and technology educators to support the above disclosure. The study aimed to develop a valid, reliable, and useful observation sheet to determine the effective use of software GeoGebra through TPACK in secondary mathematics educators. Three stages were employed when conducting this study: research, pilot study, and evaluation through applying the TPACK framework. The study results were positive in that educators displayed behaviours that were not covered in an observation form. The scholars concluded that the TPACK observation form could be used in different learning areas because it helped eradicate learners being memorisers in learning and enables them to be lifelong learners as they were actively involved in learning. The objectives of the lesson are to make learners the active participants of learning as per CAPS requirements (Maharajh, Nkosi, Mkhize, & Review, 2016). NCV curriculum is in line with the CAPS curriculum done by the DoE. Maharajh et al. (2016) further raised concerns that CAPS aim to redress the imbalances of the past that shift the learning from being educator-centered to the learner- centred, making learners active learners of the lesson and lifelong learners' citizens of the country. This suggests that when using the TPACK framework within the NCV curriculum to teach circle geometry using technology, learners and lecturers will be moving to the 4IR era. The use of technology in the classroom can be effectively aided with the TPACK framework. It can show the type of training the mathematics TVET lecturers require about technology usage in class, including the other subjects' lecturers. Malik et al. (2018) emphasised the training of educators in using technology in class. He stressed that a TPACK qualification is the most needed by the educators so that they are well equipped with the skills for creating effective teaching material for learning.

On the other hand, Khoza (2015) believes that the educational technology environment has raised the hype to attract the things that are not relevant to learning and teaching and are from the hardware and software resources. This may mean lecturers' use of technology through TPACK must focus on achieving the learning outcomes stipulated in the NCV mathematics subject guideline. A learning technology needs to be used with strict guidelines for the TPACK framework; otherwise, the lesson may be irrelevant and not benefit the learning process.

3.4. The context of the TPACK application

Representation in table 3.1 below shows context from various studies where the TPACK application is of dominant importance.

Table 3.1: The application of the TPACK framework

Zhao and Zhang (2017)	This quantitative study took place in China. The purpose of the study was to evaluate the Chinese pre-service mathematics teachers' knowledge of integrating technology in teaching mathematics. One hundred and twenty- three in-service mathematics teachers were utilized as the participant with the use of the TPACK framework. Evaluating Chinese Pre-Service Mathematics Teachers' Knowledge of Integrating Technology in Teaching	The study showed that educators need one piece of information based on technology with professional development. The study recommended using qualitative study where classroom observation and in-depth interviews get more reliable data.
Kafyulilo, Fisser, Pieters, and Voogt (2015)	This mixed-method study from Tanzania aimed to explore ICT knowledge in teaching science and mathematics. Twenty-two teachers were the participants with surveys and observation using the TPACK framework.	The findings showed that Tanzanian teachers have insufficient skills for integrating technology in teaching the subjects. This study also concluded that teachers TPACK helped with the hands-on micro team development on mastering integration for technology and

		content of mathematics and science during the teaching and learning of the subjects.
Baumgartner, Ferdig, and Education (2019)	This quantitative study was conducted in China with the survey. It investigated Chinese pre-service mathematics teachers' TPACK from three universities. Two- hundred and sixty pre-service mathematics teachers were used as the participants of this study.	The study's findings showed a gender difference in technology knowledge where females showed that they are less competent in technology. Teachers emphasized more on hard technology with the ignorance of soft technology such as TPACK. The study recommended further training of educators in the integration of technology in the curriculum.
Cahyono, Kurnianti, and Mutiaraningrum (2016)	This qualitative study is from Indonesia. The purpose of the study was to explore the application of TPACK in in-service education teaching practices. Twenty secondary mathematics in-service teachers participated in a study. All the participants were doing a master's degree and teaching practice. All twenty participants were given a course for TPACK and were expected to teach their colleagues.	The study showed that teachers benefited from the TPACK teaching practice course and excelled in their teaching practice by applying the TPACK framework even though they showed low self-esteem. The study recommended that teachers be given more time to practice self- contextualization of TPACK during teaching practice.
Alrwaished et al.	This Kuwait study explored in- and	The results for the pre-

(2017)	pre-service science and mathematics teachers' technology and pedagogy practice through the TPACK framework. Two hundred and forty-four in- and pre- mathematics and science teachers were used as participants. The results showed that these educators required more help. Then, fifty-seven in-service teachers were further enrolled and trained on the TPACK model.	workshop were very bad. Then the results after intervention were excellent, which shows that ongoing support and technology training are needed through TPACK.
Govender and Khoza (2017)	This is a South African study conducted on technology in education for teachers. The purpose of the study was to provide academics with the required awareness of the latest technology within the education sector.	This study showed that lecturers for mathematics, science and ICT struggle to use the technology in use. Therefore, the study recommended using TPACK with relevant knowledge to use technology during teaching and learning.
Rohmitawati (2018)	This Indonesian qualitative study was done using thirty junior secondary school mathematics teachers. The purpose of the study seeks to understand the characteristics of teachers' TPACK content knowledge created in a GeoGebra-based classroom-based environment.	The study's findings show that using the TPACK framework during the teachers' online mathematics technology training integrates technology and discovery learning strategies. The data collected recommended improving online training for mathematics teachers' use of technology in

		mathematics teaching.
Utama and Nurkamto (2019)	This is an Indonesian study used to critique literature review from different studies to review and analyse the technology Learning Model within TPACK as a framework.	The findings of the study show that the Technology Learning Model separates Technology Knowledge from Content Pedagogical Knowledge (CPK). The study indicated that it is not important to use technology while using the Technology learning Model.
Rahmawati, Suryani, Akhyar, and Reviews (2020)	This is a quantitative study conducted in New York City. The study aimed at exploring whether TPACK domains can develop the instrument for assessment for the effective use of technology in mathematics. One hundred and sixteen pre-service mathematics teachers were utilised as the participants for the study to complete the course for pedagogy.	The study provided the opportunity for assessing different types of teacher knowledge as defined by TPACK. It further revealed that the TPACK framework is effectively used by teachers in the integration of technology in the teaching and learning of mathematics
Mailizar et al. (2020)	This is a quantitative study from Indonesia. A survey was used to investigate the secondary teachers' knowledge use of ICT in the mathematics teaching and learning situation. Three-hundred and forty-one secondary mathematics teachers were used as participants of the study	The findings of a study show that Indonesian secondary mathematics teachers displayed insufficient knowledge of ICT and inadequate knowledge of ICT use in the classroom. The study recommended that there should be more training for ICT development and classroom usage of ICT.
Hill and Uribe-	This was a mixed-method study	The data showed that TPACK

Florez (2020)	conducted in the Mid- Atlantic region of the United States. The main aim of this study was to explore the TPACK of middle and high school mathematics and special education teachers and how they integrate technology during the teaching and learning of mathematics. Twenty-nine rural mathematics teachers were made participants.	revealed that teachers had less confidence in their technology knowledge. The study recommended professional development for teachers to learn technology and teaching strategies in mathematics.

Along with the mentioned studies above in table 3.1, the different use of TPACK concerning the application to various contexts, it is observed that TPACK's main domains (pedagogy, content, and technology) perform a vital role in the successful learning and teaching of geometry when lecturers use technology.

3.5. Conclusion

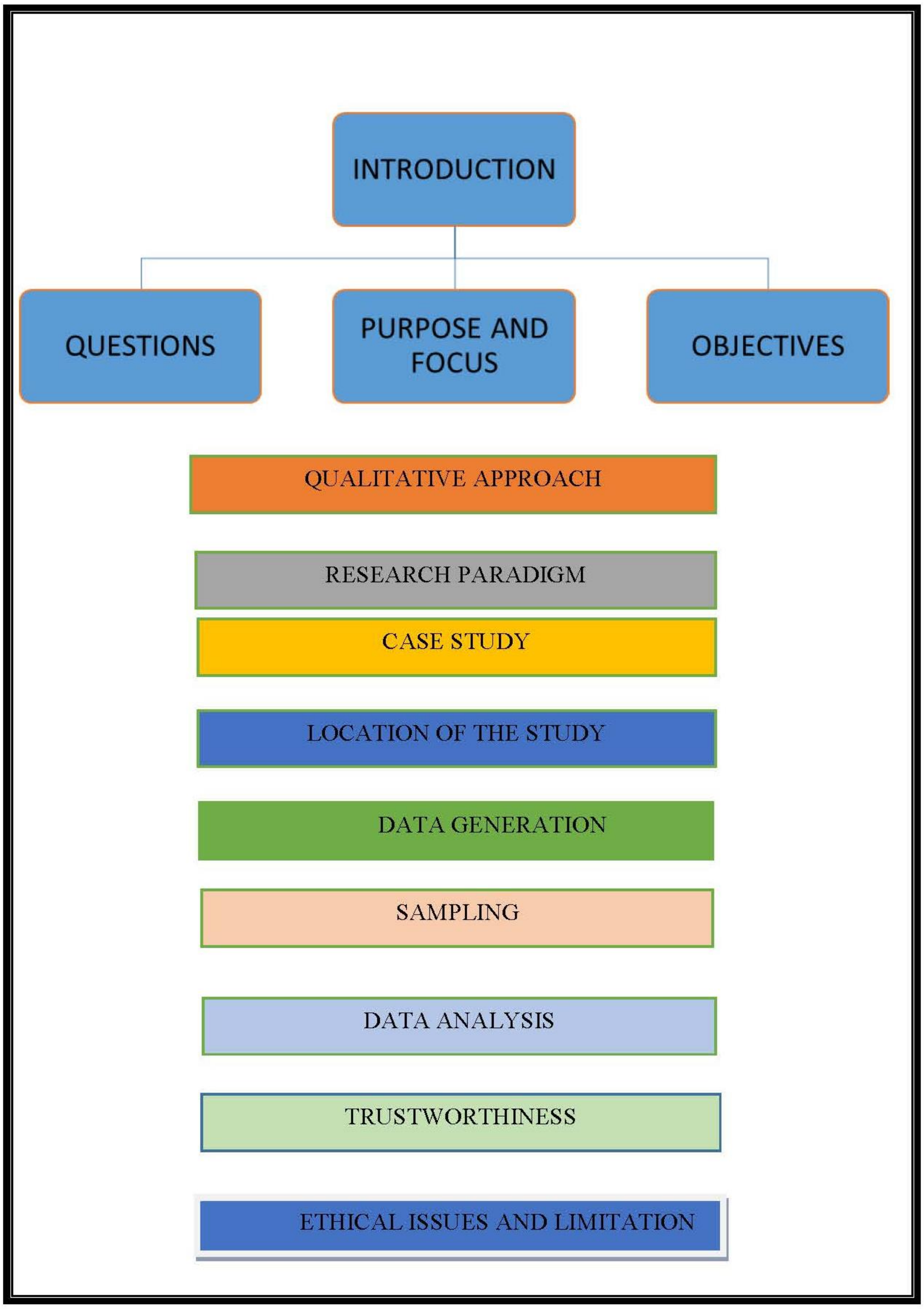
This chapter offered the framework used in the study. It began with the introduction of the chapter. A discussion was then given concerning the history of the TPACK framework, followed by the benefits of the theory. In conclusion, the demonstration of TPACK in various studies was outlined. The above discussion shows the need for using the TPACK framework in the lecturers' use of technology in the teaching of circle geometry at a TVET College in this study. The following chapter represents the research design and methodology of the study.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

4.1. Introduction

The previous chapter explained the theoretical framework on lecturers' use of technology in circle geometry. This chapter presents the research design and methodology used for this study. Figure 4.1 below shows a flow chart that outlines the structure of this chapter.



4.2. Focus and purpose

The purpose of this study was to explore mathematics lecturers' use of technology in teaching circle geometry at a selected Technical and Vocational Education and Training College in Kwa-Zulu. This research study is projected to determine 'what' technology lecturers use to unpack 'how' and 'why' lecturers use technology to teach circle geometry at a TVET College. This research study then focused on using the available technology per the 4IR of the Vision 2030 in South Africa. **The following objectives addressed the purpose of this study:**

Main objective:

To explore the experiences of mathematics lecturers' use of technology in the teaching of circle geometry to level 4 students at a selected TVET College.

Sub-objectives

1. To understand the use of technology by teachers in the teaching of circle geometry to level 4 students at a selected TVET College
2. To explore how mathematics lecturers, use technology in teaching circle geometry to level 4 students.
3. To establish the efficacy of using technology to teach circle geometry to level 4 students.

4.3. Research questions

This study explored the lecturers' use of technology in circle geometry in a TVET College. Its purpose was to discover the use of technology in teaching and learning circle geometry.

The main research question was:

What are mathematics lecturers' experiences using technology to teach circle geometry to level 4 students at a selected TVET College?

The sub research questions were:

6. What technology do mathematics lecturers teach circle geometry to level 4 students in a TVET College?
7. How do mathematics lecturers teach circle geometry using technology in a TVET College?
8. Why do mathematics lecturers teach circle geometry how do they use technology in a TVET College?

9. What do mathematics lecturers do to enhance the effective teaching of circle geometry using technology?
10. How does mathematics lecturers' use of technology in their teaching programs influence students' experiences of learning circle geometry?
11. What implications does technology have for the teaching and learning mathematics in TVET Colleges in South Africa?

4.4. Qualitative approach

Researchers may use either a quantitative approach, a mixed approach, or a qualitative approach. The type of data that needs to be collected propels a researcher's choice. If it is textual data, a researcher may opt for a qualitative study, and if it is numerical or statistical data, a researcher may opt for a quantitative approach. I attempted to understand how lecturers use technology to teach level 4 TVET students' geometry. A qualitative approach directed this study because I targeted data that is textual. The study also used a small number of participants by only focusing on Majuba District TVET Colleges.

Qualitative researchers "stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry"(Guba & Lincoln, 2005, p. 10)

Consequently, "qualitative research is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process involves emerging questions and procedures, data typically collected in the participants' setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data" (Creswell, 2014, p. 67). My research involved data generation in the participant's choice of location to be comfortable sharing their ideas with me in an unobtrusive environment. I have also presented the findings in themes. De Vaus (2004) and Zhou and Creswell (2012) assert that participants' attitudes are noticeable when interacting with them when a study adopts a qualitative research approach. This helped me observe the participants while interacting with them during the one-on-one semi-structured interviews when collecting data to get their feelings through examining the phenomenon during the interaction process.

Denscombe (2017) confirmed that behavioural and social fields use a qualitative research approach. As I am localised in the social field, the qualitative approach was suitable for attaining the required data for the study. This involved distributing a questionnaire to mathematics lecturers about using technology in their classroom settings and face-to-face zoom interviews with them about using technology in teaching circle geometry.

This study is a qualitative approach in keeping with Check and Schutt (2012) suggestions that qualitative research involves action research, case study, and ethnography research. This confirms that this study is a qualitative research method because I used a case study as a research tool.

4.5. The research paradigm

Many scholars have different ways of defining a paradigm. A paradigm is how one views the world. There are three types of paradigm, i.e., interpretive, critical, and positivist. Guba and Lincoln (1994) state that a paradigm provides the string of ideas one uses in viewing the world. Meanwhile, Cohen, Manion, and Morrison (2013) assert that different researchers use a paradigm to search for the truth for viewing the world for understanding the phenomenon.

This qualitative study was of a KwaZulu- Natal TVET College that explored the lecturers' use of technology to teach circle geometry. The primary purpose was to explore how mathematics lecturers use technology to teach circle geometry to level 4 students. I needed to relate with the NCV lecturers to encompass their experiences and how they have experienced using technology in geometry teaching to create reliable data. I decided that the most appropriate paradigm for this study is the interpretive paradigm.

I chose this paradigm because it helped me interpret lecturers’ use of technology. The interpretive paradigm targets the participants in their existing world and describes their social reality (Cohen, Manion, & Morrison, 2007). Information was created through the questionnaire and one-on-one semi-structured interviews. As interviews were face-to-face (through zoom) and one-on-one, it started visible phenomena and how most people make sense of it (Henning, 2004). This suggests that I tried to justify using technology for the comprehensive study. After a questionnaire, I interviewed the so-called participants to determine how they use technology to teach circle geometry.

A researcher does not predict what people aim to do in the interpretive paradigm. Understanding the phenomenon aims to describe how people reason about the world around them (Christiansen, Bertram, & Mukeredzi, 2018). Reality is created individually through the interpretive paradigm, as Scotland (2012) mentioned. This interpretive paradigm is best for this research study because I did not fabricates data. Instead, I conducted interviews face-to-face with the mathematics lecturers individually and created a reality about the experience of using technology in the teaching of geometry in level 4.

Conclusively, Creswell and Creswell (2017) maintain that people are creators of knowledge through understanding the phenomenon instead of positivists that emphasise one truth. This suggests that using this paradigm allowed lecturers to share their technology experiences to better understand their daily teaching experiences using technology in the teaching and learning situation. However, Cohen et al. (2013) mentioned a weakness for this paradigm where interpretivism tends to be subjective to participants when collecting data, mostly influenced by the ever-changing emotions. During this study, I avoided the weakness of a paradigm that could influence this study by sending soft copies to participants to verify the collected data.

Figure 4.2 The interpretive paradigm (Creswell, 2014, p. 4)

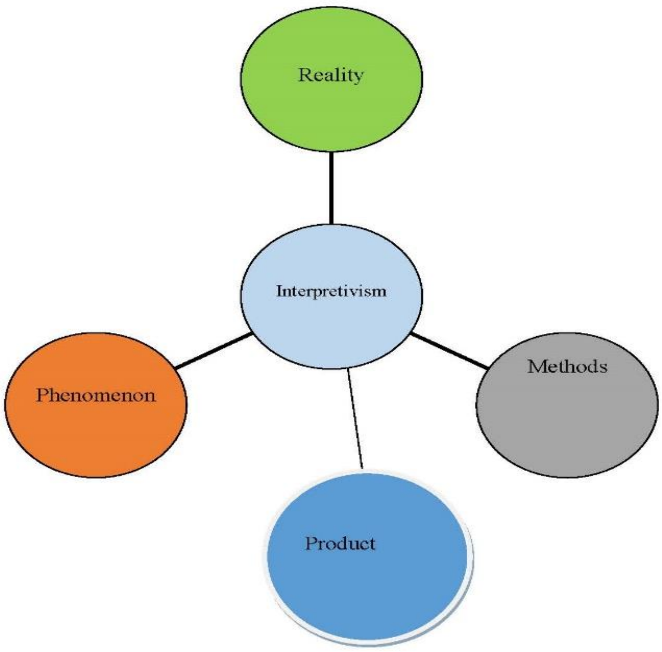


Figure 4.2 above elucidates when and how to use the interpretive paradigm. The collaborative approaches need to be used to comprehend the participant and the phenomenon more easily. Applying this interpretive paradigm helped me understand lecturers’ use of technology in mathematics classrooms when sharing their experiences on 4IR from the lecturers' perspective. This paradigm allowed the lecturers' teaching and technology usage in the classroom to interpret their experiences using technology and their experiences through social interaction, making the study more valid.

4.6. Why the use of the case study in this study?

Many researchers have displayed their different understanding when explaining the meaning of a case study. According to Yin (2012), a case study is an investigation or rather a profound scrutiny of a conjoined system (it may be a person, a time, a place, an event, and/ or a social phenomenon). Yin (2009) adds that multiple cases or a single case can be investigated over a certain period. This gives two reasons for this study to apply a case study, as Yin (2009) suggested. Firstly, ‘what’ or ‘how’ research questions explain the case study's present conditions. The main research question will focus on how TVET lecturers use technology when teaching circle geometry. Therefore, using the above definitions, I decided to use a case study approach because it helped examine the TVET lecturers’ use of technology when teaching circle geometry. The case in this study focussed on the Majuba District TVET lecturers who teach mathematics. When choosing this case study, it was close to reality because lecturers’ use of technology in the teaching is what they do every day, and the description of their daily practices is real. It could contribute to a TVET College improvement in policies for 4IR (Flyvbjerg, 2006).

