ENHANCING THE TEACHING AND LEARNING OF MATHEMATICAL GEOMETRY AT A TVET COLLEGE USING INDIGENOUS KNOWLEDGE APPROACH

By

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DECLARATION

I, Makhosi Princess Madimabe, declare that this dissertation, *Enhancing the teaching and learning of mathematical geometry at a TVET College using indigenous knowledge approach,* submitted for the qualification of Master in Education at the University of the Free State is my own independent work.

The references utilized throughout the document have been acknowledged and designated by means of complete references.

I further declare that this work has not previously been submitted by me at another university or faculty for the purpose of obtaining a qualification.

……………………………………………… ……………………….

SIGNED DATE

DEDICATION

This study is dedicated to the following significant people in my life: My mother, Nomsa Jane Madimabe, for her unflagging support throughout my life. She gave me life, raised, supported and loved me. My sisters and brother, Mamoya, Matlala and Makgoathi Madimabe for their endless love and encouragement throughout this entire journey. My son, Bokang Nathen Madimabe, for the trust he had in me and last, but not least, my fiancé, Mofokeng VL for his selfless support throughout. “I LOVE YOU GUYS.” Above all, God Almighty, who gave me the strength to try harder even when everything was working against me. “I can do all things through Christ who strengthens me”.

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****

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ABSTRACT

This study aimed at enhancing the teaching and learning of Mathematical Geometry through the integration of indigenous knowledge as an approach. This study defines Mathematical Geometry as a division in Mathematics concerned with shapes, their relationships, their properties and relations of point, lines, surface and the relative arrangement in various parts of the environment that enables students' spatial imagination. Indigenous knowledge is defined as the overall summation of the knowledge, language, and skills which individuals in a precise community retain and which enables them to get the most out of their surroundings.

The literature indicates that Education in South Africa is customized on western values. This has contributed to many students located in the Rural Areas being unable to connect the education they receive at school and their everyday experiences. Consequently, there is a high failure rate amongst Mathematics students, as well as the apparent levels of difficulty in Mathematical Geometry. It is against this background that previous work has attempted to address these challenges, but with less success, hence this study emerged. The study intends to respond to the research question by making use of a Pilot Practical Assessment Task as a means of demonstrating how indigenous knowledge can be integrated into the teaching and learning of Mathematical Geometry through the aid of indigenous teaching aids, in particular bead work.

Furthermore, the study aimed to determine challenges prevailing in the teaching and learning of MG, conducive conditions to the solution and the threats that could hinder the successful implementation of the approach. Critical Emancipatory Research coached the study while Participatory Action Research was used as a Research Methodology for generating data through Focus Group Discussion. The discussions occurred between 10 co-researchers, whereby the co-researchers were selected based on their level of experience in Mathematics using homogeneous sampling technique. It is on the basis of trying to create a link between the Geometry taught in the classroom and the students' everyday life authenticity that the study sought to integrate indigenous knowledge in the practical application of Geometry in the classroom. The empirical data was interpreted using the six steps of thematic analysis, whereby the study revealed that, Mathematical Geometry is indeed a problem in academic institutions. Moreover, lack of resources such as indigenous teaching aids, lack of planning and lesson preparation seemed to be the main contributing factors which consequently lead to abstract presentation of Mathematical Geometry, which gives room for passive learning. In light of the challenges identified, recommendations were that lecturers should be trained to prepare lessons that incorporate indigenous knowledge, use indigenous teaching aids that will vary as per learning style and strive to use a student-centered approach timeously, particularly in contextualizing Mathematical Geometry learning, so that this concept can have relevance and meaning to indigenous students.

Keywords:

Indigenous knowledge (IK), Mathematical Geometry (MG), Critical Emancipatory Research (CER), Participatory Action Research (PAR), Thematic Analysis (TA), Focus Group Discussion (FGD).

LIST OF ABBREVIATIONS AND ACRONYMS

DHET	Department of Higher Education and Training
FET	Further Education and Training
DBE	Department of Basic Education
IK	Indigenous Knowledge
ICT	Information and Communication Technology
MG	Mathematical Geometry
HOD	Head of department
CER	Critical Emancipatory Research
PAR	Participatory Action Research
TA	Thematic Analysis
FGD	Focus Group Discussion
Lolt	Language of teaching and learning
NQF	National Qualification Framework
NCTM	National Council of Teachers of Mathematics
PAT	Practical Assessment Task
SSS	Student Support Services
SWOT	Strengths weaknesses opportunities and threats
TVET	Technical and Vocational Education and Training
NCV	National Certificate (Vocational)
TIMSS	Third International Mathematics and Science Study

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LANGUAGE EDITING

To whom it may concern

Re: Confirmation of Language Editing Service

This is to certify that I, Dr. Moodiela Victor Mathobela (MA Linguistics, PhD) language edited **Ms. Makhosi Princess Madimabe's** Masters (Thesis) entitled:

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GEOMETRY AT A TVET COLLEGE

USING INDIGENOUS KNOWLEDGE APPROACH"

For further enquiries, please feel free to contact me.

I hope you find the above in order.

Kind regards,

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Date: 7 February 2020

CHAPTER ONE

ORIENTATION AND BACKGROUND OF THE STUDY

1.0 INTRODUCTION AND BACKGROUND

This chapter gives the reader the orientation and background of the problems that led to the need for an alternative approach in the teaching and learning of Mathematical Geometry. An overview of the study is outlined by providing a brief description of the theoretical framework, the research question, aim and objectives. Furthermore, the research design and research methodology used in this study are also highlighted. Lastly, this chapter discusses the value of this research, ethical considerations taken into account, as well as the layout of chapters are discussed. All these are discussed to give the reader what motivated me to view the indigenous knowledge approach as the appropriate strategy that can enhance the teaching and learning of Mathematical Geometry at the Technical and Vocational Education and Training (TVET), National Qualification Framework (NQF) level 4.