The research was located on three different campuses of this college. This case study used questionnaires and interviews to create an intensive, in-depth analysis of a case (McMillan & Schumacher, 2010). A case study provides a great opportunity for the researcher to get rich data and receive the participants’ opinions (Cohen et al., 2013). This suggests that the participants talked about their daily teaching experiences and the pedagogical skills used when using technology in teaching circle geometry at the TVET College during one-on-one semi-structured interviews. Frequently, when scholars conduct their studies on TVET lecturers, they are preoccupied with their conclusions and conjectures about lecturers’ experiences on their teaching practices and ignore exploring their use of pedagogical practices. Conclusively, Creswell (2014) maintains that a case study accepts conclusions based on a general conclusion that originates from the gathered data. Therefore, this case study permitted claims, designs, and justifications about the lecturers' use and their involvement in daily lives.

4.7. Why choose this location for the study?

For this qualitative case study, the participants from a TVET College in Newcastle in the Majuba District Municipality in Northern KwaZulu- Natal were used. They were selected from five campuses of the TVET College in KwaZulu-Natal, Amajuba District. The district was chosen based on my geographical and socio-economic background and position as a mathematics lecturer in the named district. Figure 4. 3 below shows the location of the study

Figure 4.3: The map above displaying the Majuba district in KwaZulu -Natal Province (2016).svg

Figure 4.4: The map above displaying all the districts in the KwaZulu- Natal Province (2016).svg

Amajuba district is one of eleven district municipalities in KwaZulu Natal, as shown in figure 4.3 above. It is the district where the study took place. It lies in Free State Province, Mpumalanga Province, and Limpopo. Amajuba District has three local municipalities: Danhauser, Newcastle, and Emadlangeni, and consists of Charlestown, Utrecht, Newcastle, Hattingspruit, and Danhauser towns district. Before 1994, Newcastle was the capital of the Northern Natal cluster. For over three decades, the Chinese and Taiwanese communities have contributed to the economy of Newcastle. Newcastle also relied heavily on ArcelorMittal, Karbochem, Venco, NPC, and the textile factories. In August 1996, South Africa signed the international trade agreement, which affected the socio-economy of Newcastle. Most companies are still closing, and factories employ illegal immigrants from the surrounding countries without work permits as they are cheap labour, which hinders most Newcastle residents from getting employment. Some factories are still shutting down as textile factories because China is busy with cheap trades to our country, affecting the Majuba District economy. The high rate of unemployment leads to a high crime rate in this area and the surrounding towns. Only four main sectors contribute most to the Amajuba district's economy: Business services 15,2 %; Community services 22,2%; Trade 8,6%; lastly, manufacturing 35%.

Amajuba district has formal schooling, which takes place in many high schools and primary schools and seven campuses of the TVET College with no university in the area. This TVET College, as a site of research, has eight campuses in all. The first three campuses are at Newcastle, with two being the business studies campus, and the last one is for the engineering studies. One is located at Dundee, which has both engineering and business studies. The remaining campus is the big training centre, and the last three campuses are at Madadeni Township, which is for the engineering, occupational programmes unit.

The students who attend the college are previously disadvantaged, and most are black from rural areas where they stay as far as Ngwavuma and Jozini. Therefore, during their study period, they stay at private accommodation on their own as tenants because the college does not provide for them. Some struggle to pay rent as they were raised by their grandparents, who depend on social grants, while others head their households because they have no parents. While they are heading their households, they also have children. Most students are female at the TVET College.

The college has built strong structures because it was previously a teachers' college of education, including campuses funded by the DHET. The college has a well-resourced media centre. Two years ago, the TVET College managed to have computers with the internet, situated in the staff room. As of now, there are only a few computers in good working condition. There is no internet, and those computers are infected with viruses. There are tarred roads to the township campuses. In Madadeni Township, only the main streets have tar.

4.8. Data generation

In a qualitative study, data is generated by many methods that answer the research questions that steer the study (Merriam & Tisdell, 2015). Ramrathan (2017) believes that generating data when exploring a phenomenon depends on how the participants are engaged, which helps to effectively generate data, which yields and unpacks the procedure of taking out the purpose, aims, objectives, and research questions. When using more than one method for generating data, there is high accuracy for research findings and conclusions (Yin, 2015).

A qualitative research study has specific methods that are utilised. By bearing in mind the purpose of this study, which is to explore lecturers' use of technology in teaching circle geometry at a TVET College, this research used two procedures for creating data: a questionnaire and a one-on-one semi-structured interview. When using more than one method of generating data, triangulation results and ascertains the research findings' trustworthiness and credibility in a qualitative research study (Creswell & Creswell, 2017). By using these two procedures for collecting data, the reliability of data will be addressed. Below are the discussions for each research instrument that was used.

4.8.1. Gaining access

The purpose of this study was to explore lecturers' use of technology in teaching circle geometry to level 4 students at a TVET College in KwaZulu – Natal. I have been a mathematics and mathematical literacy lecturer at this TVET College since June 2012. In addition, I have experience as a teacher of mathematics from grade 8 to 12 and a science head of department at a high school level at the Department of Basic Education from January 1992 to May 2012. This mathematics experience inspired me to conduct this study with a group of mathematics lecturers at a TVET College where I currently work. DHET and the college rector permitted me to conduct this research and get consent from the mathematics lecturers to participate in this study.

Cohen, Manion, and Morrison (2002) state that the selection of the participants needs to be based on both participants' willingness and availability. When I was selecting the participants, I was helped by the Curriculum Department Division of the college to meet with the population from which samples were selected. They gave the mathematics lecturers teaching the NCV programme a call as geometry is only at NCV content. The samples were to be selected at the college lecturer theatre of the campus, where a meeting was held. I was introduced to the target group by the curriculum division head. I introduced my study, purpose, and significance and told them how they would benefit from the study academically. I also told them that there was no form of compensation for being a participant and advised them that participation was voluntary. I asked all those who did not teach level 4 to excuse themselves and requested the remainder who were interested in participating in the study to give their contact details. Fifteen mathematics lecturers availed themselves, and I included all of them to partake if some of them withdrew at a later stage.

Therefore, I chose to focus on only those lecturing level 4 the previous and the current year because the study needs reliable data where participants need to be directly involved in teaching geometry using technology. I answered all the questions asked during that time to clarify certain issues. I asked those who availed themselves for the study to write two paragraphs about using technology in the geometry classroom. When I was looking at the submitted tasks, I found out that only eight had submitted, and from them, only five understood the task provided to them. Only five turned up for a questionnaire and an interview session. Five respondents formed the study sample (participant A, participant B, participant C, participant D, and participant E) for the questionnaire and the face-to-face interviews for data generation.

4.8.2. Research methods

4.8.2.1. Questionnaire

A questionnaire that was used for this study belongs to a qualitative study. It was used to explore the lecturers' use of technology in teaching circle geometry in a TVET College. Gray and Outreach (2011) state that questionnaires are the tools that generate data where participants are required to respond to the same set of questions as pre-organized by the researcher. Questionnaires were also the most suitable instruments for this research because they provided information about their direct involvement, motivation, views about how lecturers were ready and well equipped with technology in teaching circle geometry at a TVET College.

In this study, I used questionnaires that consisted of open-ended questions. Sarantakos (2012) mentioned that the benefit of using open-ended questions is that it prompts participants to give deeper and new insights while including their feelings, understanding, and attitude. These questions fit this study because they allow respondents to give more information, which led geometry lecturers to answer questions that I wanted them to answer concerning the use of technology in the classroom.

I delivered questionnaires by hand to each geometry lecturer chosen as a participant in a set time. I made sure that each participant was met at an appointment set individually. I ensured I was there to answer questions for any question clarification to participants and ensure that data was reliable. The questionnaire used questions of the same main topics listed in Appendix A.

4.8.2.2. One-on-one semi-structured interview

A one-on-one interview is the best instrument for collecting data because a researcher guides the process and digs deeply from the participant to address the study's objective (Ramrathan, 2017). Ramrathan (2017) further mentioned that one-on-one structured interviews compared to one-on-one semi-structured interviews lead to disaster because the leading unplanned questions that the researcher asked the researcher to a participant may require more clarity and may not be planned by a researcher during that time. When clarifying the characteristics that ascertain the effectiveness and successful interview, Creswell and Creswell (2017, p. 88) assert "finding the best-qualified person or people to provide the required information ensuring that the participants understand the aim of the study and nature of information required generating rich and descriptive data on the phenomenon being studied; taking notes of the questions being asked; avoiding 'yes' or 'no' types of questions; showing good researcher's listening to skill by not dominating the interview session and carefully observing the participants' non-verbal communication and check your non-verbal actions." Consequently, I ensured that I included experienced mathematics lecturers in the study and discussed the research objectives and questions before any data generation.

In this study, I conducted individual face-to-face interview sessions to generate data by exploring the lecturers' views, experiences, beliefs, and practices on using technology in teaching circle geometry in mathematics. Menjívar (2000) mentions that an in-depth interview must be conducted when a researcher needs people's experiences. This suggests that each participant should be allowed to choose a suitable date for the individual interview. A neutral venue that was convenient for both a participant and researcher was used. Before conducting the interview, I explained its purpose to the participants where open-ended questions were used.

Furthermore, Creswell (2014) and Ramrathan (2017) emphasise that for a study to be fit for one-on-one semi-structured interviews, basic features need to be met, which involve that the participants must be knowledgeable about the phenomenon; interview questions with the interview schedules must be clearly outlined. The venue and the time when the interview begin must also favour the participant. The interview must investigate in-depth knowledge, and the session should end harmoniously. Lastly, the participants need to be appreciated for their participation in the study. In the following paragraph is the ‘how’ where the above features are observed:

Firstly, I ensured that the participants were present at a set time for an interview suitable for them and demonstrated interest in the undertaking, and became involved in the one-on-one interview process. Purposive sampling was used to select mathematics lecturers who teach circle geometry at level 4. Five lecturers were used to generate data, whom I recruited through the curriculum division of the TVET College. Although the Covid-19 pandemic changed the environment for communicating during the interview process, I did not stop conducting the study's interview sessions. Each interview session took forty to forty-five minutes.

Open-ended questions provided better access to each participant’s interpretation of experiences and avoided limiting the participant's information. I opted for the open-ended questions to acquire enough information about the mathematics lecturers’ use of technology. Individual interviews were conducted with each of the eight participants for intervals of about forty to fifty-five minutes duration. The interview was based on the same main topics listed in the research (Appendix B). The interview was recorded, and notes were taken where transcription was done for the individual interview session. During the interview session in the actual process, the recording device helps transcribe the data collected that needs to be analysed (Creswell, 2014), which is why I used an audio recording device to record the lecturers' answers about their use of technology in teaching circle geometry at the TVET College.

Lastly, Christiansen et al. (2018) emphasised that during the one-on-one unstructured interview schedule, an interviewer needs to schedule the session so that the research study is logical and saves time. I catered for this because confidentiality, anonymity, and voluntary participation were unpacked before each session, and the geometry lecturers as participants were well informed. For example, before the beginning of the session, I explained to geometry lecturers that their participation was voluntary and no compensation was available. They could withdraw anytime, as the participation was voluntary. After the session, they could find transcribed data anytime if they wish, and copies of the findings would be sent to them through emails after the completion of the study to verify the data they had provided.

I could ask follow-up questions for more in-depth data collection clarification during the interview process. This unstructured one-on-one interview provided me with a good chance to be engaged with the participants one-on-one and study each face, reaction, and non-verbal signals to better understand their use of technology in the teaching of circle geometry at a TVET College.

4.9. Sampling

It is not practical to collect data from everyone in the Higher Education Department sector as only a small group of people is needed. Therefore, "sampling is the process of selecting a few from a bigger group (the sampling population) to become the basis for estimating or predicting the prevalence of an unknown piece of information, situation or outcome regarding the bigger group. A sample is a sub-group of the population one is interested in." (Kumar & Sharma, 2015, p. 177). The non-probability sampling, known as purposive sampling, was used for this study because lecturers are located within the same Majuba District and teach geometry to level 4 mathematics students.

Another reason for using purposive sampling was to select participants with in-depth information for the phenomenon (Ritchie, Lewis, Nicholls, & Ormston, 2013). Conveniently, I focused only on the mathematics lecturers who currently teach level 4 with the help of curriculum division administration at the TVET College. I only needed level 4 lecturers to leave out levels two and three because only level 4 has geometry in mathematics. Eight participants were eventually selected (from a possible 15 participants) to explore the lecturers' use of technology in teaching circle geometry in level 4 at a TVET College. This enabled greater exploration, and I spent more time with the participants to understand the phenomenon (Ritchie et al., 2013). More time was spent with the participants to administer a questionnaire and interview processes. Geometry lecturers are directly involved in teaching and learning using technology. Using their experiences in technology teaching made it easier for them to be participants in this study.

Creswell (2014) affirms that purposive sampling is when the researcher purposefully selects participants to participate in the research study. This created another reason for using geometry lecturers for this qualitative study. The intention was to make the participants share their views, deep knowledge, and experiences in using technology in the teaching and learning process. Purposive sampling was used for this study.

4.9.1. Data generation plan for this study

Table 4.1 below shows the data generation plan utilized to generate data for this study.

Eight TVET lecturers were used as participants for the collection of data.

Research question	Instrument	Participant	Time frame
What technology do mathematics lecturers teach circle geometry to level 4 students at a selected TVET College?	Interview/ questionnaire	geometry lecturers	September -December 2020
What do mathematics lecturers do to enhance the effective teaching of circle geometry using technology?	Interview/ questionnaire	geometry lecturers	September -December 2020
How do mathematics lecturers teach circle geometry using technology in a TVET College?	Interview/ questionnaire	geometry lecturers	September -December 2020
Why do mathematics lecturers	Interview/	geometry lecturers	September -December

teach circle geometry in the way they use technology in a TVET?	questionnaire		2020
How does mathematics lecturers' use of technology in their teaching programs influence students' experiences of learning circle geometry?	Interview/ questionnaire	geometry lecturers	September-December 2020
What implications does technology have for the teaching and learning mathematics in TVET Colleges in South Africa?	Interview/ questionnaire	geometry lecturers	September -December 2020

4.10. Data analysis

Data was organised for analysis. This subdivision shows how the analysis of the generated data during the collection of data process was processed. Two qualitative research methods were utilised for the data collection: a questionnaire and one-on-one semi-structured interviews. During the one-on-one semi-structured interview sessions, a voice recorder was utilised to facilitate the required and necessary information collection data analysis. When analysing data, thematic content analysis was utilised to identify, analyse, and report themes within the data (Pearse, 2019, p. 79). Although it is widely used, there is no clear agreement about what thematic analysis is (Tuckett, 2005).

Braun and Clarke (2012) state that a theme captures something important about the data concerning the research question, which suggests that it signifies some levels of thematic response than the data collected. This suggests that while I was collecting data, I made sure that research questions, objectives of the study, and purpose of the study, which is to explore the lectures' use of technology in teaching circle geometry, are addressed.

All interviews conducted were transcribed accurately and were returned for each participant to check individually. When analysing data, the three following stages were facilitated for each participant:

Stage 1: I began transcribing one-on-one semi-structured interviews from the voice recorder. That took a long period because generated data needed to be carefully arranged and sorted accordingly for each participant individually for the accuracy of the data analysis process. In addition, it helped with the establishment of patterns and categorisation that came from data. Using patterns and categories ensured that only relevant data was obtainable to create a sense of the lecturers' use of technology in teaching circle geometry at a TVET College. I read all the analysed data repeatedly to acquire the appropriate contextual data outline.

Stage 2: I sorted the data generated through a questionnaire instrument of data collection.

Stage 3: I returned to the participants with the transcribed data to check the correctness of their offered data. That gave a chance for the participants to give the data that I may have omitted while listening to the voice recorder.

Stage 4: I created themes for the study and repeatedly did the same process individually for all the participants. Afterward, all the findings were discussed and analysed.

The themes that emerged from the data analysis and used in this study were categorised according to the TPACK framework. The framework is:

- Technology knowledge (TK)
- Content knowledge (CK)
- Pedagogical Knowledge (PK)
- Pedagogical content knowledge (PCK)
- Technological content knowledge (TCK)
- Technological pedagogical knowledge (TPK)
- Technological pedagogical and content knowledge (TPACK)

4.11. Trustworthiness

The concept of trustworthiness in a qualitative study is the mindfulness of the researcher's theory, predispositions, and effect on the social condition (Mackenzie & Knipe, 2006). At the same time, Guba and Lincoln (1994) believe that trustworthiness is utilised to authenticate the study. This suggests that a researcher must avoid twisting and fabricating the information. The researcher needs to represent the data given by the participants as is. According to Christiansen et al. (2018), researchers must always ensure authenticity and trustworthiness in a research study to interpret the reliability and confidentiality of data.

Since there were five participants in this research study, this suggests that no generalisations were made. The procedure that I had followed shows trustworthiness because I had recorded all the minutes and procedures to provide the version of the process during data collection. This provided the accuracy of the data generated and interpreted.

By mentioning authenticity, data generated should always be original and trusted. Trustworthiness in this study was obtained through dependability, credibility, transferability, and confirmability. To ensure trustworthiness, the participants were allowed to review the draft and findings of the study. This offered them a chance to verify all the findings. There are principles of trustworthiness that were followed during this study: credibility, dependability, transferability, and confirmability.

4.11.1. Credibility

Guba and Lincoln (1989) assert that researchers should always ensure trustworthiness in research by drawing the original data from the participants and ensuring it is a correct interpretation of the participants' views. Credibility is one of the principles of trustworthiness. The credibility of this study was ensured by allowing the participants to check the findings and provide some comments (Creswell & Poth, 2016). This suggests that for this study to maintain its credibility of the findings, all five participants were given a chance to read and verify the findings to confirm whether my interpretations correctly reflect all they had expressed during the questionnaire and one-on-one semi-structured interviews. I have fulfilled the procedure for the credibility of the study. I gave all participants a chance to have feedback from the findings of the study. The transcriptions and summaries for all the generated data were also made available to all participants, and they were given time to make comments.

4.11.2. Dependability

One correct principle, which might improve the study's dependability, is to utilise 'inquiry audit' in which the assessors scrutinise both the procedure and the product of the study for consistency (Lincoln & Guba, 1985, p. 317). According to Bitsch (2005), dependability means the firmness of findings over time. It involves participants evaluating the findings and the interpretation and recommendations of the study to make sure that they are all supported by the data received from the informants of the study (Cohen, Manion, & Morrison, 1972).

This suggests that the data generated using both questionnaire and unstructured one-on-one interviews from the participants using the TPACK framework in each research method was grouped to determine consistency. There was no bias during the research process. I remained neutral throughout the data collection process to avoid influencing the participants' interactions to ensure quality findings.

"To ensure dependability, interpretive researchers must provide adequate details about their phenomenon of interest and the social context in which it is embedded to allow readers to independently authenticate their interpretive inferences." (Lincoln & Guba, 1985, p. 110). Similarly, Jones et al. (2018) believe that the participants need to check the transcribed data, data analysis, interpretations, and recommendations to make sure that it is according to what the participants mentioned during the collection of data phase. This was addressed by giving all five participants a chance to prove that all that was in data analysis was the same as they had given in the data collection phase. The geometry lecturers were happy to have access to the study that was conducted and saw that as a chance for development in the use of technology in teaching circle geometry which provided consistency in the study.