Literature indicates that the purpose and mission of South African Technical and Vocational Education and Training (TVET) Colleges is to respond to the Human Resource needs of the country for personal, social and economic developments. A transformed high quality, responsive TVET system is an important investment in the future South Africa and all its people (White Paper 4: RSA Doe, 1998a). Since the publication of the White Paper 4, TVET Colleges have been moved from the Further Education and Training to the Higher Education and Training sector, which has created new challenges, which amongst others pertain to the College curriculum and a low throughput rates (Terblanche, 2017:6). According to the Department of Higher Education and Training (RSA DHET, 2010b), the National Certificate Vocational level 2-4 Qualifications currently offered at TVET Colleges are not achieving the Curriculum objectives as envisaged by FET Act of 2006 (RSA Doe, 2006a) and the National Plan for FET (RSA Doe, 2008b). Likewise, Terblanche (2017:6) verifies this by expressing that in the previous decade, National

Certificate Vocational (NCV) has experienced poor certification and retention rate. Consequently, this has tarnished the image of the quality of the programme delivery in the TVET Colleges. This is so because South African TVET Colleges attract a large number of academically under-performing students from the school sector and this contributes to the high failure rate of students enrolled in NCV programme in Subjects such as Mathematics.

The level of difficulty in the NCV curriculum of Mathematical Geometry coupled with abstract teaching prevailing in the Colleges is not in sync with the educational level of the underachieving students (Moleko, 2014:381), hence the study aims at bridging this gap using the indigenous knowledge approach. The current approved funded TVET programme qualification mix by the DHET assumes that these programmes are "one size-fit-all" situation and lose sight of the diverse needs, aptitude and background of the intended students, as they end up being unable to relate the Mathematics they learn in the classroom and their everyday life. Hence, the study sought to enhance the teaching and learning of Mathematical Geometry through the use of indigenous Knowledge approach.

According to Nkopodi and Mosimege (2009:381), education in South Africa has been largely centered on western values. This has consequently led to the circumstance of having students from disadvantaged backgrounds being unable to see the link between the education they receive at school and their everyday experiences, as teaching and learning of Mathematics in TVET Colleges are still subjected to a teacher-centered and textbook-oriented teaching approach (Özerem, 2012:23). Hence, this study sought to use indigenous knowledge as an approach to enhance teaching and learning of mathematical geometry at TVET colleges. Mascarenhas (2004:827) defines indigenous knowledge as the overall sum of the knowledge, language and skills which individuals in a specific geographical area possess and which enables them to get the most out of their natural environment. Mathematical Geometry is a branch in Mathematics concerning to the study of space and relationships between points, lines, surfaces and higher dimensional analogues (Bhagat & Chang, 2015:86). Moloi (2013:124) suggests that African Mathematics practitioners need to take the initiative to integrate the teaching of Mathematics with indigenous cultural morals and values. The findings of this study are likely to build on Moloi's (2014) findings by focusing on Mathematical Geometry at a TVET College, specifically using the Practical Assessment Tasks (PAT) as means of integrating Indigenous Knowledge into the MG curriculum and simultaneously, fostering the culture of student-centered learning through student interaction in the classroom.

For many African learners, European knowledge constitutes a major barrier to education. In some cases, this also applies to the educators (Nkopoli & Mosimege, 2009:377). The challenges experienced by numerous indigenous students in learning mathematical geometry are thought of as a showdown of language differences and the impacts of culture (Moleko, 2014:381). Students find geometrical concepts abstract and difficult to understand, resulting in low performances, thus contributing to the declining interest in geometry (Bhagat & Chang, 2015:86). In concurrence with these authors, I agree that by seeing mathematical geometry as a discipline that represents objective facts, the discourses of teaching and knowledge remain unchallenged. This has led to the unconscious actions of lecturers in Eastern Asia using an abstract teaching approach when teaching indigenous students whose cultures and languages are not integrated with the practice of instruction (Leung, 2001:35). Research shows that students fail to see the need for proof and are unable to distinguish between different forms of mathematical reasoning, such as explanation, argumentation, verification and proof (Jones, 2002:132). According to Chabari (2013:84), studies conducted in New Zealand show that in Alaska, traditional knowledge was not acknowledged in mathematics curricula. Consequently, the following challenges were experienced by lecturers: students not providing reasons when determining angles in the various geometrical shapes; students showing little understanding of the difference between a theorem and its converse due to their inability to visualize geometric shapes; not understanding when to use the theorem and when the converse would apply, consequently resorting to assume information such as perpendicular and parallel lines, whilst not given in the instruction; and students tending to use incorrect geometrical reasoning and confusing theorems as a result of being unable to analyze diagrams correctly, which is also the case in South African curricula, as stated by the DBE (2017:171).

In light of the challenges mentioned above, I am of the view that indigenous knowledge can uphold the teaching and learning of mathematical geometry in multicultural classrooms. Various tribes around the world possess indigenous knowledge that can be integrated into college curricula (Chahine, 2013:02). Such knowledge includes: indigenous music, architecture, mural decorations, and indigenous games, bead-work, weaving and social activities (Chahine, 2013:02). This knowledge can serve as an important tool to bridge the gap in understanding the connection between the mathematical geometry taught in the classroom and students' everyday life (Chabari, 2013:83; Mwakapenda, 2008:190). According to Özerem (2012:32), problems encountered in mathematical geometry are inadequate thinking and reasoning abilities.