4.11.3. Transferability

"Transferability in interpretive research refers to the extent to which the findings can be generalized to other settings. This idea is similar to that of external validity in functionalistic research. The researcher must provide rich, detailed descriptions of the research context ("thick description") and thoroughly describe the structures, assumptions, and processes revealed from the data so that readers can independently assess whether and to what extent the reported findings are transferable to other settings." (Lincoln & Guba, 1985, p. 111). Transferability signifies the level to which the qualitative study results are transferred to other contexts with other participants, as suggested by Bitsch (2005). He further mentioned that a researcher is the one who enables the transferability judgement through the deep description and purposeful sampling. This suggests that when a researcher gives a comprehensive description of the inquiry and participants were chosen purposively, this enables the transferability of the inquiry. Wagner, Kawulich, and Garner (2012) describe transferability as the extent to which one set of the findings can be utilised in another context. This suggests that current knowledge can understand the past and the future. Therefore, this study did not aim to generalise the findings but to give a thorough understanding of the phenomena from the participants as suggested by Creswell (2014). Transferability also provided confidence in the findings because it used triangulation, a "multi-method approach" (Cohen et al., 2013). This study used triangulation because more than one method for collecting data was used. The methods mentioned here are the questionnaire and one-on-one semi-structured interviews using audio recording. Data was analysed through transferability by ensuring that consistency was used in all these methods for data generation.

4.11.4. Confirmability

According to Creswell (2014), the findings should be based on authenticated and verifiable evidence from the data generated to ensure the confirmability of the study. This suggests that the data and the interpretations of the findings will not be fabricated from the researcher's imagination. Breen (2007) claimed that to ensure confirmability, the interpretations of the findings need to be checked with the study participants. This suggests that the participants will be allowed to check the transcripts and interpretations of the findings to confirm whether they will represent what will be occurring during the data generation process.

As a qualitative researcher, I was more concerned about trustworthiness while designing this study. This study consisted of a questionnaire and one-on-one semi-structured interviews using audio recording. The lecturers from three different campuses of the TVET College were given a questionnaire. They were interviewed after I was permitted by the college principal, Department of Higher Education and Training, and research office from UKZN. The methods used in this qualitative research contributed to ensuring the validity of the study. The data was generated through questionnaires and interviews from ten participants. The participants were given a chance to read the transcripts to reflect what they had discussed during the data collection phase. By interviewing the participants, I got first-hand information, reliable and valid data as it was gathered from the geometry lecturers as participants. The quality of research was acquired by facilitating high-quality, ethical practice (Rule & John, 2011).

4.12. Ethical issues and limitations of the study

During this research process, the researcher and the participants interacted. There are guidelines for ethics for a researcher to avoid unethical issues and invade privacy during the data collection process. According to the South African (Act 108 0f 1996), everyone has the right to be respected individually and no violation of ones' space in the country's Bill of Rights. This suggests that the researcher and the participants have rights and privacy, which must be maintained. Cohen et al. (2013) state that ethics are the principles and rules that direct the researchers to certify that participants' rights, respect, and privacy are observed throughout the research process. Every research process has a research policy and guidelines that need to be followed (Nabwire, Toili, Ong'unya, & Songok, 2014). This suggests that professionalism requires being in place throughout the research process to prevent any harm to participants.

I observed ethics strategies before, during, and after this qualitative study. Before conducting the study, I wrote a gatekeeper application to the Department of Higher Education and Training and the college rector to conduct this qualitative study in three different campuses of the TVET College located in the Majuba district. Permission to conduct the study was granted. I also wrote consent letters to mathematics lecturers who teach level 4 (participants) requesting them to be engaged in the study. Each participant had a consent letter addressed to them where they were made aware that they had the right to consent to the letter by signing or to refuse to be part of the study. All the consent participants were called to the lecture theatre to inform the study, the phenomenon, purpose, and objectives. They were also informed that they had the right to withdraw during the study.

The participants' anonymity, confidentiality, and rights were taken into consideration. All the participants were provided with my contact details. They were also given individual appointments to meet the privacy criteria. I also asked permission to conduct a study from the Research Office of the University of KwaZulu- Natal, where ethical clearance was approved.

During the study, I observed all ethics issues by avoiding mistreatment of the participants regarding age, religion, family background, culture, gender, and race. During data collection, confidentiality and anonymity of the participants were done using (participant A, participant B, participant C, participant D, and participant E) respectively, and not using their real identification. I also disclosed to the lecturers that the study had no remuneration and was voluntary. The clear, appropriate and straightforward language was used. Sharing data with other researchers and other participants was avoided. Participants were informed that copies of the data would be sent to them. Confidentiality for this study was considered, and participants were informed that data would be kept for five years in a safe cabinet at the university.

4.13. Conclusion

The intention for this chapter was to represent, illustrate and demonstrate the research method and design of a qualitative study, including the population and sample selection and size, further discussing the interpretive paradigm and data collection process and deliberating on how they were created. The data generating method and plan were constructively described, including the conformation of ethical issues such as trustworthiness and authenticity. The limitation of the study was also properly explained. The following chapter will present the findings that emerged from the data generation.

CHAPTER 5

DATA PRESENTATION AND ANALYSIS

5.1 INTRODUCTION

The chapter, as mentioned earlier, offered the research design and methodology. The purpose of the study was to explore the lecturers' use of technology in the teaching of circle geometry level 4 at the TVET College. The data produced was addressing the following questions:

1. What technology do lecturers use to teach circle geometry to level 4 students?
2. How do mathematics lecturers teach circle geometry using technology in a TVET College?
3. Why do mathematics lecturers teach circle geometry in the way they do?

This chapter represents the research study's findings, using ten themes and categories created through two research methods (one-on-one semi-structured interviews and the open-ended questionnaire). The direct quotations cite the presented evidence from the participants.

Participants' profiles.

Participant A has fourteen years teaching experience but with twelve years teaching mathematics and only four years teaching level four mathematics. Participant B has five years teaching experience and also taught mathematics for five years with three years teaching level four mathematics. Participant C has ten years teaching experience with ten years mathematics teaching experience while has only taught level four for only three years. Participant D has eight years teaching experience and mathematics while has only taught level fours for two years. Participant E has twenty- six years of teaching experience and mathematics with only nine years in the teaching of level four mathematics.

The main purpose of gathering this information is to institute their experience in the lecturing and teaching field. It represents the profiles of the participants purposively sampled from a group of fifteen participants who teach mathematics at a college because only lecturers who teach level 4 geometry were included. Yin (2015) states that purposive sampling is selecting the participants' identity and relevance to the study with the direct involvement in the process through experience that contributes to the study, which aids with the deep understanding of the research questions. The collected data through one-on-one semi-structured interviews and open-ended questionnaires were analysed using the themes that emerged from the data collected. The data were categorized according to the themes that emerged. Questionnaires and semi-structured interviews were conducted in English. Interviews were recorded and later transcribed. Some interviews were recorded via zoom and telephone for Covid-19 regulations. The interview analysis began with coding the themes that were identified from the data collected. The themes were created around the technology use of lecturers in the teaching of circle geometry with the expectations for changing the education policies at the TVET Colleges.

Table 5.1.1: below represents the participants' qualifications

Lecturer/ Participant	TVET College	Qualifications
A	A - Engineering	BSc in Applied Chemistry, PGCE majoring in mathematics
B	B- Engineering	Diploma in Engineering and PGCE majoring in mathematics and natural science
C	D- Business	BSc in mathematics and PGCE
D	C- Engineering	BSc and PGCE
E	B-Engineering	STD majoring in mathematics, Degree, Honours and Masters majoring in mathematics

Table 5.1.1 represents the profiles of the participants purposively sampled from a group of fifteen participants who teach mathematics at a college because only lecturers who teach level 4 geometry were included. Yin (2015) states that purposive sampling is selecting the participants' identity and relevance to the study with the direct involvement in the process through experience that contributes to the study, which aids with the deep understanding of the research questions. The collected data through one-on-one semi-structured interviews and open-ended questionnaires were analysed using the themes that emerged from the data collected. The data were categorized according to the themes that emerged. Questionnaires and semi-structured interviews were conducted in English. Interviews were recorded and later transcribed. Some interviews were recorded via zoom and telephone for Covid-19 regulations. The interview analysis began with coding the themes that were identified from the data collected. The study's data analysis themes are below while administering a

questionnaire and one interview during data collection. The themes that emerged from data analysis are the following table 5.1. 2:

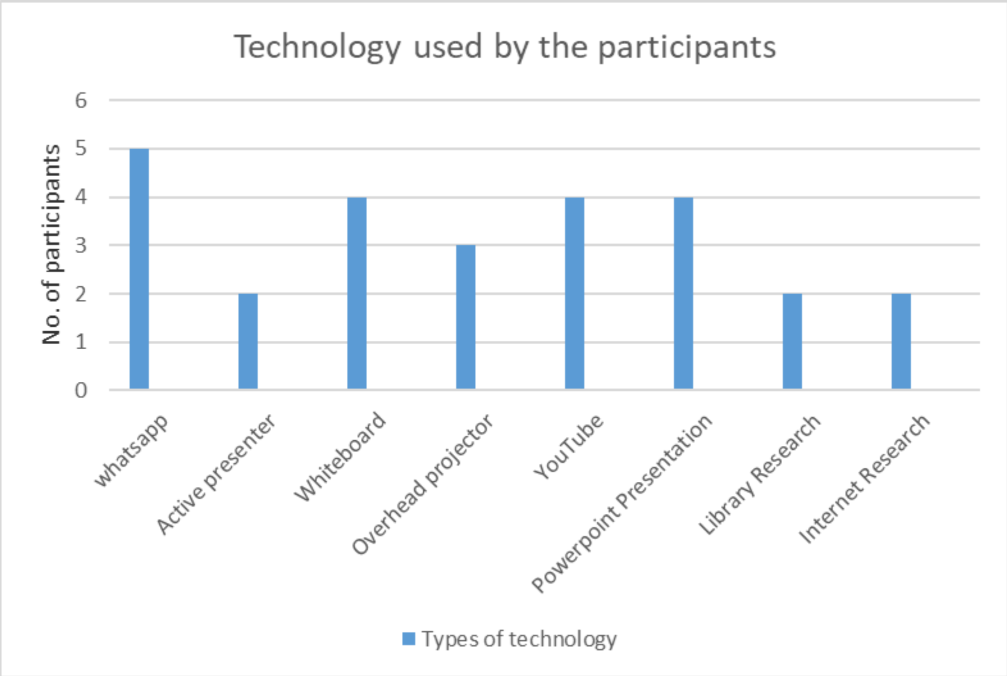
Table 5.1.2 displays the list of themes that emerged from data analysis

THEME NUMBER	THEME NAME
ONE	Experiences and challenges regarding the use of technology
TWO	Students' performance
THREE	Content Knowledge
FOUR	Mathematics teaching and Pedagogical Knowledge
FIVE	Pedagogical Content Knowledge
FIVE	Technological Content Knowledge
SIX	Technological Pedagogical Knowledge
SEVEN	Pedagogical Knowledge
EIGHT	Technological Knowledge
NINE	Technological Pedagogical and Content Knowledge
TEN	The use of technology in geometry teaching

5.2 EXPERIENCES AND CHALLENGES REGARDING THE USE OF TECHNOLOGY

The first theme of lecturers' experiences with educational technology answered the first research question from an interview question to which this research study pursued to answer. Table 5.2 summarises all the participants' responses on one-on-one semi-structured interviews conducted to have their background based on educational technology use and experiences. The interview questions were structured according to the TPACK framework to assess technology knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, and Technological Pedagogical and Content Knowledge.

Table 5.2.1 below are the types of technology that the participants used for this study.



The purpose of the research study wanted to find out the lecturers' use of technology in the teaching of circle geometry at level 4 students. Geometry is only done in level 4, the NCV program's exit level, where students meet geometry for the first time. It takes longer to teach them because geometry has unique content. During one-on-one interviews, the lecturers were asked if they were aware of the meaning of technology. They were asked: What does technology mean to you?

All the participants gave various meanings of technology. It is interesting to observe all the lecturers gave different opinions concerning the meaning of technology.

Participant C stated: "*Technology to me is advanced it also means the accessibility, most of the time when we think of technology we think of okay, well students have a cell phone or the campus has internet, but we need to also to be understanding that technology means that everyone is on the same level when it comes to having the same information at the finger tips, so it's not just because one learner has data they benefit, it's going to apply to everybody and everyone that has technology.*"

This lecturer mentioned that technology is accessible, the same level to everyone concerning data and the internet. This is surprising to see the students fail the online learning because of lack of accessibility to the TVET College. There are computers in the staffroom in one of the colleges, but they have been lying there without the internet for almost seven years. During the pandemic, the students were promised laptops in 2020 to learn online when they were not physically at the TVET College. This means that there is no accessibility of technology to some of the students. Some parents could not afford to buy gadgets to resume online learning. The lecturers and the students have no Wi-Fi access even if they have gadgets but cannot use them.

Participant D said: "*Okay yeah, for me, technology will mean the tools, the resources I use, and the aids that will help the teacher deliver the lessons. But I also understand that technology is how to make a process better. So really it is teaching maths, it will be how to make the teaching and the delivery of lessons maybe how to make that more effective and more dynamic and more with the times and not just rely on the old-fashioned textbook and the whiteboard.*"

Each participant gave a different explanation. This shows that all the participants are aware of the meaning of technology.

If they were familiar with the technological knowledge concept, they were asked: Are you familiar with the concept of technological knowledge?

Participant A uttered: "*Technological Knowledge, on the other hand, is talking about so I can say that a person who has been trained some many years ago…. may not have Technology Knowledge because then that technology was not there. So, Technology Knowledge now is to do with the knowledge of all these technologies in terms of how you can be able to make use of them in the context of the subject under the circle geometry.*"

Participant D articulated: "*Technological Knowledge is the what I will think, is the tools, resources that we use for…. teaching and learning, but according to the definition realize it's also the actual technology of a particular subject like in physics if there's some even like in biology if there's some new technology like in like now like that thing for covid- 19.*"

Participant E stated: "*Technological Knowledge is knowing how to use technology in your teaching and learning—how technology interacts with technology. There are many facets of technology. It can be the cell phone, the computer, it can be many facets*"

It was very interesting when all the lecturers showed that they knew the technological knowledge concept. They displayed various explanations of technological knowledge. One of the participants mentioned that a person does not have technological knowledge when a lecturer trained for teaching some few years ago. This means that those born before knowledge within the same education system know nothing about it. Those born after the technology has been introduced, making them experts of technology. Because all the lecturers have laptops provided by the TVET College, they are familiar with some technology. This suggests that although they were born with technology, they do not know anything about it. For the sake of this study, technological knowledge is the knowledge of the use of technology in the teaching of circle geometry. Another lecturer (participant C) mentioned the technology resources used for teaching and learning and the need for technology use during the pandemic (Covid-19). These were the times that exposed the challenges of technology knowledge in lecturers. There was no time for training, but the lecturers were only shown through voice notes by the TVET College to use the LSM, named ACTIVE PRESENTER, to teach all the subjects in the college.

On questioning the lecturers about the technical knowledge, all the participants showed that they have the technological knowledge for teaching geometry. They were asked: Do you have the technical skills required to teach a technology-based geometry lesson? If yes, which? They all said yes and mentioned different technology names for teaching geometry.

Participant B: *Yes, GeoGebra and Blackboard*

Participant C: *Yes, I have a diploma in Instrumentation and computer-based training*

This shows that all the participants have received training and have technical skills to teach circle geometry. On mentioning GeoGebra, the software was designed only for teaching calculus, algebra, and geometry (Vasquez, 2015). It is a very popular programme worldwide, and it can be downloaded from the GeoGebra website known as http://www.geogebra.org (Ocal, 2017). Farrajallah (2016) states that GeoGebra is a unique programme based on global mathematics standards and supports the curriculum, which helps learners construct the geometry figures and institute Euclidean Geometry proofs through riders and proofs associated with appropriate reasons. This suggests that when TVET College level 4 students can learn circle geometry with GeoGebra, they would be exposed to constructive learning, making learning more meaningful to them and passing mathematics with ease, making it easier to complete their NCV certificates.

All mathematics lecturers' knowledge goes as far as diagnosing a problem when using the mentioned technology because they were trained to do so. This may be because they are mathematics lecturers and not trained technicians, which could mean that they were trained on a specific programme, but they may forget it. Most participants mentioned that they could learn about any technology with ease should it be introduced to them. When asked about updating the new technology question: Do you keep updated with various new technologies and pick new technologies incorporated in geometry lessons? Elaborate on your answer.

Most participants mentioned that they are up to date about the new technologies although they are not using them at the college and can learn the skill fast since technology usage is currently most important.

Participant C said: "*Yes, one can self-learn through online courses, etc.*"

This shows that the mathematics lecturers are concerned. They can learn online with the new technologies should they be incorporated and used in geometry teaching. In that case, they may be the generation that wants to use technology to teach circle geometry. They showed a very positive attitude on technical knowledge. One participant mentioned that it is useless since they are not using any technology to teach circle geometry which suggests that lecturers have a high level of technical knowledge. However, the study is based on how the lecturers can use technology to teach circle geometry in the NCV programme to benefit teaching and learning.

Similarly, in the TVET context, the lecturers find some challenges preventing them from using circle geometry technology. For instance, when looking at some classrooms, technology was installed but was removed, although, in some lecturers' classrooms, it can be observed that technology is still installed.

Figure 5.2.2. shows the classroom which belongs to participant D with the data projector mounted on the ceiling and no interactive board used but white board available. A laptop provided by the college is used and can be connected to the data projector to show what is on the laptop like previous question papers.

Figure 5.2.3 indicates participant C's classroom inside with the technological tools fitted. According to the participant, there is a data projector, interactive board, internet port with no internet for almost seven years, a laptop provided by the college, and the learnerscape software that terminated its use and no license renewed.

5.3 STUDENT PERFORMANCE

Matric is equivalent to NCV level 4 (Engelbrecht, Spencer, & Van Der Bijl, 2018). That is why the advertisements of the South African jobs start with the basic requirement, which is grade 12 or NCV level 4 Certificate. The entry-level for NCV is grade 9, grade 10, or grade 11. Mathematics lecturers need to be informed about the mathematics matric results after matric students come to a TVET College for study. To be always informed with matric results is the requirement for each mathematics lecturer to be aware of what is happening in mathematics at the matric level. When mathematics lecturers were asked the question about matric results: Do you follow the matric results in mathematics? Please elaborate.

All the participants mentioned that they always follow matric results.

Participant E stated: *Yes, one of the favourite subject results. As a mathematician, we have to follow the results because they are the one that feeds into our system. Most of our students come from matric. So, it can impact our rate as well. Although normally we are supposed to take grade 9, our students are mostly matric, so we closely follow them and know the pass rate. Currently, I am also researching that and the pass rate, the performance of students in mathematics.*

This is one of the participants that follow the matric pass rate. The participant mentioned that following the matric results was very important because mathematics is a very special subject after matric students join the TVET sector. This suggests that following the matric results provides a direction to TVET mathematics lecturers and gives them a starting point on what group of students they are having in a particular year.

Some participants view matric results as very poor and not improving, while some say the matric results are controversial.

Participant E stated: "*My views are a bit controversial, especially when it comes to the pass mark of 30%, yes, the pass mark of 30% is fine, but still you find that the pass rate, in general, is too low. I would suggest that the pass rate may be range around 50% and then make a lot of bloodbath in terms of pass rate. Why? Because many students are going to fail. So, it is a challenge at the same time the 30% pass mark is there, but it is a challenge that students are not reaching it, so my view is why I have that view? I want students who will be competitive in the marketplace. Doing mathematics at the higher level at the university, most of them are dropping off their studies because they have met the mathematics there, which is a bit pitched, so I think that is why a pass rate needs to be raised it is not about having more students passing, it's about students that are getting the quality at least there.*"

It may mean the mathematics matric results may be of low quality because of a low pass mark of 30% as a requirement. Having 30% as a pass mark, mathematics is not giving quality in the marketplace, and there is no competition to pass mathematics at a higher level. If the pass mark is increased, it may motivate students to unlock their potential to increase the mathematics pass percentage in passing the subject by decreasing the university and TVET dropout rates. Some students tend to drop out of the TVET sector due to failing mathematics as a subject (Ragulan, 2021).

When the lecturers were asked why failing mathematics, the participants mentioned different reasons. For instance, participant C said:
"The problem with mathematics at the moment is the curriculum is not specifically catering for the diversity of the learners. We tend to forget that some students never had the opportunity of having the best school education. They were not able to work with puzzles of which helps. It builds abstract knowledge. Some children never have advanced crayons to colour with and learn a visual space and play with the abacus. When we are in a country where every learner has been given that opportunity, we are failing students who have been going to private schools, and their mathematics pass rate will be high. They had access to technology and decent food and nutrition, so they developed their brains. You looking at children in rural areas and townships areas, and they are just two different modes of hearts."
This participant mentions the reasons as a curriculum that does not cater for diversity, less exposure to abstract thinking, private schools getting more benefits on education than public schools, and the lack of access to technology, especially in rural schools. This suggests that there is inequality in the education system in South Africa. It shows that the learners in private schools prefer resources to public schools.

Participant B stated: "*I think learners are not used to writing tests we as teachers we are trying to push the syllabus without training the learners in terms of how to attack a question, how to manage time because most of the time learners can't manage time when it comes to exams they relax without like managing the three-hour paper I think it's the time and also they are not used in writing a test because they are… I think they give them the assignment and also the test just for the ICASS, and they do not give them an extra test to check if what they deliver to students are the students align with the lesson or not"*

Participant B is raising the issue of assessment. Learners are not given enough time to be trained for writing assessments, especially the tests, thereby making students unable to finish the examination paper. The lecturers focus on the completion of the syllabus. This suggests that the lecturers tend to focus on finishing the scope of work for the academic year and forget about training the students for test writing on how to answer certain questions they come across in the examination. This may mean that participant B's issue is insufficient to prepare for the examinations.

Participant E concluded: "*Poor results are results of the many factors some can be school-based, some can be educator based, some can be from home when I say school-based it depends on the discipline, the environment of the school, the students have a library to study, do they have time? The type of transport from home, the students have time to rest, the students always between home and school the time they waste to move in there. Be another factor. There are many other factors for the lecturer/ the educator. The educator may have poor knowledge of the subject. It may also contribute to or is poor initial in teacher training it may also affect the pass rate. So, if the lecturer is confident in teaching the subject, the student also has confidence.*"

Participant E has mentioned many factors that may cause poor performance in mathematics, which may be either school-based or home-based. Home-based issues arise because the students may be staying with grandparents who cannot supervise them or help them with the homework given from school. Most students stay at private accommodation during their academic year, and there is no one to help them with their homework or provide food. They are on their own regarding their everyday needs and studies. The lecturers' lack of content knowledge and insufficient pedagogical knowledge may lead the students to lose confidence in a subject, leading to poor performance in mathematics. This suggests that there may be many factors that hinder students from good performance in mathematics. The learners' performance was either extrinsic or intrinsic, and therefore all the blame cannot be allocated to the students themselves. Students need to be given support from both school and home.

When participants were asked about where any particular sections/aspects affect the mathematics pass rate:

Participant C replied: "*I feel that there are sections in mathematics which become a challenge. I would not say it's with every group of learners. It becomes like 90% the problem. Geometry is a challenge for students. Trigonometry is a challenge to students, calculus, anything that needs to be visualized in the mind's eye. Most learners find it challenging to understand, but then again, a child is different, so when one looks at mathematics, we do have specific sections. Still, some students struggle even when they just come to standard basics, exponential rules. It seems to be that mathematics as a whole is just a challenging subject for a student.*"

Participant E stated: *(Firstly, he asked for the question clarification). "…yes, that is correct. I have noticed that some teachers don't teach certain sections because the pass rate is 30% when it comes to teaching. They focus on a few aspects which they understand they are comfortable with. Students will pass the level and move to the next step, but they don't touch them in certain sections. For, example some don't even teach geometry, some don't even teach probability. They shun that. However, still, students will pass because the pass mark is 30%, so it is happening with some lecturers Or some educators they teach the specific sections like, for example, there is data, the educator may teach data and focus on data let's say paper two then the students will pass just learning one topic then they leave the rest so, it must support by these aspects if the parents or the home situation or the school doesn't have an intervention programme to cater for these students then students may pass but not yet learn certain aspects like geometry, probability, trigonometry, they still pass."*

Most participants mentioned that geometry is the hardest section of mathematics. Even teachers and lecturers do not teach that section and other easy sections to make students pass at least 30% and move to the next section. This may mean that lecturers may have difficulty teaching geometry, or it may also mean the students fail to understand geometry concepts. This may also be why there is less motivation in teaching geometry.

On improving the matric mathematics results, the participants gave different ideas whereby:

Participant B suggested: "*The matric results can be improved if they train the learners to understand the maths not like only to try and push the syllabus because when you try to push the syllabus, you won't be able to know if learners they understand what you are doing or not because you can push the syllabus but if you don't give them a test to check and* *analyse where they make a problem and also to try and adjust and improve in that particular section before the exams. I think that part can help improve the pass rate of maths."*

Participant C responded: "*I do not believe that this will be something that is going to be changed overnight, but I think that we need to start when we speak of having an inclusive education. When a syllabus has been structured or a specific or area in SA has been looked at, we need to look at the education as a learner-friendly approach instead of a size fit all. It's not going to be an overnight thing. It will require years of getting down to the basic reasons, but I think how matric pass rate could be improved the restructuring of the curriculum that is learner-friendly that is inclusive."*

Most participants have highlighted that improving mathematics results will not be easy overnight. As mentioned by participant A, training the learners to learn for understanding and not for syllabus may be the best approach for improving the performance in mathematics. This suggests that the way learners are taught is still challenging because it may mean they are taught to cover the syllabus only. This may mean that using technology in the classroom for better conceptual and procedural understanding in mathematics can uplift mathematics performance. In geometry, the use of van Hiele's levels of geometric thinking together with technology can yield better results in mathematics. The teaching practice for each mathematics lecturer in the classroom needs to be encouraged to achieve greater performance scores in mathematics.

Thurm and Barzel (2020) conducted a study in Germany to investigate the efficacy of a half-year professional development program for teaching mathematics with technology. The findings indicate that the educator's technology-related principles positively impacted professional development. This suggests that when mathematics lecturers are developed using technology to teach geometry, it may greatly impact a subject's performance. Curriculum developers also need to reconsider the restructuring of the TVET curriculum. Participant C emphasizes the restructuring of geometry. This may s help as geometry is only done in the exit level, level 4, and it covers all the circle geometry theorems. The Basic Department of Education states that circle geometry is split into grade10, grade 11, and grade 12. This shows a need to restructure geometry to be split to level 2, level 3, and level 4 in the NCV curriculum, as it is happening with CAPS. This suggests a need for ongoing professional development on lecturer's programs where they will be developed to help students learn their subject knowledge and develop lecturers on pedagogy and knowing their content knowledge.

Most participants mentioned a link between the teaching strategies and mathematics pass rate, which cannot be separated. On questioning them: Do you think there is a link between teaching strategy and mathematics pass rate in matric? Please elaborate:

Participant C stated: "*Yes, I do, hmmm… Suppose I'm thinking now about teaching strategies. In general, we all know that mathematics is not something that I just put on the board. I expect the students to understand it's about developing the attitude of the learners towards the subject. In that case, it is developing the learners' confidence. It is letting the learner make mistakes. So that they can learn and understand the challenging area or the confusion that is coming in from teaching strategies help them. We need more than inclusive teaching strategies means of group work-based learning and learning that is aware a student needs to have the basic background knowledge to from I understand this to understand the new many a times to see maths teachers just put on a board, okay…….*"

Participant E replied: "*The teaching strategy yes, there is a link, although sometimes to a lesser extent, from some studies it has been noted that students who have a lot of intervention sometimes fail because they rely on the intervention they won't study for themselves won't take time to learn but will discover students who are given time to learn and understand, will learn and even pass better and even retain the information they have.*"

These participants consider that the way students are taught impacts the performance through results. The lecturers that do not frequently teach students in class and rely on revising the question papers lead the students to fail in the subject. Only teaching students with different strategies yields the best results in mathematics learner performance. Together with the officials from DHET, the South African educational policy documents emphasize student-centered lessons. Teaching a student-centered lesson does not mean effective strategies for mathematics are used. Kyriacou, Kunc, and education (2007) believe that effective teaching strategies require learner-centered practice in the classroom and demand educational activities that will motivate and unlock learners' abilities. Also, student-centered principles endorse an individual's development to detect unlocking of personal abilities and skills for the lecturers to further them in facilitating the development of the student (Hoadley & Jansen, 2013). To understand the lesson better, they also require their prior knowledge to link with the new content. This means that students learn better if a lecturer designs a learner-centered lesson combined with activities that will actively involve the students in learning.

When the participants were asked if there is a link between teaching strategy and geometry results, most participants agreed that the way lecturers teach geometry is displayed through the students' achievement and performance.

When asked: Is there a link between teaching strategy and geometry results? Please elaborate. Participant C said: "*Yes, I do believe that there is because if we are going to use learners friendly teaching strategies, be it group work, be it visual aids, be it that we are fortunate enough to have the resources through interactive boards, through the videos, through allowing the learners the time and allowing them to build what they understand on to the next level teaching strategies that will help with the understanding of geometry.*"

While Participant D responded: "*I do, yes I do think there's for geometry it has to be a specific strategy in where the students will be exposed to the theorems first and those theorems need to be the teacher think has to take the time to you know summarize all of the theorems and make sure that the students understand because when it comes to the applications of theorems that is where the students battle maybe a lot of practice it what will help.*"

According to the participants, geometry teaching strategies are the ones that help yield greater performance in geometry. On mentioning that group work and visual aids are the best for building understanding in geometry, means that through cooperative group work, the students are taught. Co-operative learning happens when the students are divided into small groups of three or fewer. They talk to one another through exploratory talk, working together and demonstrating how the geometry problems are done or solved. Everyone is involved in a lesson and works as a member of a team. When students work as a team, their thinking levels are improved, thereby unlocking their intellectual abilities. Vygotsky's constructivism theory emphasizes that students learn better when put in small groups instead of working alone to solve any geometric problem (Woods, 2017).

5.4 CONTENT KNOWLEDGE (CK)

During the one-on-one interviews, the lecturers were asked if they were familiar with the concept, content knowledge. It is interesting to reveal that all the participants were familiar with this concept. They revealed a variety of knowledge and gave different answers:

Participant A stated: "*Yes, I am familiar with concepts. Content knowledge is talking about the knowledge of a subject. I then say that Content Knowledge is about knowing what I have as a maths person. This is central to my knowledge of mathematics or my purpose as a mathematics teacher. That's what I believe was learnt over the years. The time you started learning, that's the content. Then, of course, when you talk about Content Knowledge in a particular case, the Knowledge you are talking about is the geometry itself. Forget about the other parts of mathematics. So, geometry, the circle geometry is specific in this day."*

Participant E said: *"Yes, I am familiar with these terms. Content knowledge of the teacher is subject content. It is also very important for the teacher to know what to teach. The Content Knowledge, you discovered that CK is the various aspect. It can be a teacher, can be a student, can be, as you say, technology. But the most important thing for people to understand the content is to know the subject matter, so that is the driving or the starting point."*

All the participants know a content knowledge concept. The lecturers mentioned that it is "what" you know about circle geometry. This suggests that this is the knowledge that has been accumulated over the years in schools during the formal learning periods of mathematics and knowledge from everyday lives as required by the curriculum documents. Content knowledge of a lecturer is very important because a lecturer must impart what they know to students, which shows that the lecturers must be the experts in their subjects. Using content knowledge, a lecturer must use technology to represent, communicate, solve, and explore mathematical content, ideas, or problems without considering teaching approaches (Mailizar et al., 2020).

On questioning the lecturers about the content knowledge, all the participants showed sufficient knowledge of circle geometry to level 4 students. When asked a question:

Do you have sufficient knowledge of geometry required for level 4? If yes, please, elaborate.

Participant A: "*Yes, I have sufficient knowledge for the level. With the knowledge I have, I have never come across a question that I cannot solve because of some content inadequacy. The syllabus has nothing unfamiliar about level 4 geometry."*

This illustrates that all the participants have sufficient knowledge because they all have majored in mathematics as a subject. Content knowledge for an educator is very important and is a basic requirement. Content knowledge for a lecturer in circle geometry encompasses knowing theorems, meaning for concepts and terms, riders, the terminology involved, axioms, drawings and angles, explanations for the concepts, and the procedures when solving the geometric problems. This may mean that all the participants have content knowledge that helps them impart knowledge during teaching and learning.

Regarding the importance of content knowledge, the lecturers were asked: How important is CK for a teacher? Elaborate.

All the lecturers showed an understanding of the importance of content knowledge.

Participant A: *Content Knowledge is very important. You need to know what to teach. You can be a teacher like, for example, I am a trained teacher with the skills. But then, if you have to go to teach in America, let's say in Italy, to teach Latin, I won't be able to do anything because I don't have the content. I'm just empty as far as Latin is concerned. So, if you don't know mathematics yet you are teaching in, you can be good pedagogically. You can be good technologically, but then all these are coming in as tools, pedagogy is a tool, technology is also a tool for transmitting the content knowledge. So now, if you have the tools to transmit, but you don't, then that needs to be transmitted, so you cannot do anything. So, Content Knowledge, therefore, is very important*

Participant D: *It's close to paramount importance for the teacher to know their subject matter well.*

Participant E: *I think I have to put a bit of flesh. According to one study, content knowledge for a teacher was found that some teachers in grade 6 could not answer even a question paper. The grade 6 hardly scored favourable marks at grade 6, so when it comes to grades 10,11, and 12. Even from grade 7, where geometry starts, you discovered that if an educator's content knowledge is not right, it will also affect how they teach. Either they avoid the topic and leave it to the students to sell unshattered water. They cannot be kept. The students become a challenge through the storm of geometry, so I think it is very important that the teacher has the content knowledge. And that needs to be put in initial teacher training. Yes, I have seen some workshops still being done even if you do a workshop, and if content knowledge for a teacher is not right. It will not be very effective unless the teacher is innovative enough to use that.*

The lecturers emphasize the importance of content knowledge. One even mentions that if a teacher is taken to any country as long as a teacher is well equipped with content knowledge, a teacher will survive in that environment because the important thing a teacher needs to impart to learners is knowledge. Participant E quoted a study conducted in the Western Cape by Spaull and Enterprise (2013), where it was found that grade 6 learners out-performed the rural mathematics teachers in a mathematics test in which the teachers failed. It was observed from that study that:

- Mathematics teachers have insufficient basic content of mathematical knowledge.
- Lack of conceptual understanding of mathematics because mathematics teachers could not add fractions that were in a test
- South African mathematics teachers have lesser content knowledge than the grade 6 teachers from other countries like Swaziland, Tanzania, and Uganda.

This suggests that lack of content knowledge in mathematics lecturers could lead to students not knowing the necessary knowledge by the level 4 geometry students.
This means that those teachers lacked content knowledge. Lecturers' content knowledge is the foundation or a starting point of learning circle geometry.

On asking about the various strategies that they use in developing an understanding of geometry, the participants answered:
Participant A outlined: "*I use three-dimensional objects like cardboard boxes for learners to visualize, particularly where I will be teaching angles. I also make use of the classroom itself. When introducing aspects such as circle theorems, I find that proving the various theorems is very important and more important than just committing content to memory."*
Participant B conveyed: *"I make sure that learners are familiar with postulate whereby if they see it they know it, in that way, I am developing rational analysis. Introduce the basics of geometry, then go through the theorems and their application. Teach them how to analyse the given statement and relate it to the shapes, and how to attack the questions."*
While Participant C responded: "*I use models and cooperative learning."*
Participant D quoted: " *I emphasize mastery of the knowledge of theorems with my learners."*
Participant E indicated: "*Not Sure."*
The participants showed various strategies for teaching geometry. Participant C mentioned that cooperative learning might mean that a successful teaching strategy is utilized whereby

students are divided into small groups according to their abilities to improve their understanding of circle geometry. Using 3-D objects, the lecturer contextualizes the lesson using visual aids and models to make a lesson practical. This suggests that the participants have a broad and deep understanding of circle geometry required for level 4 NCV mathematics students. Conclusively, it is evident that all the lecturers are aware of the concept ‘content knowledge’ of circle geometry level 4, which they have acquired in their educational training. Although they displayed that they were aware of the ‘content knowledge’, it was not measured. The lecturers require ongoing professional development regarding geometry as the results reveal that students score lower in geometry level 4 in mathematics.

5.5 MATHEMATICS TEACHING AND PEDAGOGICAL KNOWLEDGE

For this study on a theme, mathematics teaching strategies used to teach mathematics, pedagogical knowledge, and teaching strategies used in teaching geometry will be discussed.

5.5.1 PEDAGOGICAL KNOWLEDGE

During the one-on-one interviews, the participants were asked if they were aware of the concept of pedagogical knowledge. The question was: Are you familiar with the concepts of pedagogical knowledge (PK)? Please elaborate.

Participant A stated: “*In PK, we are talking about you then, use maybe your training or your knowledge, your understanding of how you can deliver so the content knowledge you have you have acquired. So, the PK comes from pedagogy, which is co-transmission of knowledge to other people as guiding the student to know. So Pk yes, the various knowledge is concerning how we can transmit knowledge to those who need it with this particular case to those who need knowledge of geometry.”*

Participant D replied: “*Pedagogical Knowledge is how the students learn and the teaching approaches.”*

All the participants revealed that they are aware and know the concept called ‘pedagogical knowledge’ The lecturers have done educational training, including pedagogy, the “how” part of teaching and learning presented by a lecturer. During the one-on-one interview, each participant was asked: How important is Pedagogical Knowledge for a teacher? Elaborate.