The role of the teacher is very crucial to overcome this problem. The teacher should explain to students in detail regarding what they should be careful of in image-based questions. Teaching should be done using visual indigenous teaching aids. To teach mathematical geometry effectively to students of any age or ability, it is important to ensure that students understand the concepts they are learning and the steps that are involved in each proof, instead of students solely learning rules (Gordon & Browne, 2014) and imposing knowledge on students, lecturers should design classrooms and activities in such a way that it will assist students to construct knowledge internally (Mulaudzi, 2016:12). Furthermore, lecturers should provide students with concrete learning materials, such as indigenous teaching aids, assisting them to explore geometrical patterns and to use them in their own ways of understanding and rationalization of angles (Gordon & Browne, 2014). Mulaudzi (2016:12) proposes that there should be continuous interactions between students and lecturers in the classroom in order for students to construct knowledge that makes sense to them and their environment.

There are, however, anticipated coercions that could hinder the successful integration of indigenous knowledge in the teaching and learning of mathematical geometry, such as: poor management of the learning space, students inconsistently focusing on the set objectives, and lack of motivation (Lekhu, 2013:13). In addition, educators experience uncertainty as to what the usage of indigenous knowledge entails, a lack of sufficient sources such as indigenous teaching aids, according to Metzger (2015:6). These coercions can be prevented if lecturers could undergo training on how to design mathematical classroom environments and activities that allow students to interact amongst each other with the aim to understand mathematical geometry knowledge that makes sense to them (Mulaudzi, 2016:12).

Findings from an Australian study reveal that the use of native knowledge proved to be more effective in increasing Mathematics achievement (Chigeza & Whitehouse, 2016:48). Moreover, a study among the Chokwe people in Angola concluded that making connections of the materials learned with the surrounding environment stimulates interest amongst students to learn (Chabari, 2013:83). However, research done by Tarım and Akdeniz (2007:84) in Turkey shows that using indigenous knowledge as compared to that of Western learning has the effect of positively increasing students' attitude towards Mathematics. The above-mentioned studies prove that the use of indigenous knowledge elevates students' self-esteem and eliminates their uncertainties and inhibitions (Arzadon, 2010:13). It is hoped that this pedagogy will support the experiences and the processes used for the teaching and learning of mathematical geometry, and that lecturers and students will authentically explore the integration of hand and mind tools used by indigenous cultures in planning, conceptualizing, visualizing and executing activities as part of their daily lessons (Chahine, 2013:3).

1.1 Problem of the Study

The consulted literature has shown that there are numerous challenges experienced in the teaching and learning of mathematical geometry at the TVET College. Students often fail to develop the visualization and exploration skills vital for geometrical concepts, problem-solving and geometric reasoning (DBE, 2017:171). According to Bhagat and Chang (2015:86), the lack of understanding when learning mathematical geometry comes as a result of abstract teaching which discourages students' interest and consequently, lead to poor performance in the subject area. With this said, this study intends to bridge this gap by incorporating indigenous knowledge in the teaching of Mathematical Geometry.

1.2 Purpose of the study

The purpose of this study is to enhance teaching and learning of mathematical geometry at NQF level 4 at TVET College using the indigenous knowledge approach.

1.3 Research Question

The following comprehensive research question was posed, based on the above discussion and problem statement:

How can indigenous knowledge be used as an approach to enhance the teaching and learning of Mathematical Geometry at NQF level 4 at the TVET College?

1.4 Research Objectives

Based on the aim of this study, the following research objectives have been formulated:

- To determine challenges prevailing in the teaching and learning of Mathematical Geometry which necessitate the integration of IK.
- To determine possible solutions to the identified challenges in the teaching and learning of Mathematical Geometry.

- To identify conditions conducive to the teaching and learning of Mathematical Geometry through the integration of IK.
- To anticipate threats that could evade the successful integration of Indigenous Knowledge in the teaching and learning of Mathematical Geometry.
- To indicate the evidence of success in the teaching and learning of Mathematical Geometry through integrating Indigenous Knowledge approach.

1.5 Theoretical Frameworks

Critical Emancipatory Research (CER) is the paradigm that coached this study. CER is a research paradigm that embodies a perception of knowledge production that can be of benefit to disadvantaged people, such as Mathematics students located in the rural areas of South Africa (Noel, 2016:27). CER maximizes the prospective of those who are minoritized and researched to remain voiceless with its ontological position of empowerment and liberation (Behar-Horenstein & Feng, 2015:46). It assists lecturers in creating inviting academic settings in the classroom that will place students at the center of their learning process, directly involve them and relate the mathematical geometry they learn in the classroom to their environment.

This practice of inquiry necessitated a considerable level of transparency which is in alignment with the methodology used in this study, known as Participatory Action Research (PAR). The incorporation of indigenous knowledge calls for change in the classroom culture, attitudes, beliefs and practices, given that indigenous knowledge is marginalized. Lecturers should be introduced to the concept of emancipatory research during content-related training and workshops that disseminate mathematical geometry in order for them to recognize the impact of their own privilege in their preparation and develop classroom interventions that will be sensitive to the students' backgrounds and cultures (Noel, 2016:27). The said classroom interventions should encourage student participation and motivation, and improve their confidence and academic performance (Hlalele, 2012:275). This pedagogy will assist in bridging the identified gap of understanding the connection between the mathematical geometry taught and learned in the classroom and the students' everyday life (Mwakapenda, 2008:190).

According to Behar-Horenstein and Feng (2015:46), CER relates to the teaching and learning of mathematical geometry by compelling lecturers to become aware of the indigenous knowledge that is taken for granted, which can be used in the classroom to enhance students' assimilation, geometrical analysis and problem-solving skills. The central role of this paradigm is to help lecturers in creating an authentic representation of mathematical geometry, which can catalyze students' cognitive levels of thinking through their learning process. This theory maintains that students should be empowered to be active participants in their various academic settings as opposed to the key assumption that knowledge is only possessed by the 'dominant or lecturers' (Noel, 2016:29).

1.6 Methodology

Participatory Action Research (PAR) was adopted as methodology for this study. According to Caswell (2011:53), PAR is a framework for creating knowledge, where the guiding principle is that the people most affected by an issue are involved directly with the design and process of research on the issue. PAR, thus fitted well with the study because it allowed me as researcher to become immersed in the context of teaching and learning of mathematical geometry, which provided a sense of authenticity, allowing me to generate data accurately. In addition, students were directly involved since their performance in mathematical geometry was under enquiry. This methodology assisted me as researcher to bring the mathematics lecturers, subject experts and NQF level 4 students together in discussions on how the teaching and learning of mathematical geometry can be enhanced through the guidance of Gerald Susman's PAR Model (1983).

PAR embodies a democratic approach to research, which gels well with the emancipatory research paradigm as it permitted the research team to work collectively in the generation of new knowledge to address research problems (Jacobs, 2016:48). The PAR process involves co-researchers in the identification of the issues of concern and with its collaborative elements on how to study the issue in order to raise awareness or develop critical consciousness, to improve the lives of those most affected by the issues by empowering them to work towards social change and to transform underlying societal structures that are inequitable (Caswell, 2011:53). Thus, PAR is a form of knowledge-building inquiry with a focus on democratic empowerment for social change, which combines forms of community building, social activism and critical analysis (Rutman, Hubberstey, Barlow & Brown, 2005:250).

1.7 Data Generation

As a form of generating data, the research team critically engaged in discourses through focus group discussions (FGDs) in a form of meeting, which summed up to a total of six gatherings. The research team consisted of, NQF level 4 students of Campus A, lecturers and Mathematics subject specialists. A focus group discussion is defined as a discussion between small groups of people with common characteristics and/or experiences about a topic guided by a facilitator (Resic, Santic & Cajic, 2016:109). The role of the FGDs was to critically discuss how the teaching and learning of mathematical geometry can be enhanced, what could be the benefits of indigenous knowledge in the communities, how these benefits can be translated into various Mathematics classroom settings and what the indicators of success could be of using indigenous knowledge in a mathematical geometry context.

These discourses were guided by the methodology utilized in this study, PAR, as a form of knowledge-building inquiry which focused on the democratic empowerment for social change that will be brought on by the integration of indigenous knowledge in the Mathematics classroom and/or which aims at combining different forms of community building, social activism and critical analysis in a geometrical context (Rutman et al., 2005:250). The FGDs assisted me in gathering authentic information that will contribute to the improved performance of students in mathematical geometry and by increasing the NQF level 4 certification rate. The FGDs were recorded and transcribed accordingly.

1.8 Selection of the Research Team and Sampling

The research was conducted in the TVET sector of the Department of Higher Education and Training. The research sample constituted of the following: four mathematics lecturers, individually drawn from four different campuses of the TVET College, namely Campus A, B, C and D, based on their level of experience in offering Mathematics; the research team consisted of 10 co-researchers, namely: 2 HODs, 2 Mathematics Lecturers, 1 Former Teacher, 1 Mathematics specialist, 1 Senior lecturer, 1 Mathematics Tutor and 2 Mathematics students.

1.9 Data Analysis

The empirical data generated from the focus group discussions was recorded, transcribed, analyzed and interpreted using Thematic Analysis. Thematic Analysis is an encoding process whereby qualitative information is analyzed. This encoding process is mainly based on categorical "codes". It may range from a list of simplified themes; to a more complex model of themes, depending on which theme gives a comprehensive sense to the study (Braun & Clarke, 2006). Themes may be initially generated inductively from the raw information, such as the objectives of the study or generated deductively from theory and prior research. In this study, Braun and Clarke's six phases of thematic analysis were adopted to make sense of what the study intends to achieve. These steps were also conjoined by Wolcott's (2008) to give meaning to the data description, analysis and interpretation. According to Nowell, Norris, White and Moules (2017:04), these phases are: familiarization of data by the researcher, generation of initial codes throughout the transcript, identification of themes in the transcript, reviewing and evaluation of themes, defining and refining themes and production of the analysis.

According to Nowell, Norris, White and Moules (2017:02), thematic analysis is a decoder of qualitative analysis. It also provides a common ground for researchers who use different qualitative methods to easily communicate their findings and interpretation of meaning to others who are using different methods. According to Coffey and Atkinson (1996:27), the advantage of using thematic analysis is that it gives qualitative information access to facilitate communication with a broad audience of research. It can bring researchers of varying orientations and fields under one umbrella (Denzin & Lincoln, 1994; Miller & Crabtree, 1992). This increased ability to communicate gave a more comprehensive understanding to the aim of this study. It is in connection with the utilization of this method of analysis in combination with the methodology (PAR) of this study that there was an understandable relationship between discourse and power. The recorded discourses and transcriptions were the primary source of data for answering the research question and the set objectives of this study.

1.10 Value of the Proposed Research

The value of this study lies in enhancing the teaching and learning of mathematical geometry at NQF level 4 in TVET colleges through the integration of indigenous knowledge, giving lecturers the opportunity of becoming authentic emancipated facilitators in a Mathematics classroom. This study may help lecturers close the gap that seems to be present between the classroom activities and activities outside the classroom, ensuring that mathematical geometry learned in the classroom is not done in isolation (Mosimege, 2004:462). Additionally, the study may afford students the opportunity to honor diversity and use real-world problems as a means of reflective thinking (Chahine, 2013:8). This study outlines the importance of being an emancipated practitioner through using indigenous knowledge as a way of allowing students to be at the center of their learning journey. This approach will help me to better prepare lessons and assist lecturers to teach, with the desire to promote social justice and liberation (Warburton, 2016:265).