Participant C said: “*Pedagogical Knowledge, I must say it is the most important because I am not just there, reading the book and expecting my learners to know about them it doesn’t* *work that way, it has to come by me mediating the lesson and to facilitate it's got to come from me also being able to realize what is the best approach, what is going to be the best teaching strategy in which sections with the group work activity work in which sections I, am I going to help the learner that has made me having a disability to understand, am I going to bring in visual aids, what am I going to do it's how we then take what we know, and we can tell it to the learner that they can then understand and build and broaden their knowledge and its very important to the Pedagogical Knowledge."*

Participant E said: "*Pedagogical Knowledge for a teacher is. You discover that a teacher should know how to deliver content which is a necessity. Maybe if you even have a lot of knowledge, but if you do not know to "how" to deliver to the students, it becomes a problem. You need to know how to make these students understand what they should write. So, the lecturer or the teacher must know the pedagogic of the content they are teaching. There is a lot that a teacher needs to know, the Pedagogical Knowledge as I said, you need to know how the students learn, their development how their psychology, when it comes to their development you need to know they are of which stage their development are there, they are there in the adolescent stage, how to handle them the disciplinary issues, we all need to know that, you need to know the tough sometimes students are not in the mood to learn, you need to know how to approach them so that you can make them learn or they have challenges at home, you need to address those challenges especially, maybe you make use of the social workers or senior teachers to assist you to assist, in case of colleges we need SSS that these support services may assist you. Once those social issues are dealt with, you can teach in the classroom. So, the pedagogy is a broad term that may require a lot of knowledge, and you will be fine. So that is how you need to know the Pedagogical Knowledge of a teacher."*

Looking at the above importance of pedagogical knowledge as mentioned by the participants revealed that the participants are aware of the importance of pedagogical knowledge. When students do not understand, a lecturer needs to devise another methodology to impart knowledge to students. Participant E mentions this, when students are unable to understand in class, a lecturer goes as far as identifying a problem and involving stakeholders to help a student to be able to learn in class. This question aimed to determine if the lecturers know their daily classroom tasks. When people are aware of pedagogical knowledge, they go to classrooms prepared.

5.5.2 TEACHING STRATEGIES USED IN MATHEMATICS

When teaching mathematics, different teaching strategies are used by the lecturers. When lecturers were asked about mathematics teaching, the following questions were asked: What teaching strategies do you use in teaching mathematics?

Participant A stated: "*Well, when I teach mathematics, I always find it easier for me if I first form because I find it best to use examples. I give examples from the book, but I always prefer to use my examples, so I give examples, work them out, then ask the learner to work questions out, so I then use past examination papers.*"

When teaching, there are two approaches that a lecturer needs to follow. It is either a learner-centered approach or a teacher-centered approach. With the learner-centred approach, learners are active participants in a lesson. In contrast, a teacher talks during a teacher-centered approach, and learners are passive during the lesson (Hoadley, 2017). When participant A presents a lesson using the approach as he stated, this is a lecturer-centered approach. NCV curriculum, together with CAPS curriculum, is learner-centered approach oriented. This may mean that lecturers have insufficient knowledge about teaching strategies and may require lecturer development from the TVET College management.

Participant B said: "*I teach mathematics based on the. By giving the background of the students if they are aware and having the background in mathematics because sometimes you teach learners like pushing the syllabus without knowing if they have a background and basis of mathematics or not, so I do my part to get the background of learners in terms of knowing the basis of mathematics before I continue with anything else which is ahead of them.*"

Participant C replied: "*I most commonly use group work- based strategies most of the time; otherwise I do also resort to giving the students work on their own to do where I use scaffolding to the system, for them to carry on applying their knowledge on what they have learnt on their own. Its either they individually do the questions or they do it collectively in a group.*"

These two participants use the learner-centered approach as needed by the NCV curriculum. Clarke and Roche (2018) stated that effective mathematics teaching strategies include the active involvement of students in the teaching and learning process and making connections with new content through the connection of prior knowledge. Participant B looked at learners' backgrounds to get the learners' previous knowledge by finding the mathematics knowledge the students possess. Participant C uses group-based strategies, scaffolding, applying the students' knowledge in learning, and working individually or collectively in a group. Some of the participants know effective teaching strategies to use in mathematics, while the other participants require professional development in the effective strategies for teaching mathematics.

Participant E concluded: "*Mathematics is a hands-on subject although abstract so, you have to use the variety of methods, e.g., the lecture method is the common one to college and then you need to blend it with other activities where you put some investigations, some practical activities, you also need to use technology in the process."*

This concludes that most lecturers have sufficient knowledge of the teaching strategies, although they prefer to use the lecture method most of the time, which suggests that they prefer the easier way of teaching mathematics because of time constraints in the TVET College.

On answering the question if these strategies have worked, most participants have said the strategies have worked except for participant D, who said:

"You know the problem I find, I find with students, is that sometimes when the foundation is not good, then what happens is that I have to re-check maybe the material that they have started in level 2, maybe in school and that is the challenge."

The problem that is mentioned by participant D is that students lack a basic foundation in mathematics. They come to level 4 without the necessary background of mathematics that is required in level 4. This may mean that the lack of foundation was caused in schools before reaching level 2 at the college, or the level 2 and level 3 foundations for mathematics were not good. It may mean that the lecturers are using the same teaching strategy because of time and are interested in finishing the syllabus only and not instilling the concepts in students, as mentioned by participant E:

"These strategies they have worked where it is necessary especially you want to complete the syllabus we usually use the lecture method because you want to complete, but if you want the students to understand as well, that is where you have to use practical activities. You also need to use things as we give them homework to do, it is hands-on, sometimes because of time

some strategies don't work because we have limited time to finish the other strategies like games, the other strategies like whereby students have to do some practicals, they are not feasible because of some hindrances like technology which is not available or is there but is not working, or because the management is not maintaining it or sometimes is broken down, or sometimes we don't have time to use it."

When asked which teaching strategies they use for geometry: What teaching strategies do you use to teach geometry? The participants mentioned different teaching strategies that they use to teach circle geometry.

Participant A stated: "*Now in teaching geometry, I prefer again starting with introducing the subject with like defining the circle, what the circle is, the sector, the radius, and then after defining, I prefer to start now with the first theory and I go to this theory rather than narrating what is in the textbook. The first theorem, I prefer drawing it so that for sure it is what it is because then the other theorems are easy to prove from the one that has started with first."*

While participant B indicated*: "What I use the teaching strategies in teaching geometry is making sure that the learners are familiar with the angles and they know how to apply the principles, and there the theorems in terms of attacking the geometry…and also making sure that the learners understand the statement before they are tackling the problem of geometry because the main cure is on the principles and the statement that is given to the learners based on the circle geometry."*

Also, participant C declared: *"OK. Usually, modelling is one way to help with geometry because it is special-based subject learners who battle to see it for themselves through models tend to help the learners. I found geometry specifically if you can give a physical model and you able them to guide them through. It just becomes better by demonstration for them to understand what is going on."*

All the above participants have mentioned different teaching strategies for geometry which are not the same as teaching mathematics. The teaching strategies that they are using for circle geometry are specific to geometry. Below are the participants who experience difficulty in the teaching of geometry.

Participant D affirmed: *"For the geometry, I must say it's difficult, the thing that I use is a whiteboard, then I use the projector and project the exam paper or textbook resources to the board, but it is very difficult for the students to grasp a concept especially because there are many theorems and they tend to confuse them."*

This shows that the strategy that is used by participant D may be working for students and the lecturers. A participant uses technology in the lessons, which shows that teaching circle geometry using technology may be effective for this particular participant in that particular TVET College.

Participant E highlighted: *"Mostly is lecture method because the technology available is not working. And the time is not permitting because, like we have the smart board but all these, they were disconnected, they are not there, the projectors are not there, have not marked the way the smart board, and there is certain software like GeoGebra, they are not there. It is difficult to install them in our class because the IT guy doesn't have permission to install them on our computers. So, at the end of the day is not easy to teach geometry using technology, but when it comes to the teaching method, the way you write and draw a few things, we look in the book. When you look in the book, you say go to page so and so can, you see that diagram happening at the end of the day students are just using examples from the book sometimes it becomes a challenge."*

This participant seems to use the same strategy for teaching mathematics and circle geometry. The prominent teaching strategy for both is a lecture method. This shows that development may assist the participant and the rest of the mathematics lecturers in using various teaching strategies to effectively teach mathematics and circle geometry.

Most participants mentioned that these strategies have worked for them since they finished the syllabus. This may mean that the participants are teaching to cover the syllabus. Not even a single participant has mentioned whether they had attained the teaching-learning outcomes for the circle geometry. The participants stated that they had learned these strategies when studying for their educational qualifications. One of the participants mentioned that teaching strategies were emphasized when doing PGCE. This suggests that lecturers benefit greatly from pedagogical knowledge when they pursue their studies. This shows that if lecturers further their studies, they can learn more teaching strategies. Effective teaching strategies can be learnt in workshops on an ongoing process. A study conducted in the Eastern Cape by Webb and Webb (2004) found that teachers' beliefs about innovating teaching and learning were only displayed in theory and not in practice. This suggests that the mathematics lecturer may facilitate effective and innovative teaching strategies through monitoring through ongoing development.

Pedagogical knowledge involves the knowledge of the lecturer in terms of constructing the lessons, classroom management where students are being motivated by a lecturer to participate in the classroom, assessment of the students (before, during, and after the lesson), and managing the heterogeneous groups in the classroom during the teaching and learning process (König & Kramer, 2016). However, with this study, the focus on pedagogical knowledge was based only on students' performance and assessment, teaching adaptation based on students' understanding, teaching adaptation based on students' interest and skills, diversity in learning assessment, familiarity with student misunderstanding, explaining with illustration as well as the class management and organization of a lecturer with the use of technology in class.

How do you assess student performance with a technology used in the classroom? Only 40% of the participants mentioned that they do not currently use technology for assessment. This shows that the lecturers have insufficient resources concerning technology for use in the assessment. At the same time, the remaining participants mentioned various answers.
For instance, Participant C: *Assessment by ways of question and answer sessions, group activities, and written assessment*

This shows that only a lecturer gives the questions to students to answer while using the technology provided. This may mean that a lecturer uses the laptop provided by the college to read the questions while students provide the answers, which suggests that students are not involved in the technology used to follow what a lecturer is doing in the classroom.
Concerning the teaching adaptation based on students' understanding, the participants were asked: Can you adapt to the teaching style based upon what students currently understand or do not understand about the lessons using technology? Elaborate. Most participants mentioned that it is impossible due to a limited time.

Participant A: *In theory, yes, but in practice, there may not be enough time for that. We will always want to push the syllabus.*

This shows that the lecturers are experiencing difficulty using technology due to the limited time to cover the syllabus. This may mean that the completion of the syllabus is more important than the learning process of circle geometry using technology. It may also mean that lecturers are willing to do that in the classroom, but insufficient time is the problem.

Only 40% of the participants mentioned adapting to the teaching style.

Participant B said:

Yes, I can adapt because it helps a lot to know where the students understand or what they understand before you start to develop them

This may mean that these lecturers are concerned about understanding the students' subject matter. They go the extra mile by scaffolding the lesson for the students to understand lesson. Time and syllabus may be important, but the students' understanding of the content is very important, concerning the lecturers' adaptation based on students' interests and skills. Most lecturers mention that they adapt the teaching style to different learners depending upon their interests and technology skills. The problem they experience is the lack of data for using technology, and they would like to gain more knowledge using technology for teaching circle geometry. At the same time, another participant said that teaching circle geometry enables learners to visualize the problem. This suggests that learners learn and understand better when they see an object and tend not to forget.

The lecturers gave various answers concerning assessment. When asked about diversity in learning assessment, can you assess student learning in multiple ways using that technology? Elaborate.

Participant A replied: "*Yes. For example, I stop videos and allow group discussions or individualized attempts to solve the problems. The other method would be using quizzes where google classroom is in use. This, however, is still unfamiliar ground."*

Participant B responded: "*Yes, I do so that while assessing in different ways, the learners in class also learn the technology used."*

Participant C conveyed: "*We haven't adopted multiple assessment methods on campus."*

Participant D said: "*No. Limitations of the package we currently use*."

Participant E stated: “*Yes, but no opportunity given.”*

Most participants mentioned that they could use multiple ways to assess the students' learning using technology. While only 40% of the participants said, they have not started using technology multiple assessing methods because they are limited by what is available in the college. This means that the lecturers can use technology for assessment, but they are limited by the availability of resources for this study. Lack or insufficient resources limit the teaching and learning of circle geometry at this TVET College, especially during this difficult time when online learning is required to curb the spread of the Covid-19 virus among the students and lecturers during physical contact on campus. This may mean that lecturers have all the required skills to teach circle geometry and use technology for assessment, but it could mean that there is a limit in using technology to assess students even though the lecturers have some skills for assessment. Still, insufficient time for using technology is not utilized for this study's purpose. Participant E mentioned that he has some skills for assessing using technology but has no opportunity to do that in class. This may mean time is not sufficient for the lecturers to use technology for individual assessments for the students, which suggests insufficient time to cover all this work in level 4 during the teaching and learning of circle geometry.

When asked about the familiarity with students' misunderstandings, the participants were asked: Are you familiar with common student misunderstandings and misconceptions about technology usage in lessons?

Participant A uttered: “*Yes. Students may not understand the teacher in a video, preferring the one they can see. Students may not understand different accents if a YouTube video is used.”*

Participant B stated: “*Yes, some learners fail to differentiate the shapes, for instance, circle and oval, so I always make sure that if they choose a circle, they think of a ball so that they can relate it with a circle.”*

Participant C said: “*Yes, you get to know the misconceptions through homework and allowing learner self- based activities.”*

Participant D highlighted: “*Yes.”*

Participant E concluded: *“Technology is not being used to teach per see, hence irrelevant to the situation.”*

Misconceptions are the thinking difficulties originating from insufficient teaching, poor remembrance, or informal thinking. When students experience misconceptions in circle geometry, the lecturers need to identify and eliminate them through teaching skills they possess. Zuya, Kwalat, and Research (2015) study revealed that teachers need to know their students by demonstrating the strategies to discourse the students' problems when they have misconceptions about geometry learnt. While Baumert et al. (2010) stated that the key constituent required, a teacher's sound knowledge makes a competent teacher. The more teachers' knowledge of their students is displayed, the more the learning skill of students is improved (Dixon et al., 2012). Most participants agreed that they were familiar with the students' misconceptions. The lecturers can easily identify the gaps created during the teaching and learning and then fill the gaps to erase the misconceptions created.

Özerem and Sciences (2012) study revealed that students have numerous misconceptions and insufficient knowledge related to geometry. Nine students mentioned that lessons are more interesting when learning by a computer in their findings. Most students stated that learning is easier when using the computer in geometry lessons. They tend to remember better because they visualize the geometry, and through visualisation, learning becomes permanent. This suggests that students enjoy their learning through technology. Through the drawings done by technology, visualization is mastered by the students when learning geometry which makes them remember the drawings, concepts, angles, axioms, and theorems of geometry. Mthethwa (2015) also agrees that when teaching with technology, learners' performance increases. This shows that lecturers' knowledge concerning the use of technology during teaching and learning will also help identify misconceptions during the instruction.
Using technology, the participants were asked to explain with illustrations: How do you explain the abstract geometric concepts through visible illustrations? Elaborate.

Participant A said: *"I look for good videos on the internet and use them alongside my explanations."*
Participant B stated: *"Relating it with the real-world situation, and also using whiteboard if they are lost."*
Participant C conveyed: *"Use of models and an interactive board."*
Participant D said: "*The program usually does this. It is built-in*."
Participant E indicated: *"Not empowered."*

Most participants said they use technology to explain and demonstrate abstract geometric concepts using visual illustrations with technology. One indicated that videos are used from the internet, meaning that YouTube is downloaded and utilized to clarify some concepts for circle geometry. While students are viewing the video, a lecturer tries to explain using their voice to students. Some lecturers even go as far as using real-life situations in explanations. This shows that the context is used during the learning. When lecturers use the students' environment during learning, learning becomes easier. The study conducted by Lieberman and Hoody (1998) discovered that when students' environment is included in learning, students have better performance on academic achievement, there are fewer discipline problems in classrooms, and students increase their engagement in the classroom during learning. This shows that the participants go the extra mile in teaching using technology. The last participant mentioned that there is no empowerment. Some lecturers may lack interest in using technology to teach circle geometry, causing students to perform poorly in geometry and mathematics at level 4.

Looking at the classroom management and organization while using technology, lecturers were asked the following question: How do you organize and maintain classes taught using technology?

Participant A: *I usually ask learners to move up front, especially those with visual impairments, which they cannot see from the back of the classroom. Not much can be done to rearrange the sitting plan because our benches and desks are fixed, leaving no room for rearrangement*

Participant B: *Marking registers using the laptop and testing them with an overhead projector while saving papers. They also work in groups since the resources are not enough.*

Participant C: *Lessons are based on learner prior knowledge, models utilised, and group activities incorporated*

Participant D: *Yes*

Participant E: *The teaching is mechanical, so no technology is used. The mathematics rooms were disrupted, so no more projectors and interactive boards were utilised.*

Most participants show that they are trying to use technology for classroom organisation. When one of the participants stated that no technology is used, there is inequality amongst the TVET lecturers in using technology in circle geometry teaching NCV level 4 students. Marking registers using laptops that the TVET College provides is the classroom administration. One of the participants mentioned that models are used for teaching, and group activities are also incorporated during the lessons. This suggests that lecturers may use a learner-centered approach when facilitating learning as per the need for an NCV curriculum.

5.6 PEDAGOGICAL CONTENT KNOWLEDGE (PCK)

Pedagogical content knowledge is not content knowledge that is added to pedagogical knowledge. A teacher's knowledge is displayed in the classroom practice, forming pedagogical content knowledge (McNamara, 1991). At the same time, Shulman (1986) defined Pedagogical Content Knowledge as a content knowledge needed for teaching where knowledge of formulating environment and context is more conducive to better understanding the lesson during learning and teaching to others. For the sake of this study, only selecting the focused lessons category using the technology is studied. On selecting the focused lessons,

Participant A conveyed: *I introduced the topic using the classroom, angles, and parallel lines. I ask them to tell me what they already know. About the topic. I also make use of worked examples.*

By so doing, participant A starts from the knowledge to make a lesson more meaningful using the previous knowledge for instilling the new knowledge to students while using their teaching practice in the classroom. Jing-Jing and Research (2014) agree with Shulman (1986) that clarifying pedagogical content knowledge comprises three types of knowledge that a teacher needs to have viz. 1. Knowledge of the subject matter 2. Knowledge of teaching strategies to present the subject content, and lastly, 3. Knowledge of the students' topic understanding. This has been affirmed by participants C and E when

participant C said: *prior knowledge used to build upon understanding, group activities.*

Also, participant E emphasized what has been said when mentioning: *teach from known to unknown.* These statements strongly agree with participant B that having different shapes on the screen and letting them correlate with their names gives basic knowledge, using tools that give *answers when calculating, for instance, calculator.* All these participants emphasize prior knowledge when teaching circle geometry which means that a lecturer needs to identify the students' knowledge and where to start during teaching.

Lecturers show various approaches to guide students' thinking and learning in geometry in technology-focused learning. They showed that they use the knowledge that students have already to introduce the new knowledge. This means that prior knowledge is used to build upon understanding group activities. They teach from known to unknown. On answering a question: What teaching strategies do you use in teaching mathematics? The participants responded:

Participant C: *I most commonly use group work-based strategies most of the time otherwise, I do also resort to giving the students work on their own do where I use scaffolding to the system for them to carry on applying their knowledge on what they have learnt on their own it either they individually do the questions or they do it collectively in a group.*

Participant D: *when teaching (I classified to her the meaning of teaching strategies) Basically when I start the lesson, do lecturing in the class, and then give the class the problem, then I always use group work.*

Participant E: *Mathematics is a hands-on subject although abstract so, you have to use a variety of methods, e.g., the lecture method is the common one to college and then you need to blend it with other activities where you put some investigations, some practical activities, you also need to use technology in the process.*

The participants mentioned that the strategies have worked for them because they got 30% as a pass mark.