1.11 Ethical considerations

Permission to conduct this study was sought by myself from the Ethics Committee and Committee for the Title Registration (CTR) of the University of the Free State and it was granted. The ethical clearance number of the study is UFS-HSD2019/0040/0207 (**see APPENDIX C**). Department of Higher Education and Training through the office of the Deputy Principal: Academic Affairs of the TVET College was also contacted for permission to conduct the study in this institution (**see APPENDIX F**), and it was granted as well (**see APPENDIX D**). A brief summary, together with an informed consent letter, was provided to the co-researchers regarding the field and type of research to be conducted (**see APPENDIX B)**. The co-researchers were assured of their freedom and confidentiality to participate and their right to withdraw from the study at any point should they wish to do so (McMillan & Schumacher, 2010:250). In addition, the co-researchers were not pressurized and the discourses were fair, free and open throughout.

1.12 Layout of the Chapters

Chapter 1: This chapter provides an overview of the whole study. The problem statement, aim of the study, research design and methodology, ethical considerations, value of the study, as well as the layout of the whole research.

Chapter 2: This chapter highlights the theoretical framework underpinning the study and also focuses on the literature review. The chapter highlights the following: the challenges encountered in the teaching and learning of mathematical geometry, the solutions recommended to address these challenges, the conditions under which the proposed solutions could be implemented, the threats to the successful implementation of the strategy and the success indicators of the successful implementation of the approach.

Chapter 3: This chapter outlines the research methodology and design used to generate the empirical data.

Chapter 4: This chapter is about Data Presentation, Analysis and Interpretation of the findings as gathered in the Focus Group Discussions meetings.

Chapter 5: This chapter discusses the findings, recommendations and conclusion for integrating indigenous knowledge in the teaching and learning of mathematical geometry. The findings are organized in accordance with the objectives of the study. It further presents the findings in the light of the literature review, challenges, and solutions, favourable conditions for the applicability of the strategy, and risks and threats that could potentially threaten its operationalization in relation to the evidence of its applicability.

This chapter also presents the conclusion of the study alongside with recommendations. The recommendations were made in regard to each finding on how students' performance in this concept can be improved through the enhancement of the teaching and learning of Mathematical Geometry at the TVET College.

1.13 CONCLUSION

This chapter provided the background to the study. The purpose of the study was clearly captured in this chapter. Furthermore, the problem statement, aim and research objectives, which were derived to assist in responding to the main comprehensive research questions, were highlighted. The core of this chapter was to highlight the challenges lecturers and students encounter in the teaching and learning of mathematical geometry and this was done with the aim to emphasize the need to indigenize the Mathematics curriculum, particularly the Geometry concept as an attempt to respond to the challenges and thus, enhance the teaching of this Mathematical genre in a Mathematics classroom consisting of indigenous students.

The subsequent chapter focuses on the theoretical framework underpinning this study by discussing its origin, epistemology, benefits and its relevancy to this study. Furthermore, the chapter outlines the literature review by unpacking the singled out objectives with the aim to give the reader a deeper exploration of how the objectives and the aim of this study function together in responding to the research question of the study.

CHAPTER TWO

THEORETICAL FRAMEWORK AND LITERATURE REVIEW FOR ENHANCING TEACHING AND LEARNING OF MATHEMATICAL GEOMETRY AT TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING (TVET) COLLEGE USING THE INDIGENOUS KNOWLEDGE APPROACH

2.0 INTRODUCTION

This chapter reviews the literature about the study, as the study intends to apprehend authenticity in relation to the teaching and learning of Mathematical Geometry. This section presents the operational concepts, theoretical framework steering the study, which is the theoretical framework of Critical Emancipatory Research (CER). Under CER, it starts by tracing it back to its historical origin, giving attention to the ontology, epistemology and rhetoric of CER, as a basis for justifying its use towards the operationalization of the objectives of the study. The researcher reflects on the use of CER, by highlighting the strengths and weaknesses associated with it. This chapter also reviews literature on challenges experienced by unpacking on visualization, attitude, abstract presentation of concepts, omitting reasons when determining angle in the theorems and students being unable to relate the Mathematical Geometry taught in the Classroom to their everyday lives (Environment) and respond to these challenges by outlining the strategies used by other people in trying to solve these challenges thereof. Furthermore, the chapter highlights the conducive conditions, threats, and evidence of success to the implementation of the effected strategies utilized by other researchers. The purpose is to develop constructs that will help the study interpret and make sense of the empirical data gathered in chapter three.

With this said, the subsequent section discusses the definitions of the operational concepts utilized in this study.

2.1 DEFINITION OF OPERATIONAL CONCEPTS (TITLE KEYWORDS)

This section presents the operational definitions of terms used in this study under the following headings: Teaching and Learning, Mathematical Geometry and Indigenous Knowledge to make it understandable to the readers and these terminologies are discussed in as subsections. The following addresses the first subsection, namely, teaching and learning.

2.1.1 Teaching and Learning

According to Carter (2003:3) teaching is defined as a procedure of transcending capability, knowledge and perception to students, such as knowledge and capability having been procured through a routine of experienced and professional training. Neil (2012:4) adds on this by stating that teaching involves professional support and guidance to students who are less proficient or are undergoing the procedures of learning. Teaching in this study is considered as a guiding process, whereby the lecturer facilitates learning, mentors, insight or support students who are undergoing learning. On the other hand, De Houwer (2009:20), characterized learning as a demonstration or procedure of gaining information or abilities and which is done in different structures. Learning is a deeply rooted procedure of transmuting attitude, information, skills, behaviours and experience into knowledge (Cobb, 2009:99). This study, characterizes learning as a cooperative gesture, whereby students learn interactively through hands-on activities and or interfacing with peers and discourses.

In the next subsection, the principal researcher gave the reader a better understanding of the title of this study by unpacking on Mathematical Geometry as a branch in Mathematics.