When asked about the teaching strategies they use for geometry, what teaching strategies do you use to teach geometry?

Participant B: *What I use the teaching strategies in teaching geometry is making sure that the learners are familiar with the angles and they know how to apply the principles and there the theorems in terms of attacking the geometry and also making sure that the learners understand the statement before they are tackling the problem of geometry because the main cure is on the principles and the statement that is given to the learners based on the circle geometry*

Participant D: *For the geometry, I must say it's difficult. The thing that I use is the whiteboard, then I use the projector and project the exam paper or textbook resources to the board. Still, it is very difficult for the students to grasp a concept, especially because many theorems confuse them.*

Participant E: *mostly is lecture method because the technology available is not* *working. And the time is not permitting because, like we have the smart board but all these, they were disconnected, they are not there, the projectors are not there, are not marked the way the smart board, and there is certain software like GeoGebra, they are not there. It is difficult to install them in our class because the IT guy doesn't have permission to install them on our computers. So, at the end of the day is not easy to teach geometry using technology, but when it comes to the teaching method, the way you write and draw a few things, we look in the book. When you look in the book, you say go to page so and so can, you see that diagram happening at the end of the day students are just using examples from the book sometimes it becomes a challenge.*

When looking at the teaching strategies these lecturers use for mathematics and geometry, they use the same lecture method, group work. They teach for examinations because their strategies are measured on performance, but that does not mean they are the best. When a lecturer projects a question paper on a whiteboard, a lecturer teaches for a pass.

While focusing on the mathematics lecturers from the three different campuses of the TVET College in the Majuba District Municipality, the study reveals that the teaching of circle geometry using technology is indefinable. In theory, there is technology on all campuses, but clearly, this is not so. They have been supplied with laptops in practice but not specifically for geometry. They use laptops for administration purposes and not for lesson presentations in the classroom. The participants felt that they were not given the necessary support for teaching and learning.

5.7 TECHNOLOGICAL CONTENT KNOWLEDGE (TCK)

Below are the responses for the lecturers on technological content knowledge. Most lecturers could not mention other technologies and use them to understand and pursue circle geometry to level 4 students. Only one out of five of the participants showed knowledge of technology. The rest could not respond. This may mean that the lecturers are not familiar with other types of technology that can be used. Only one was quoted saying:

Participant C: "*Heard of virtual reality software used in Japan, for example.*"

This shows that this participant is aware of technology's taking place worldwide. This is evidence that some lecturers may have insufficient confidence in using technology to teach circle geometry.

5.8 TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE

Technological pedagogical knowledge is about choosing the right technology to teach a certain subject. For the sake of this study, certain aspects concerning technology will be discussed. These are the criteria for choosing technology for the teaching approaches of geometry lessons applied to choose technologies for the students learning circle geometry and how they were used. With the aid of the questionnaire, the participants were asked the following question concerning choosing the right technology for teaching circle geometry to level 4 students: Which criteria did you use to choose technologies for the teaching approaches for geometry lessons?

The participants mentioned different criteria. For instance, participant C said: "*Must be visually suitable.*"

Participant C has chosen the technology used for teaching geometry due to visualization, which means that the chosen resources for teaching circle geometry must make the drawings visible for learning to occur. This shows that students learn better if they see what they are taught. Whereas participant A has answered differently from the other participants.

Participant A stated: "*For the most part, the college chooses for us via campuses.*"

This emphasizes that the TVET College chose the technology available. The resources are chosen on campuses. Even if a lecturer is interested in a certain resource, they must use what is available.

Participant B mentioned: "*The language used is more understandable and it easier to draw shapes and do calculations on it and also write on it using blackboard." to write on it using blackboard.*"

Participant B chose the technology because its language was simple and could draw visible shapes, and it was possible to write on it. This means that language for learning and teaching was more important for the participant. Circle geometry has its unique concepts and language, and a clear explanation is required. It also has diagrams. Students must draw the diagrams to apply the drawings during proofs and applications of proofs when doing circle geometry. This shows that all the participants had their way of choosing the technology to teach circle geometry. They are supposed to use what a college offers.

The strategies applied to choose technologies that the participants can use in students' learning for geometry lessons and how they are used. Only 60% of the participants could answer the strategies used. Participant A mentioned: "*User friendly to learners simple and straight forward"*

Participant E stated: "*Use study packs and projectors and question papers."*

Participant C responded: "*Model-based teaching, to aid visual conception, group-based learning to aid cooperative learning."*

The responses mentioned above show participants use different teaching strategies, but they could not show how they use them. This suggests that the participants lack the teaching strategies they use with technology in circle geometry. When the participants were asked:

Have you thought deeply about how technologies can influence the teaching approaches used in the classroom? Elaborate.

There were 40% of the participants who said "no," while 40% could not answer this question.

Participant B answered:

"*Yes. It is time-consuming teaching geometry on the whiteboard as it requires time to draw and explain the different types of postulates, including diagrams, explaining theorems. Technology helps in time consumption as it makes life easier for teachers and learners."*

Participants were asked: Can you adapt to using technology for different teaching approaches? Elaborate.

Most participants said yes.

Participant B responded:

"*Yes. Technology is being upgraded and developed in different ways to make the world a better place, so it is important to adapt."*

Participant E stated: "*Yes, with exposure and training."*

This shows that the participants are willing to use technology for different teaching approaches. At the same time, some could not answer the question in a questionnaire given, and only one participant said "*sometimes*," showing uncertainty regarding adaptation. Participants B and E know that adaptation is necessary through exposure as technology is constantly being upgraded. The participants stressed the importance of exposure to technology and emphasized training. Technology will be used without any difficulty through the ongoing professional development and training of lecturers in the use of technology for teaching circle geometry. This shows that there is a problem experienced in the use of technology. There is a need for the lecturers to be developed and trained in using technology for teaching and learning. Only 40% of the participants indicated in the questionnaire that they could measure/assess the outcomes/impacts of incorporating technology in the teaching approaches. This may mean that geometry lecturers as the participants for this study lack knowledge for choosing and identifying the right technology for use in the teaching of circle geometry to level 4 NCV students.

5.9 TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE

The lecturers' technological, pedagogical and content knowledge was measured using an open-ended questionnaire. During administering a questionnaire, technological pedagogical and content knowledge was evaluated through a combination of knowledge, determining knowledge requirements, self-assessment, and the self-adjustment of technological, pedagogical, and content knowledge for geometry lessons. The participants were asked: Can you teach lessons that appropriately combine mathematics/geometry, technologies, and teaching approaches? Elaborate.

Participant A responded: "***I can.*** *Whether my ability will be up to scratch or not highly depends on the judgment of a given student grouping. The pass rate is often used to reflect ability though students still fail no matter how good one might be at teaching the subject."*

Participant B stated: "***Yes****, using a blackboard requires a projector, smartboard, and installed software. When teaching graphs, you will be required to plot using GeoGebra as one of the technologies."*

Most participants showed that they could appropriately combine mathematics, geometry, technologies, and teaching approaches. These participants are willing to go for any training to develop the skills for combining technology and teaching approaches in mathematics and geometry. This shows a need for software to make mathematics and geometry more understandable. The results show that most lecturers can combine mathematics, geometry technologies, and teaching strategies when teaching. Still, there is a lack of technology to be used during teaching and learning as the participants were asking for software to be bought by the TVET College to make learning more practical. One of the participants mentioned that he could not teach while combining mathematics, geometry, technology, and the teaching approach. This means that the participant is not trained to use technology in teaching or that a lecturer was born before technology. Another participant was undecided about answering the question because the question was not answered. Interestingly, most of the participants can combine technology and different teaching approaches in circle geometry.

The participants were asked: Is it easy to determine geometry lessons' technological, pedagogical, and content knowledge requirements? Elaborate:

Most participants affirmed. This also means that technology use will not be a problem with the teaching of circle geometry.

Participant B stated: "*It is easy since the technologies used do not require different knowledge or different language. It is the quality that is required.*"

Participant E said: "*Yes.*"

The participants showed no problem determining geometry lessons' technological, pedagogical, and content knowledge requirements. This suggests that lecturers in the system are more determined to use technology since they see no difficulty because they were trained and have learnt about technology in teaching and learning. If there is a chance for introducing the software development to use in the teaching of circle geometry, there would be fewer problems for the lecturers. Participant D was undecided and did not answer the question. More interesting is that the lecturers can easily determine the technological, pedagogical, and content knowledge requirements for geometry lessons.

Concerning self-assessment of knowledge domains, the participants were asked: Can you assess the technological, pedagogical, and content knowledge for geometry lessons? Elaborate.

Most participants mentioned assessing geometry lessons' technological, pedagogical, and content knowledge. This is interesting since most participants can assess using technology. Although previously, one of the participants mentioned that the laptops the TVET College gave them are used for the assessment setting. There is confusion here; whether the participants mean that or assess using the technology illustrating that the participants may have difficulty understanding the question. Participant E said: "not sure," while another participant could not answer the question. This may mean the participants are experiencing difficulty and confusion since they could not determine which level they should assess with technology.

On self-adjustment of knowledge domains, the participants were asked: Can you adjust technological, pedagogical, and content knowledge for geometry lessons depending upon situations? Elaborate.

Most participants said they could adjust technological, pedagogical, and content knowledge for geometry lessons depending upon the situation.

Participant B stated: *"Yes. I should know when and how to teach. I also need to adapt to the diverse interests and abilities of learners and the ways of representing and formulating the subject that makes it understandable to others."*

Participant C said: *"Yes, use the mediation of teaching and learning."*

The participants mentioned that they could adjust. They were waiting only for the TVET College to provide technology for the geometry lessons.

Participant E responded: "*technological is challenging since college is not capacitated."*

This emphasises a challenge in using technology to teach circle geometry. The TVET College may provide and develop the lecturers using technology to teach and learn circle geometry suggesting that the lecturers are willing to use technology, but it is not available. This means that there is a lack of technology use in the teaching of circle geometry. The lecturers seem to have skills for technology, but the problem lies with the TVET College that is not providing the resources.

5.10 TECHNOLOGY USE IN THE TEACHING OF GEOMETRY

The study is about the lecturer's use of technology in circle geometry. Some lecturers may be familiar with using technology to teach circle geometry. These participants displayed different emotions with technology use while I was conducting interviews. When asked: What are your views on using technology in teaching geometry? Which one do you use the most and why?

Participant C stated: "*I have positive views towards it because, as I said earlier, I mean through technology, a student can be exposed to the multiple ways in which it can be given to them. They also can visualize the shape of whatever they are working on within the geometry questions. I believe it also gives them more knowledge, more exposure. Kids can then also, I'm not in the house during the day, but if they have access to the technology, it's like having a lecture right there the whole day, the whole night is there to assist them."*

Participant E said: “*My views are that I support the use of technology in mathematics, but there are challenges that need to be addressed… but technology on its own is good if it is properly annexed and used. So, I affirm the use of technology in the teaching of mathematics and geometry though with a lot of preparation, prior.”*

All the participants agree that using technology in geometry is beneficial. Participant C stated that when using technology, its importance is that even learners who were not in class during the day but with access to technology can catch up with their work. This means that the students will always be learning without physically attending a class during the pandemic when students are supposed to attend 50% of the capacity of the classroom. Those that are not in class are required to study online using technology. This shows that even though the college is obliged to use technology because of the pandemic, it is not using technology for learning. This helped with the learning when students did not understand properly during class. They will keep on repeating what was done. Technology also helps with visualization of what is learnt, and it makes learning very easy, and students tend to remember what they have seen. Participant E has mentioned that technology use is good, but lecturers experience some challenges and need much training to be prepared for its use. Through ongoing professional development, mathematics lecturers can use technology to teach geometry.

Although all the lecturers see the need for technology in the teaching of geometry, the challenge is how many are using it and what type of technology they are currently using. When asked what resources are available for using technology in the teaching of geometry in the TVET College, which one do the lecturers use the most and why? Most lecturers mentioned different types of technology they use to teach circle geometry, except for one participant using technology to set the assessments and not teaching circle geometry in the classroom. They all have different answers:

Participant B stated: “*In my college, videos, there is a computer lab for the student to watch videos, we have an overhead projector, and we have WhatsApp, and we have been using WhatsApp for teaching. So, for me, I usually use the overhead projector and the whiteboard to also use WhatsApp to send videos and communicate with the learners via the audience, write notes on the papers, and help them attack the problems. I prefer it because most of the time, for instance, for WhatsApp.”*

Participant C responded: *Okay, we have interactive board, data projector, laptops, and access to the software, so I’m that’s the resources and the access to technology we are currently using at the campus.*

Participant D said: "*You know currently we are using the whiteboard because the technology as you know learnerscape we used it like two years ago I think and then the license was expired. So currently, or though we would like to have the learner scape package or some kind of IT package to assist us, you know the reality is that we don't have access to learner scape. Because there's no internet connection, we can't broadcast the YouTube videos because although we have laptops and projectors and screens, we don't have connections to the internet. So basically, at the moment, we are just relying on the textbook and the past year's exam papers, whiteboard."*

Participants displayed that there are various technologies they are using to teach geometry. Among the resources, they counted laptops given to all the lecturers by the college, interactive board/smartboard, data projector, videos, WhatsApp, and learnerscape software. Using WhatsApp for teaching circle geometry is limited as it is only for communicating and sending videos by the lecturer to the students. It is being used together with the textbook and previous question papers. The participants have mentioned a software known as learnerscape, which the mathematics lecturers were utilizing, but the license was not renewed for the software, which allowed it to expire. Only one participant mentioned that none of those mentioned above technology is being used due to some experienced challenges on campus.

Participant E responded: *"Technology s there as I said above, but the challenge is as I said that the resources are not in good shape and those which are there they are not being utilised because they have been vandalised if you go into some college for especially like where I am you discover that the smartboard is there, but we are sharing a class with somebody who doesn't know that it is a smartboard…. We are sharing the maths room with the people some people are stealing the projectors even in case if you want to look for YouTube there is no data, or you want to look for free software, we don't have the free software like GeoGebra to install on the college computers because the ITC doesn't want to install it, so it becomes a challenge so none of these we are using them"*

This suggests that some colleges are using technology to teach circle geometry. Interestingly, all colleges were provided with technology to use in teaching. Participant E mentioned that data projectors are stolen, indicating security could be an issue. In the case of shared classrooms, the solution can be addressed by not sharing mathematics classrooms as some colleges already do. There are mathematics classrooms that mathematics lecturers use only with high security. Sharing of information between colleges regarding security would be beneficial to all. When participants complain about the shortage of data, it shows that even if there are resources, the use may be limited because of data shortage. This shows that TVET Colleges function differently due to technology use in the teaching of circle geometry.

The participants were asked if they experienced any change when teaching circle geometry with the technology that they are using. The participants replied with different answers, and their facial expressions showed unhappiness when answering that question. They displayed mixed emotions when talking about it. The question asked was: How has technology changed how you teach geometry? Please include an example.

Participant D said: "*I would say it has improved the way that I teach geometry and if I can use the example of learner scape to say you know that it's a more effective way of delivering the geometry content to the students.*"

Participant D has been using the learnerscape software to teach circle geometry to level 4 students. It was the most effective way of teaching circle geometry content to level 4 students, but unfortunately, it happened only for two years, and after that, the license expired. This means that the college did not renew the license for using the software. The software simplified the content to students, which benefitted both the lecturers and the students. This may mean a lack of support for a software upgrade for the use in the teaching of circle geometry.

Participant E said: *"…as I said when it comes to teaching geometry, as I alluded to the above question, it has not changed anything because we are not using it."*

Participant (E) has never used any educational technology in geometry teaching, and nothing has changed for him. Things have been the same since the beginning. This may mean that the TVET colleges are operating differently regarding bought resources. The management of each TVET college may experience difficulty in security and management of resources, thereby making the lecturers of mathematics suffer regarding technology use in teaching circle geometry. This may mean a lack of support in maintaining security for the technology available for teaching circle geometry.

Participant B responded: *"…geometry in technology I think it helps a lot with time consumptions because I can attend learners without rushing them …the shape is clear so if I'm using the technology, for instance, the overhead projectors or maybe using the PowerPoint presentation I can just put the shape on the board so that the learners can see it* *without even making any mistake or erase it. I just explain what is happening then also to be able to attend the learners' problems efficiently."*

For this participant, technology saves time during teaching and learning. In other words, a lecturer plans the lessons before time using a PowerPoint presentation. Preparing a lesson before going to the classroom makes a lesson easier for students, and there is more time available to help students if they experience difficulties. This suggests that after presenting a lesson, a lecturer has ample time to do individual attention to those who experience misconceptions.

Lecturers who are using technology have changed the way students learn. The participants were asked: How has technology changed how your students learn geometry? Please include an example.

Participant B mentioned: "*I think a lot has changed, based on the productivity will come to the syllabus because now we can use more time even after hours we can communicate even if they have problem with geometry they can text or send audio to ask if I can help them."*

Participant (B) mentioned that they can now communicate with students after hours, which may mean that those who do not have data suffer and benefit from learning. Secondly, it means technology is used as a tool for communication if students encounter problems and not as a tool for learning.

Participant C replied: "*It makes me as I said a while ago, it makes me more think like how would the learner wants to perhaps see that angle so then it gives me the access example online or to the ability to look for software that is possible that maybe I can turn a shape you can maybe move the angle, you can maybe then cause we know that learner can't see the 3D image so it's given us that advantage that of putting ourselves in their shoes of thinking I may be the learner would like to see the backward of the shape, maybe the learner would like to see maybe the front of the rectangle, it gives us that advantage and the ability to think let me just make it easier for the students so that they can see everything that is going on and understand space in a way."*

Participant C said using technology has encouraged lecturers to be lifelong learners and researchers. The lecturers always go the extra mile to prepare for the lessons and spend more time planning while downloading the required shapes. During the lessons, the students are

shown whatever they like to see regarding the lesson for the day. While the students find it easy to learn, the technology limits them because only a lecturer could draw using it, and the students are shown what is already drawn beforehand. The students are supposed to be involved in using technology and draw the diagrams of circle geometry using the technology available. When were the participants asked whether technology changed or broadened the "curricular knowledge" to be gained, learned, or applied? Please include an example.
Participant D said: "*you know the technology that we use in line with our curriculum with the syllabus. So, I can't say that it has broadened the curriculum. It doesn't add to the current syllabus that we are doing."*

While participant E stated: "*.... we are not using it, so cannot change anything, so that is the challenge which needs to be addressed that technology is available, but we are not making use of it."*

Most participants have mentioned that no curricular knowledge was broadened because it added nothing to the syllabus of circle geometry. No value so far was added because of the lack of technology use. This means that there is no benefit in terms of the availability of the technology. The TVET College has bought technology to use, but not all are using it. This means that there is not enough monitoring done by the senior management of the TVET College, which made other colleges ignore the available technology.

The participants were asked whether teachers needed to use technology in mathematics teaching: 80% of the participants believed that technology should be made compulsory for lecturers and teachers in mathematics teaching. They voiced different ideas concerning its requirement.
Participant A responded: "*Yes, it has to be made compulsory because in this fast-changing world if you don't change, if you don't upgrade your knowledge one day, you will just find yourself you are being substituted in your place so we will, we are forced to adopt the new knowledge and adapt to this situation otherwise you become irrelevant……"*
Participant B said: "*Yes, it saves time and helps learners to communicate with their teachers easily, and teachers will have enough time to finish syllabus while having time to attend learners' problems."*
Participant C highlighted: "*Yes, I do believe it should be"*

Participant D replied: "*yeah, I do think it should be going in that direction that we use that ICT component in our teaching, and I think another thing is a lot of students they or learners do they can't put the learning of maths, or they put the context that we teach them, it's like they feel that are learning for nothing and they won't use it in their lives at any stage, and I feel this is where technology comes in, …… So, I think that the technology adds to why I am learning this maths. Where many students feel like just a boring subject, it doesn't contribute anything towards their, or the job they want to do."*

While most participants support the idea of the technology being compulsory for use, only one of the participants mentioned that it should not be compulsory; therefore, it should be optional.