2.1.2 Mathematical Geometry

In the DoE CAPS report (2011:8), Mathematics is demarcated as a semantic that utilizes symbols and notations for relating numerical, geometric and graphical connections. As indicated by Elaine (2014:1), Mathematics is a form of science that deals with the rationality of shape, quantity, and arrangement, a significant subject through which students acquire different abilities, knowledge, and understanding that will benefit and simplify their everyday life endeavours. Geometry is a branch in Mathematics concerning the study of space and connections between points, lines, surfaces and higher dimensional analogs (Bhagat & Chang, 2015:86). In support of this, Mamali (2015:1) also explains Geometry as a field of Mathematics, which deals with the study of various arrangement of shapes, plane or solid. I concur with Luneta (2014:72) when expressing that geometry is an exploratory field of Mathematics that has links with culture, history, art, and design, and its associations with these indispensable human constructs provide opportunities to make geometry lessons intriguing and stimulating. Mamali (2015:01) further supports these afore referenced authors by stating that Geometry does not begin from formulating definitions and hypotheses. However, it begins from arranging spatial encounters that lead to the plan of definition and hypotheses. I therefore define Mathematical geometry as a division in Mathematics concerned with shapes, their relationships, their properties and relations of point, lines, surface and relative arrangement of various parts of the environment that enables students' spatial imagination.

With the aim to fully define the title of the study, the following subsection addresses the definition of Indigenous Knowledge.

2.1.3 Indigenous Knowledge

As expressed by Loubser (2005:76), the term ‘indigenous' is defined as being similar to ‘traditional', ‘native', ‘vernacular', ‘African', ‘Black', and ‘native American'. Missing author name (2004:827) defines indigenous knowledge as the overall summation of the knowledge, language, and skills which individuals in a particular community possess and which enable them to get the most out of their surroundings. It is knowledge contained by people located in the rural areas, which was passed on from generation to generation grounded by their ancestral lived experiences (Sinclair & Walker, 1999; Phuthego & Chanda, 2004). It is known to be accessible within the local rural communities. Notwithstanding that, there are disparities in its exact definition, depending on the various schools of thought associated and related with various disciplines, such as humanities, agriculture, and the environment. Authors tend to define indigenous knowledge in terms of its association with culture, people's values and their ways of life. Such a definition excludes the fact that it is sometimes produced by incorporating external influence (Briggs, Sharp, Yacoup, Hamrmed & Roe, 2007:243). The segregation of external forces in its generation procedure infers that IK is place-explicit meaning. IK differs from living space to living space, every condition has its very own special structures and types.

The generation of IK is then simply dependent on a given domain, culture or society and other social elements. For example, convictions (Kolawole, 2001:14). Homann and Rischkowsky (2001:7) elaborated this point by stating that indigenous knowledge is a social product that is firmly connected or even compelled, to its cultural and environmental context. Its use and role are not limited by its definition (Agrawal, 1995:5). The term indigenous implies being changing, as it includes influences from external sources by incorporating changing times. However, since the process of IK production is mainly based on what local people can see with their own eyes (Phuthego & Chanda, 2004:67), it is viewed as static and backward, hence this study seeks to refute such views by making use of this rich knowledge by creating truth to be told. The term indigenous in the study has implications of being changing, as it incorporates impacts from outer sources by joining evolving times. In any case, since the procedure of IK generation is for the most part dependent on what neighborhood individuals can witness (Phuthego & Chanda, 2004:67), it is seen as static and in reverse. Consequently, this investigation seeks to eliminate such views by utilizing this rich knowledge by proving clarity for a better understanding of the mathematical concept and also merging the gap that is currently experienced by indigenous students located in the communities.

Section 2.2 validates my choice of Critical Emancipatory Research as a relevant theoretical stand guiding the usage of IK as an approach to enhance the teaching and learning of MG in Mathematics class. I discussed the historical background of CER, its epistemology and ontology, principles and rhetorics, so as to achieve the aim and objectives of this study.

2.2 THEORETICAL FRAMEWORK

Critical Emancipatory Research is adopted to rationalize this study. Critical Emancipatory research advances emancipatory praxis in the participating practitioners; that is, it advances a critical consciousness that exhibits itself in political, as well as practical action to promote change as stated by Grundy (1987:154). There are two goals that a researcher using this approach aims at, one is to increase the closeness between the actual problems encountered by co-researchers in a specific setting, to clarify and resolve the challenges (Mahlomaholo, 2009:225). The second goal, which goes beyond the other three approaches, is to assist co-researchers in identifying and expressing essential issues by raising their collective consciousness (Holter & Schwartz-Barcott, 1993:302).

As indicated by Esau (2013:28) Critical Emancipatory research is a participatory, democratic process concerned with developing concrete knowledge in the pursuit of worthwhile human purposes grounded in a participatory perspective. As Noel (2016:12) stated that CER seeks to bring together action and reflection, hypothesis and practice, in participation with others, in pursuit of practical solutions that can be of benefit to the challenges experienced in the teaching and learning of mathematical geometry. More generally, giving back the drive for indigenous students to do Mathematics with confidence having the indigenous knowledge flourishing in their communities, making sense to them. This type of action research approach seems to suit the study with the aim to empower lecturers and the students that I work with, as well as myself. Walker (1990:61) adds on this, by saying that CER permits 'lecturer's voices and those of their students as accomplices in the research enterprise to be heard as producers of educational knowledge' in a form of co-researchers, as lecturers and students are concerned with changing and improving their practice in the classroom. Yet, in addition, there are inconsistent relations in the more extensive social setting. Here, processes in the College are seen in relation to the macro-environment in which the College is situated. Knowledge is looked at critically in terms of how it is socially constructed and how it thus, shapes and ideally changes reality.

In the subsequent section, I now wish to give the reader clarity on the historical background of CER.