Participant E answered: "*It should not be compulsory, but it should be one strategy to use because some lecturers may use charts with those diagrams to draw. So, it should be an option because some colleges or institutions may not have the financial muscle to enrol in technology. So, if you make it compulsory, it means you have first to put the hardware software and train the people, making it compulsory. But if it is, as it stands now, is a challenge."*

This suggests that this participant is thinking about the funding instead of thinking of the needs of the students and the lecturers. This era needs technology, especially because of the pandemic where students need to attend a subject for two weeks due to social distancing as a regulation for Covid-19. This means that the TVET Colleges and DHET are pressured to use online learning, which was drastically introduced without thorough individual training for the lecturers.

All the participants were familiar with the concepts content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Maybe the reason was that we administered the questionnaire before the interview questions.

5.11 CONCLUSION

This closing chapter positioned the findings of research that resulted from the data collected through the interviews and questionnaires. Critical research questions that were answered are:

1. What technology do lecturers use to teach circle geometry to level 4 students?

2. How do mathematics lecturers teach circle geometry using technology in a TVET College?
3. Why do mathematics lecturers teach circle geometry in the way they do?

The findings from the study and conclusion will be detailed in the following chapter.

CHAPTER 6

DISCUSSION ON FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1. Introduction

This research study analysed mathematics lecturers' use of technology in teaching circle geometry at a selected Technical and Vocational Education and Training College in KwaZulu -Natal. This research study was qualitative, contained by the interpretive paradigm and a case study design. It was further projected to determine 'what' technology lecturers use and the 'how' and 'why' lecturers use technology to teach circle geometry at a TVET College. This research study then focused on using the available technology per the 4IR of the Vision 2030 in South Africa. Mathematics lecturers were interviewed and given questionnaires, and the lecturers' feedback was collected. The generated data through one-on-one semi-structured interviews and open-ended questionnaires were transcribed and analysed using the themes that emerged from the data. Chapter 6 represents the summary of the findings during data collection, the significance and limitations of the study, and the recommendations and suggestions for further study.

The main research question was:

What are mathematics lecturers' experiences using technology to teach circle geometry to level 4 students at a selected TVET College?

The sub research questions were:

- What technology do mathematics lecturers teach circle geometry to level 4 students in a TVET College?
- How do mathematics lecturers teach circle geometry using technology in a TVET College?
- Why do mathematics lecturers teach circle geometry in the way they do?
- What do mathematics lecturers do to enhance the effective teaching of circle geometry using technology?
- How do mathematics lecturers' use of technology in their teaching programs influence students' experiences of learning circle geometry?

- What implications does technology have for the teaching and learning mathematics in TVET Colleges in South Africa?

6.2 Summary of findings

The first research question was pursued to understand what type of technology the participating mathematics lecturers use during the teaching of circle geometry to level 4 students. The results showed insufficient relevant technologies to teach circle geometry level 4 at the TVET College. This research study provided evidence that all the lecturers have the laptops provided by the TVET College, which suggests that the lecturers have technology that they are using, but it is not specifically for circle geometry teaching. The laptops are supposed to be used for teaching, learning, and administration purposes. There are computers in all classrooms for life orientation that the students also use, which suggests that all NCV students use technology on campus while most have no online access to technology. It is only in circle geometry that the students and lecturers use no specific technology. The data analysed revealed that most mathematics lecturers have no access to different technologies. It would help if the TVET College and DHET encouraged all mathematics lecturers specifically for geometry level 4 to use relevant common technology to teach circle geometry.

The second question was how mathematics lecturers teach circle geometry using technology to level 4 students at the TVET College. The data analysis revealed that mathematics lecturers encountered many challenges concerning the lack of relevant technology, specifically teaching circle geometry. This suggests that technology for teaching circle geometry is lacking. DHET and TVET Colleges are recommended to provide access to the training of technology and development programs to mathematics lecturers concerning the use of technology in teaching circle geometry.

Another conclusion from the data analysis is that all mathematics lecturers were familiar with the concepts content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). They have high technological, pedagogical, and content knowledge, high technological content knowledge, and high technological pedagogical knowledge. It is evident from the outcomes that lecturers have difficulty identifying the relevant technology, including when and how to use it in the NCV curriculum. This suggests that as mathematics lecturers have high technology skills, they can learn easily about the relevant technology to be used in the teaching of circle geometry through technology as it had happened during the Covid-19 pandemic when lecturers were only given steps to follow in the implementation of the ACTIVE PRESENTER which is the LSM used at the TVET College. The use of technology in the teaching of circle geometry is recommended, especially during the pandemic era where physical attendance on campus is prohibited due to the increase of the high infection numbers of Covid -19.

The DBE and DHET operate differently concerning curriculum development. Mathematics lecturers revealed that the FET phase mathematics syllabus is different from NCV level 2 to 4, whereas they are equivalent according to the DHET. A recommendation of curriculum planners for these two departments is needed to work together on the curriculum designing process to close the gaps.

Using technology in circle geometry requires pedagogical knowledge, content knowledge, and technical knowledge. The mathematics lecturers showed that they were trained in different institutions to use technology to teach circle geometry during their studies. All the lecturers have pedagogical knowledge and content knowledge of mathematics and circle geometry because they all have majored in mathematics subjects. They have the technical skills needed for a technology-based geometry lesson. This suggests that mathematics lecturers have gone for training and have technical skills to teach circle geometry. However, those skills are not utilised because there is no relevant technology to teach circle geometry. The DHET and the curriculum department of the TVET College need to liaise and provide the relevant technology to be used to teach circle geometry level 4 in a TVET College.

Mathematics lecturers believe that teaching students impacts their performance through results. Geometry teaching strategies are the ones that help yield greater performance in geometry. Using technology in the classroom for better conceptual and procedural understanding can uplift mathematics performance. Only teaching students with different teaching strategies using technology yields the best results in mathematics learner performance. The findings indicate the strongest impact of the professional development depended on the lecturers' technology-related principles. On-going professional development concerning teaching strategies to teach circle geometry is recommended by the DHET and the TVET College.

There is evidence that most lecturers have sufficient knowledge of the teaching strategies, although they prefer to use the lecture method most of the time. Students lack a basic foundation in mathematics and come to level 4 without the necessary background in mathematics. This may mean that the lack of foundation was caused in schools before reaching level 2 at the college, or the level 2 and level 3 foundations for mathematics were not good. It may mean that the lecturers are using only the same teaching strategy because of time and are interested in finishing the syllabus and not instilling the concepts in students. This is illustrated by the fact that the teaching strategies that the mathematics lecturers are using for circle geometry are specific to geometry, and they experience difficulty teaching geometry. On-going professional development concerning teaching strategies to teach circle geometry is recommended by the DHET and the TVET College.

Most lecturers mentioned that they adapt teaching styles to different learners depending upon their interests and technology skills. The problem they experience is the lack of data for using technology which shows that lecturers would like to go an extra mile on using technology for teaching circle geometry. At the same time, one participant said that teaching circle geometry enables learners to visualize the problem because they learn and understand better when they see an object they tend to remember. The DHET and a TVET College must provide network access to TVET Colleges.

Lecturers can use technology for assessment, but available resources limit them for this study. Lack or insufficient resources limit the teaching and learning of circle geometry at this particular TVET College. Professional development is recommended for mathematics lecturers to be conducted by the DHET and TVET College for the mathematics lecturers concerning the use of technology to assess circle geometry.

There is no opportunity for the lecturers to use technology for individual assessments for the students. This suggests insufficient time to cover all this work in level 4 during the teaching and learning of circle geometry.

Mathematics lecturers mentioned that they could identify when students had misunderstood the lesson. The lecturers can easily identify the gaps created during the teaching and learning and then fill the gaps to erase the misconceptions created. Professional development is required for the mathematics lectures to close the gap available in using technology to teach circle geometry.

Most of the lecturers showed that they are trying to use technology for classroom organisation, but it is not relevant for circle geometry. When one of the participants stated that no technology is used, there is inequality amongst the TVET lecturers in using technology in circle geometry teaching NCV level 4 students. Relevant technology for circle geometry is recommended to be supplied to mathematics lecturers.

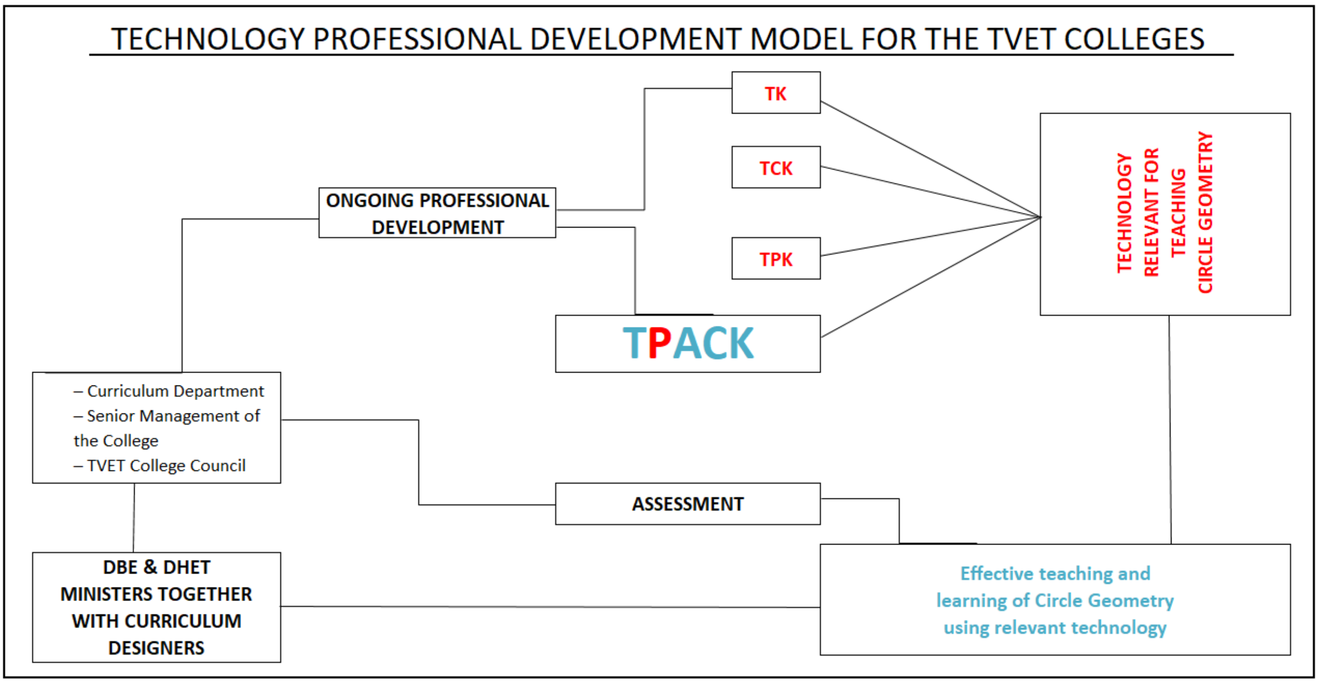
Mathematics lecturers showed that most lecturers could combine mathematics, geometry technologies, and teaching strategies when teaching. This illustrates that the lecturers are well equipped with the necessary skills to teach circle geometry and mathematics. However, there is a lack of technology to be used during teaching and learning as the participants were asking for software to be bought by the TVET College to make learning more practical. A technology relevant to circle geometry is recommended to be supplied to the DHET and the TVET College mathematics lecturers.

There is evidence that inequality exists because some colleges are using technology to teach circle geometry. Interestingly, all colleges were provided with technology to use in teaching. The inequality gap created amongst the TVET Colleges needs to be addressed by the college council, the DHET, and the senior management of the TVET College.

Mathematics lecturers were confronted with many challenges concerning the lack of teaching and lecturing conditions due to security challenges on campuses to enable technology to teach circle geometry at level four in the TVET College. Participant E mentioned that resources like data projectors are stolen. Security is recommended in the TVET College and is to be instilled and monitored by the management of the college, TVET academic staff, students, and the College Council.

The results revealed that mathematics lecturers have content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK). Although there is no technology relevant to teaching circle geometry, mathematics lecturers identify as incompetent in using technology in their circle geometry teaching activities. Mathematics lecturers do not hold technology knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge ((TPK), and technological, pedagogical, and content knowledge (TPACK) **relevant** for circle geometry. Thus, mathematics lecturers are not competent in using technology-specific for circle geometry to teach level four in a TVET College. This suggests that mathematics level 4 students would not be taught effectively using technology relevant for circle geometry. It is recommended that mathematics lecturers be supplied and trained in technology to teach circle geometry level 4 at the TVET College.

6.3 Recommendations shown in figure 6.1



6.4 Explaining the model for circle geometry teaching using technology

TVET Colleges should provide mathematics lecturers with the required opportunity to teach circle geometry level, four students, using technology. The proposed model has suggested the following:

6.4.1 Mathematics lecturers' development of TK, TCK, TPK, TPACK, and ASSESSMENT as the new concept adding to TPACK theory

TPACK has seven components, but through the findings of this study, assessment is added as the eighth component that is important for teaching circle geometry using technology at a TVET College. Lecturers lack technology knowledge and skills in the teaching of circle geometry. The above model is proposed based on the findings obtained while using a qualitative study. Although lecturers have mentioned that they were using certain technologies during their teaching training, it is of no use because the study results showed no technology used specifically for the teaching of circle geometry. This suggested model needs a professional development program that will enable the mathematics lecturers of the TVET colleges to teach circle geometry effectively using technology. Through professional development, necessary skills will be acquired. DeHaven and Wiest (2003) stressed using technology in the teaching and learning of mathematics. Mukiri (2016) discovered that most educators could not use technology to teach mathematics and geometry. The recommended professional development on technology use needs to be a priority to the Basic Education Department. This is the same with this study as the Department of Higher Education needs to prioritise the staff development in the use of technology in the teaching of circle geometry to TVET students.

Based on the findings of the study, the DHET, together with the College Council, should arrange training and development sessions for training the TVET staff through the professional development programmes and mathematics lecturers for level 4 needs. This model will develop lecturers' technology knowledge, content knowledge, technological pedagogical knowledge, and content knowledge and assessment. Based on the training needed for professional development, each lecturer needs to be well equipped with the necessary skills for lesson preparation that can cover technology knowledge, technology content knowledge, technology pedagogical knowledge, technological pedagogical, and content knowledge and assessment while using technology. Lecturers need to design the lessons together when planning where content knowledge and technology knowledge should be prioritised where content knowledge is demonstrated or applied by the students in the world of work at the end of schooling. The content used by the lecturers is in the curriculum documents, which need to be taught in the classroom using technology. Using this model recommends professional development organised by the DHET and college councils where both ministers (DBE and DHET) must intervene through national curriculum planning.

6.4.2 Explaining the recommendations through the professional development model

Mathematics lecturers at the TVET College should create great opportunities for teaching mathematics and circle geometry using technology to lecturers and students. A model is proposed that can enable better learning opportunities is discussed below:

The study has displayed gaps regarding the lecturers' use of technology in circle geometry level 4. Technological knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical and content knowledge are the critical categories that need to be addressed in the mathematics lecturers' development concerning the use of technology in the teaching of circle geometry in level 4 students. All these identified gaps need to be addressed by the TVET College to achieve the institution's mission and vision. There is a need for the DHET to work together with the DBE to design a mathematics curriculum for the FET Phase and NCV Programme. Technologies require to be made available in the TVET College with the help of senior management of the college, the College Council with the help of the Curriculum Department of the college, and the subject specialists. Training needs to be given to mathematics lecturers. Evidence shows that more time is needed to teach and learn circle geometry since it is done for the first and the last time in level 4, the exit level. Using technology to teach circle geometry may make learning faster, easier, and more understandable. Both mathematics lecturers and level 4 students will appreciate the benefit and the significance of using technology in teaching and learning mathematics. Using the proposed model, mathematics lecturers in the TVET College will be able to identify the relevant technology to be used in the teaching of circle geometry through a professional development program provided by the curriculum department and the senior management of the TVET College. Using this model, technological knowledge, technological and content knowledge, technological pedagogical knowledge, and technological pedagogical and content knowledge for the professional development of mathematics lecturers could enrich their teaching skills using technology.

6.5 Recommendations for future research

The findings of the data collected and the suggestions given by the mathematics lecturers had helped the researcher to identify the below-stated recommendations for further research study:

- This research study recommends the same study should be done with a larger sample consisting of mathematics lecturers at the TVET College, including different provinces, to increase the generalisations of the study.
- The use of digital technology is relevant in the learning of circle geometry by the mathematics students at the TVET College.
- A research study should compare three provinces using technology to teach circle geometry.
- The use of digital technology in the learning of mathematics during the Covid-19 pandemic.
- The use of social networks in the teaching and learning circle geometry at the TVET College.
- How mathematics lecturers were teaching mathematics during the pandemic era.
- How TVET lecturers were trained in the use of LSM during a pandemic.

6.6 Limitations of the study

This study is limited to mathematics lecturers in the TVET College lecturing NCV level 4 students. There might be a great possibility of including other mathematics lecturers in TVET Colleges in another province using technology to teach circle geometry. Future studies should also include private and government colleges and lecturers from other learning areas from different provinces within South Africa.

6.7 Conclusion

The findings on the mathematics lecturers' use of technology in the teaching of circle geometry at the TVET college are:

Lack of provision of technology relevant for teaching and learning circle geometry and the lack of working together of the DBE and DHET ministers in the curriculum designing process. This shows that if these two ministers can work together, there will be no problem with the mathematics level syllabus of the scope of learning, especially geometry level 4. Most lecturers are technologically competent, but they do not have relevant technology for teaching circle geometry level 4. Findings also revealed that some colleges do not have the technology to use in the classroom that is vandalised. This showed a lack of security in the TVET College from staff and senior management. This suggests that when relevant technology is introduced for use in circle geometry teaching, professional development needs to be facilitated by all mathematics lecturers. These times demand online learning due to the pandemic that has hit our country and continent. Technology is a must to be used to teach and learn mathematics and circle geometry. To conclude, it is expected that technology should be made available in the teaching and learning of circle geometry at the TVET College to facilitate effective learning.