2.2.1. Historical background of CER

Critical Emancipatory Research (CER) is rooted in critical hermeneutics, Neo-Marxist theories, Sociology, Psychology and Education (Habermas & Freire, 1972; Holzkamp, 1983). Critical Emancipatory and Participatory Action Research can be located in Australia, New Zealand, Austria and South Africa through their durable applications and trace (Walker, 1990, Boog, 2003, Hoogwerf, 2002; Kemmis & McTaggartt, 1998; Zuber-Skerritt, 1996). On the other hand, authors such as Kemmis and McTaggert (1988), Zuber-Skerrit (1992), Holter and Schwartz-Barcott (1993) argue that action research originated with Kurt Lewin (1976), an American psychologist. McKernan (1988 as cited in McKernan ,1991) adds to this by stating that CER has advanced over the last century and literature attests to this by indicating that action research is a root derivative of the scientific method, reaching back to the Science in Education movement of the late nineteenth century as a method of inquiry (McKernan, 1991:8).

Numerous conventions are made in linking to the commencements of CER, in any case, researchers concur that it is a part of the basic hypothesis of the Frankfurt School, which emerged in Germany in 1923, and which was created by Jürgen Habermas. Amongst clarifications for the ascent of CER is that of McKernan (2013:423), who believes that critical theory was first hinted at by Emmanuel Kant, a German philosopher, in 1871. Expressed by McLaughlin (1999:109), CER was recovered as a result of a "Marxist research organization established by an affluent child of a German Mr. Weil, who helped the Frankfurt School to make a creative brand of logically situated radical sociology. In spite of contradictions about who presented the thought, CER to a larger extent shadowed the Frankfurt School for Social Research built up in 1923 at the University of Frankfurt. It was crafted by Habermas, who was affected by Marxist point of view on financial and social inquiries (Schmidt, 2007:51). During the mid-1980s, researchers required an increasingly basic, socially-mindful way to deal with frameworks of reasoning and practice (Jackson, 1982; Mingers, 1980).

According to Sinnerbrink (2012:370), it was during this period of Habermas, when CER strained to respond to the historical and social conditions of transforming the existing social structures and replace them with emancipatory ones. Literature revealed that Habermas was able to achieve this transformation "through communication research in analysis of social problems, suggesting changes within the existing social structures" (Hardt, 1993:59). This study seems to be in alignment with Habermas when stating that CER is a theory that seeks to transform society, especially those oppressive and dehumanizing structures of society and curriculum, and interchange them with the ones that emancipate people. In other words, this study seeks to utilize indigenous knowledge that is rich in the communities to transform the lens in which indigenous students located in the rural areas view and perceive MG.

Given the above, I am of the view that Habermas adds an important dimension to CER, where the ultimate goal is an improvement of human conditions. Once emancipation has occurred, it generally follows that the human condition is improved. I engage CER in my study specifically to achieve improvement of the human condition. I am of the view that relevant indigenous knowledge and teaching artifacts should be integrated in the MG curriculum with the intention to improve human lives. IK can be used to close a gap that seems to be existing in the communities, whereby students seem to fail to connect the MG learning in the classroom to their everyday lives.

2.2.2 Epistemology and Ontology of CER

CER centers around the subject of what is the truth. In this hypothesis, the researcher preserves that knowledge is true, in the event that it tends to be transformed into practices that enable and transform the lives of the individuals and that hypothesis is the fundamental device that helps the researcher to discover new certainties, which are reliably improved by relating it to the practices foreseen (Neuman, 1998). In this study, the researcher is genuinely associated with a field where individuals have different substances formed by Social, Political, Cultural, Economic, Race, Ethics, Gender and Disabilities (Mertens, 2010:32). True knowledge in this context lies in the collective meaning-making by the people, through the utilization of focus group discussions, with the objective of group discussions that will consequently improve the lives of the individuals influenced by the recognized difficulties and gap of students being unable to relate the Mathematical geometry taught and learned in the classroom to their everyday lives.

As indicated by Mertens (2009:12), knowledge is developed from the co-researchers' frame of reference. The connection between the researcher and the co-researchers is not dependent on a power hierarchy, but involves a transformation and emancipation of both the co-researchers and researcher. Knowledge is socially built through encounters, organizations, and society (Cohen, Manion & Morrison, 2007:27). This research aims at challenging the deficit thinking and recreate an assortment of information that conveys trust and advances change and social change among the verifiably mistreated, reconstruct a body of knowledge that carries hope and promotes transformation and social change amongst the historically oppressed by utilizing participatory, liberating and transformative research approaches and methodologies that draw from Indigenous Knowledge (IK).

CER dwells into what the researcher believes about the nature of reality and the social realities as defined by the society at large (Horkheimer, 1972:236). Social reality is socially constructed through media, institutions, and society and this tends to influence individuals' social behaviour as it is most often dependent on what is viewed as a dominant in the communities, factors such as fashion, culture, morals, etc. (Cohen, 2007:26). According to Wellmer (2014:706) CER upholds the stand that social reality is historically destined and is continuously changing, depending on factors emanating from various points of view, namely, social, political, cultural and power-based.

The motivation behind why I chose CER is because it clarifies the strength of Western research dominance and the underestimation of information delivered by the different cultures. As indicated by Noel (2016:01), one of the key assumptions in emancipatory research is that there are multiple realities, and that research is not only created by the dominant or elite researcher as opposed to what the Mathematics Curriculum centers around. It contains knowledge that emanates from the Western researchers, yet being disseminated to indigenous students.

2.2.3 Principles of Critical Emancipatory Research in the usage of indigenous knowledge

As indicated by Semeraro (2006:1237), an individual is a complex being that consists of various patterns of thoughts, behaviour, and taste that encode a certain cultural understanding. Each single human being cannot be defined by the social class attachments, but the amount of each kind of principles he or she possesses.