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SYSTEM: TEACHERS'EXPERIENCES IN THE LIBODE EDUCATION MEGA-DISTRICT. WALTER SISULU UNIVERSITY,

APPENDIX A
QUESTIONNAIRES FOR GEOMETRY LECTURER'S USE OF TECHOLOGY IN THE TEACHING OF GEOMETRY IN NCV MATHEMATICS AT A TVET COLLEGE

PARTICIPANT: ____

SECTION A: BIOGRAPHICAL DATA

CATEGORY	RESPONSE
Language of instruction at College	
Highest qualification	
Number of years teaching	
Number of years teaching mathematics	
Number of years teaching mathematics t level 4	

SECTION B: TECHNOLGY USED

Please indicate in the blocks with a tick (√) which of these technologies do you use as a lecturer to support teaching and learning

TECHNOLOGIES USED	RESPONSE	COMMENT (if any)
WhatsApp		
Active Presenter		
Whiteboard (dry erase)		
Overhead projectors		
Internet video, that is YouTube, etc.		
Digital cameras		
E-mail communication with students for instruction		
Online discussion forums		
Assigning task requiring computers		
Teaching in a computer lab		
PowerPoint presentation		
Blackboard or Wise Up		
Library research		
Internet research		
Personal e-mail		
Other (name it)		

SECTION C: TECHNOLOGICAL KNOWLEDGE

Technology Knowledge

Technological Knowledge (TK)
Technical skills: Do you have the technical skills required to teach a technology-based geometry lesson? If yes, which ones?
Problem solving: Do you know how to solve technical problems with the technology used during geometry lesson? Elaborate
Technology learning: Can you easily learn skills for technology relevant to geometry lessons? If yes, please elaborate
Related technologies: In addition to a using geometry technology, do you have the knowledge and skills about other technologies related to geometry lessons? Elaborate
Updating new technologies: Do you keep updated with various new technologies and try to pick new technologies that may be incorporated in geometry lessons? Elaborate your answer
Content Knowledge (CK)
Geometry
Discipline knowledge: Do you have sufficient knowledge of geometry required for level 4? If yes please, elaborate
Thinking: Can you use a geometry way of thinking while using technology? Please elaborate
Understanding: Which various ways and strategies of developing the understanding of geometry do you have? Elaborate
Pedagogical Knowledge (PK)
Performance assessment: How do you assess student performance with a technology used in the classroom?
Teaching adaptation based on student's understanding: Can you adapt to the teaching style based-upon what students currently understand or do not understand about the lessons using technology? Elaborate
Teaching adaptation based on student's interest and skills: Do you adapt to teaching style to different learners depending upon their interest and skills of technology? Elaborate
Diversity in learning assessment: Are you able to assess student learning in multiple ways using that technology? Elaborate
Familiarity with student misunderstanding: Are you familiar with common student misunderstanding and misconceptions about usage of technology in lessons? Elaborate
Explaining with illustration: How do you explain the abstract geometric concepts through visible illustrations using technology? Elaborate
Class management and organization: How do you organize and maintain classes taught using technology?
Pedagogical Content Knowledge (PCK)
How do you select effective teaching approaches to guide students thinking and learning in geometry in technology focused lessons?
Technological Content Knowledge (TCK)
Which other technologies do you know that you can use for understanding and pursuing geometry?

<u>Technological Pedagogical Knowledge</u> <u>(TPK)</u>
Which criteria did you use to choose technologies that are used for the teaching approaches for geometry lessons?
Mention strategies that you applied to choose technologies that can be used in students' learning for geometry lessons and how did you use them?
Have you thought deeply about how technologies used can influence the teaching approaches that are used in the classroom? elaborate
Are you able to adapt in using technology for different teaching approaches? Elaborate
Are you able to measure/assess the outcomes/impacts of incorporation of technology in the teaching approaches? Elaborate
<u>Technological Pedagogical and Content Knowledge (TPACK)</u>
Combination of knowledge domains: Are you able to teach lessons that appropriately combine mathematics/geometry, technologies and teaching approaches? Elaborate
Determining knowledge requirements: Is it easy to determine the requirements of technological, pedagogical and content knowledge for geometry lessons? elaborate
Self-assessment of knowledge domains: Can you assess the technological, pedagogical and content knowledge for geometry lessons? Elaborate
Self-adjustment of knowledge domains: Can you adjust technological, pedagogical and content knowledge for geometry lessons depending upon situations? Elaborate

APPENDIX B

ONE-ON-ONE SEMI-STRUCTURED INTERVIEW

Introduction

1. Please introduce yourself.
2. For how long have been teaching?
3. For how long have been teaching mathematics?
4. Did you train to be a mathematics teacher? Please elaborate.
5. What is your current position at the College?

Questions on mathematics teaching

6. What teaching strategies do you use in teaching mathematics?
7. Please elaborate on your answer above. (Have these strategies worked? Have they not worked? Why?)
8. What teaching strategies do you use to teach geometry?
9. Please elaborate on your answer above. (Have these strategies worked? Have they not worked? Why?)
10. How did you come to know of these strategies mentioned above? (At College when you training to become a teacher? Alternatively, at workshops? Perhaps through reading?)

Student performance in mathematics?

11. Do you follow the matric results in mathematics? Please elaborate.
12. What are your views on the pass rate in matric mathematics? Why?
13. What do you think are the reasons for the poor results in matric mathematics? Why?
14. Do you think that the mathematics pass rate in mathematics is affected by any particular sections/aspects of mathematics? If so, what are these sections/aspects?

15. How may the matric mathematics results be improved? Please elaborate.
16. Do you think there is a link between teaching strategy and mathematics pass rate in matric? Please elaborate.
17. Is there a link between teaching strategy and geometry results? Please elaborate.

Questions on technology

18. What does technology mean to you?
19. Provide some examples of technology.
20. Did you receive any training in the use of technology for teaching? If so where? What kind of training did you receive? OR
21. Did you teach yourself to use technology?
22. How important is it to use technology in teaching? Please elaborate.
23. What are your views on using technology in mathematics teaching?

Questions on technology and geometry teaching

24. What are your views on using technology in teaching geometry?
25. What resources are available to promote the integration of technology in the teaching of geometry in the college? Which one do you use the most and why?
26. How has technology changed the way you teach geometry? Please include an example.
27. How has technology changed the way your students learn geometry? Please include an example.
28. How has technology changed or broadened the "curricular knowledge" to be gained, learned, or applied? Please include an example.
29. Should it be made compulsory for teachers to use technology in mathematics teaching?
30. Are you familiar with the concepts content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK)? Please elaborate.
31. How important is CK for s teacher? Elaborate.
32. How important is PK for a teacher? Elaborate.

33. How important is TK for a teacher? Elaborate
34. Do you currently feel that you are effectively integrating technology into your geometry classroom and why?
35. Are there any technology barriers that you think exist in the teaching of geometry using technology? What are they and how do you think these can be solved?

APPENDIX C: GATEKEEPER LETTER

higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

DHET 004: APPENDIX 1:

APPLICATION FOR M FOR STUDENTS TO CONDUCT RESEARCH IN PUBLIC COLLEGES

1. APPLICANT INFORMATION

1.1.	**Title (Dr /Mr /Mrs /Ms)**	Mrs	
1.2	**Name and surname**	Rejoice Hlengiwe Mhlungu	
1.3	**Postal address**	P. O. Box 15079 NEWCASTLE 2940	
1.4	**Contact details**	**Tel**	N/A
		Cell	0842083927
		Fax	N/A
		Email	hlengiwer66@gmail.com
1.6	**Field of study**	CURRICULUM STUDIES	
1.7	**Qualification registered for**	*Please tick relevant option:*	
		Doctoral Degree (PhD)	√
		Master's Degree	
		Other (please specify)	

2. DETAILS OF THE STUDY

2.1	Title of the study
	Mathematics Lecturer's use of Technology in Teaching Circle Geometry at a selected Technical and Vocational Education and Training College in Kwazulu-Natal.

2.2	Purpose of the study
	To explore mathematics lecturer's use of Technology in Teaching Circle Geometry at a selected Technical and Vocational Education and Training College in Kwazulu-Natal.

2.2	Purpose of the study
	To explore mathematics lecturer's use of Technology in Teaching Circle Geometry at a selected Technical and Vocational Education and Training College in Kwazulu-Natal.

3. PARTCIPANTS AND TYPE/S OF ACTIVITIES TO BE UNDERTAKEN IN THE COLLEGE

Please indicate the types of research activities you are planning to undertake in the College, as well as the categories of persons who are expected to participate in your study (for example, lecturers, students, College Principals, Deputy Principals, Campus Heads, Support Staff, Heads of Departments), including the number of participants for each activity.			
3.1	Complete questionnaires	Expected participants (e.g. students, lecturers, College Principal)	Number of participants
		a) Attached	**10**
3.2	Participate in individual interviews	Expected participants	Number of participants
		a) Lecturers	**10**
3.3	Participate in focus group discussions/ workshops	Expected participants	Number of participants
		a) N/A	
3.4	Complete standardised tests (e.g. Psychometric Tests)	Expected participants	Number of participants
		a) N/A	**N/A**
3.5	Undertake observations ***Please specify***	**N/A**	**N/A**
3.6	Other ***Please specify***	**N/A**	

4. SUPPORT NEEDED FROM THE COLLEGE

Please indicate the type of support required from the College (Please tick relevant option/s)

Type of support		*Yes*	*No*
4.1	**The College will be required to identify participants and provide their contact details to the researcher.**	**√**	
4.2	**The College will be required to distribute questionnaires/instruments to participants on behalf of the researcher.**		**√**
4.3	**The College will be required to provide official documents.** *Please specify the documents required below*		
	NCV CURRICULUM POLICY **NCV MATHEMATICS SUBJECT GUIDELINE** **NCV MATHEMATICS ASSESSMENT GUIDELINE**		
4.4	**The College will be required to provide data *(only if this data is not available from the DHET).*** *Please specify the data fields required, below*		
	LECTURERS WHO TEACH NCV MATHEMATICS LEVEL 4 AND THEIR CONTACT DETAILS		
4.5	*Other, please specify below*		
	N/A		

5. DOCUMENTS TO BE ATTACHED TO THE APPLICATION

The following 2 (two) documents must be attached as a prerequisite for approval to undertake research in the College	
5.1	**Ethics Clearance Certificate issued by a University Ethics Committee**
5.2	**Research proposal approved by a University**

DECLARATION BY THE APPLICANT

I undertake to use the information that I acquire through my research, in a balanced and a responsible manner. I furthermore take note of, and agree to adhere to the following conditions:

a) **I will schedule my research activities in consultation with the said College/s and participants in order not to interrupt the programme of the said College/s.**

b) **I agree that involvement by participants in my research study is voluntary, and that participants have a right to decline to participate in my research study.**

c) **I will obtain signed consent forms from participants prior to any engagement with them.**

d) **I will obtain written parental consent of students under 18 years of age, if they are expected to participate in my research.**

e) **I will inform participants about the use of recording devices such as tape-recorders and cameras, and participants will be free to reject them if they wish.**

f) **I will honour the right of participants to privacy, anonymity, confidentiality and respect for human dignity at all times. Participants will not be identifiable in any way from the results of my research, unless written consent is obtained otherwise.**

g) **I will not include the names of the said College/s or research participants in my research report, without the written consent of each of the said individuals and/or College/s.**

h) **I will send the draft research report to research participants before finalisation, in order to validate the accuracy of the information in the report.**

i) **I will not use the resources of the said College/s in which I am conducting research (such as stationery, photocopies, faxes, and telephones), for my research study.**

j) **Should I require data for this study, I will first request data directly from the Department of Higher Education and Training. I will request data from the College/s only if the DHET does not have the required data.**

k) **I will include a disclaimer in any report, publication or presentation arising from my research, that the findings and recommendations of the study do not represent the views of the said College/s or the Department of Higher Education and Training.**

l) **I will provide a summary of my research report to the Head of the College/s in which I undertook my research, for information purposes.**

I declare that all statements made in this application are true and accurate. I accept the conditions associated with the granting of approval to conduct research and undertake to abide by them.

SIGNATURE	
DATE	**28/05/2020**

FOR OFFICIAL USE

DHET 004: APPENDIX 1: APPLICATION FORM FOR STUDENTS TO CONDUCT RESEARCH IN PUBLIC COLLEGES

Please tick releVant decision and provide conditions/reasons•where applicable		
Decision		Please tick relevant option below
1	Application approved	×
2	Application approved subject to certain conditions. Specify conditions below	
3	Application not approved. Provide reasons for non-approval below	

NAME OF COLLEGE	MAJUBA TVET COLLEGE
NAME AND SURNAME OF HEAD OF COLLEGE	SANELE MLOTSHWA
SIGNATURE	[redacted]
DATE	[redacted] 12 / 06 / 2020
	MAJUBA TVET COLLEGE CENTRAL OFFICE 1 2 JUN 2020 TEL 034 - 326 4888 PRIVATE BAG X6602 NEWCASTLE 2940

Appendix D

Information Sheet and Consent to Participate in Research

Date: September 2020

Dear Sir/ Madam

My name is Rejoice Hlengiwe Mhlungu from University of KwaZulu-Natal (Edgewood campus) in South Africa. I am a PhD/Doctoral candidate. I am interested in exploring how **mathematics lecturers use technology in teaching circle geometry to level 4 students at a Technical and Vocational Education and Training College.** My email address is hlengiwer66@gmail.com . My contact number is **0842083927** and I reside at Arbor Park in Newcastle. I am gathering information/data from Mathematics lecturers, hence my interest in involving you in my study, exploring using of technology in teaching geometry.

You are being invited to consider participating in this study that involves lecturers' use of technology in the teaching of geometry and purpose of this research is to gain an in depth understanding about the explored phenomenon of lecturers use of technology. The study is expected to enroll **10 participants** of a particular TVET College. It will involve the following procedures: **a questionnaire and interviewing the participants individually,** as acquisition of data. The duration of your participation if you choose to enroll and remain in the study is expected to be **three months.** The study is funded by the University of KwaZulu-Natal.

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 individual interview may last for about 30- 45 minutes.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- There will be no limit on any benefit that the participants may receive as part of their participation in this research project;
- 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 participants are free to withdraw from the research at any time without any negative or undesirable consequences to themselves;
- Real names of the participants will not be used, but pseudonyms (false names) will be used to represent participants' names;
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (**Approval no. HSSREC/00001826/2020**)

In the event of any problems or concerns/questions you may contact the researcher at 0842083927 and email hlengiwer66@gmail.com or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows: Research Office, Westville Campus, Govan Mbeki Building, Private Bag X 54001, Durban , 4000, KwaZulu-Natal, SOUTH AFRICA 04557-, Fax: 27 31 2604609, Email: HSSREC@ukzn.ac.za

You may also feel free at any time to contact my supervisors using the following details:
Main Supervisor: Dr L.R.Maharajh
Tel: 031 260 3829
Email: maharajhlr@ukzn.ac.za

CONSENT

I ____________________________________ have been informed about the study entitled ____by ____

I understand the purpose and procedures of the study.

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

If I have any further questions/concerns or queries related to the study, I understand that I may contact the researcher at ____

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact: ____

Additional consent, where applicable

I hereby provide consent to: (please tick)

Audio-record my individual interview

YES		NO	

____________________ ____________________
Signature of Participant **Date**

____________________ ____________________
Signature of Witness **Date (where applicable)**

APPENDIX E: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

16 September 2020

Ms Rejoice Hlengiwe Mhlungu (216072561)
School Of Education
Edgewood Campus

Dear Ms Mhlungu,

Protocol reference number: HSSREC/00001826/2020
Project title: A case study of Mathematics Lecturers use of Technology in Teaching Circle Geometry at a selected Technical and Vocational Education and Training College in Kwazulu-Natal.
Degree: PhD

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 12 August 2020 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 16 September 2021.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

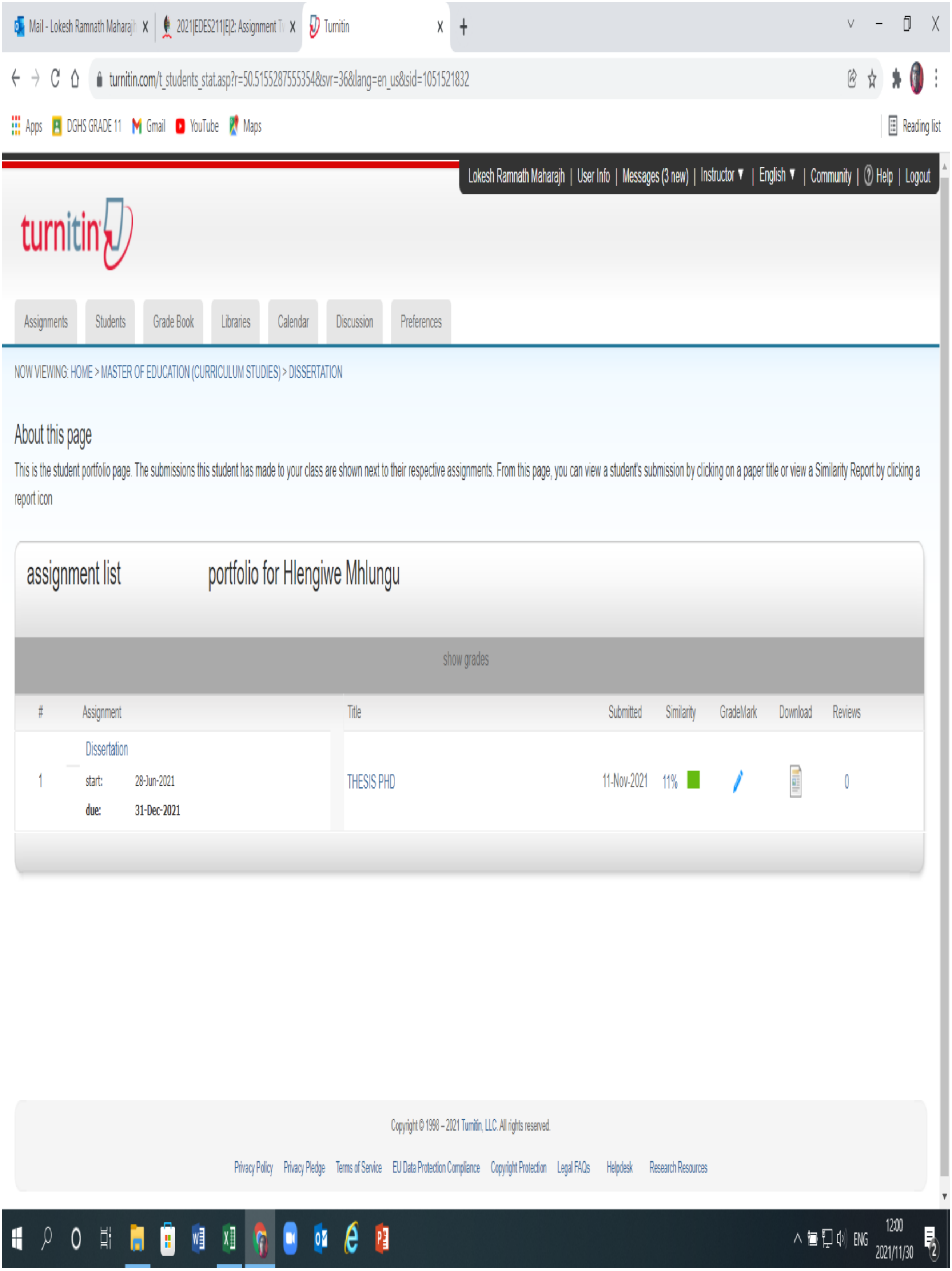
/dd

Humanities & Social Sciences Research Ethics Committee
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Tel: +27 31 260 8350 / 4557 / 3587
Website: http://research.ukzn.ac.za/Research-Ethics/

Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

INSPIRING GREATNESS

APPENDIX F: TURNITIN



APPENDIX G: EDITOR'S CERTIFICATE

Angela Bryan & Associates

6 Martin Crescent
Westville

Date: 01 December 2021

To whom it may concern

This is to certify that the Doctoral Thesis: Mathematics Lecturers' Use of Technology in Teaching Circle Geometry at a Selected Technical and Vocational Education and Training (TVET) College in KwaZulu-Natal written by Hlengiwe Mhlungu has been edited by me for language.

Please contact me should you require any further information.

Kind Regards

Angela Bryan

angelakirbybryan@gmail.com

0832983312