The place of values in which the Critical Emancipatory Researcher draws guidelines as all science must start with a worthy position, despite the fact that a few positions are correct and some are not. They are some set principles, as per the following: the six principles for the conduct of critical field research in this study will help characterize what makes basic analysis distinctive. Though some have scrutinized the practicality and included estimation of basic research (Tsoukas 1993), a key commitment of this study is that it distinguishes characterizing attributes for critical emancipatory research and suggests how it can be conducted. These principles of CER articulate some of the differences between critical and interpretive research concerning prominent critical theorists. Winter (1989:13) likewise gives a comprehensive overview of the six key principles, namely; the Principle of using Core Concepts from Critical Social Theorists, the Principle of Taking a Value Position, the Principle of Revealing and Challenging Prevailing Beliefs and Social Practices (Democracy), the Principle of Individual Emancipation, the Principle of Improvements in Society (Transformation) and the Principle of Improvements in Social Theories (Social Orientated).

The next subsection discusses the first principle of using Core Concepts from Critical Social Theorists in the usage of Indigenous knowledge.

2.2.3.1. The Principle of using Core Concepts from Critical Social Theorists

The first principle marks to some extent departure from pure interpretivism (CecezKecmanovic, 2001b; Kincheloe & McLaren, 2005; Prasad & Caproni, 1997). However, CE researchers comprehend a social theory not as determining how they see the world, but as helping them formulate queries and strategies for exploring it (Kincheloe & McLaren; 2005:306). This principle suggests that critical emancipatory researchers ought to organize their data generation and analysis around the identified objectives, consecutively from one or additional critical social theorists. Examples of this principle are Ngwenyama and Lee's (1997) article, which uses core concepts from Habermas to critique information richness theory amongst many others.

2.2.3.2. The Principle of Taking a Value Position

The second principle expressly acknowledges the importance of taking a value worth position for motivating and grounding a critical research project. According to Cohen, Manion and Morrison (2007:36), critical theorists advocate values such as open democracy, equal opportunity, or discursive ethics. This value position, along with the theoretical concepts of the first principle, provide the foundation for the principles that follow (Semeraro, 2006:1224). Of course, this principle is not meant to imply that positivist or interpretive researchers do not have their values. Between the two critical theorists, Habermas is the most explicit in articulating a value position. Habermas proposes discourse ethics anchored in his theory of communicative action. He argues that the validity of a claim to normative rightness depends upon the mutual understanding achieved by individuals in argument (Habermas 1993; Habermas, 1992). According to Bourdieu (1977:67), symbolic violence is the imposition of categories of thought and perception upon dominated social agents who then not only take the social order for granted, but also consider it to be just. Applying this idea to education, Bourdieu was critical of the unfair class structures which limit social mobility in France (Bourdieu 1977, 1990). In my view, these authors have focused their arguments based on their values and their secular Westernization.

However, there are other possible value positions for a critical research project such as indigenous knowledge, students' backgrounds and experiences that are not in their perceptions. According to Winter (1989:13), regardless of the researchers' value position, all critical researchers do not take their values for granted, but subject these to critical analysis. This principle recognizes values and culture as important objects of inquiry, the comparison of competing for value sets and with this, the determination of a defensible ethical stance in matters of social orientation. This principle in critical emancipatory research will examine how ethics may be effectively integrated into the methodology employed (Adam, 2005:69).

2.2.3.3. The Principle of Revealing and Challenging Prevailing Beliefs and Social Practices (Democracy)

This principle builds on the challenging prevailing assumptions, beliefs, values, and practices which seem to have suppressed IK, with the aim to reconstruct and put this valuable information which could be of benefit to the current generation to good use. Winter (1998:294) stipulates that this principle is particularly important for CE researchers because the concept of Mathematical Geometry, is thought off as Eurocentric concept that does not reflect any connection between the mathematical geometry taught and learned in the classroom and their students' everyday life, most specifically for students located in the rural areas (Mwakapenda, 2008:190). The principle analyzes the relations or forces determining what counts as knowledge and who their legitimate uses are (Winter, 1989:13). Critical pedigree expresses knowledge in two ways: how knowledge is power oriented through "establishments of the truth," and how knowledge can be used as a component of power. This principle thus escorts attention to the multifaceted relationships between human interests, knowledge, power, and forms of collective mechanisms at various levels in human society, and how they interact to bring about change (Mahon, 1992).

2.2.3.4 The Principle of Individual Emancipation

The fourth principle is the first of three relating to the transformative element of a critical research project. The fundamental notion of human emancipation in critical theory arises from Winter's (1983:3) definition that human education comprises intelligent autonomously, undictated by external authority, which entails the elements of Participatory Action Research (PAR). More recently, Alvesson and Wilmott (1992) projected the following criteria for critical research to be emancipatory. Critical emancipatory research must:

1. Be apprehensive of how human existence should facilitate the realization of human needs and the necessary conditions which will enhance human potential thereof.

2. Encourage the notion of critical self-reflection and associated self-transformation. This is supported by Ulrich's (1983:260) principle that social design should not only be goal driven in isolation, but there should be a plan in place, from beginning to end and this plan should also entail how the elements of emancipation will be reflected as change for those affected.

3. By all means, be thoughtful to a broader set of influential issues relating particularly to social justice, due process and human freedom (Alvesson & Willmott, 1992:434). The principle of emancipation requires that the researcher should always take the aspects such as human conditions into consideration in each research. As in some potential cases, research may be unjust or harmful or at least unfair for some subgroup. The critical researcher thus has the important analytical task of recognizing prospects for modification, both in their physical and social situations (Brocklesby & Cummings, 1996:742).

With all this being said, it is therefore crucial that the Critical Researcher be alert at all times as a distinct inaccuracy can cause harm and affect the research process in totality.

2.2.3.5. The Principle of Improvements in Society (Transformation)

Building on the previous principles, this principle suggests that improvements may be possible, not just at an individual level, but in society as a whole. It can be argued that one of the purposes of social theory is to suggest improvements to organizations, institutions, and society. Critical theorists have argued that improvements at all levels must go hand in hand because their success is contingent on each other. This principle thus suggests that the critique of social conditions or practices should not only lead to better understanding (enlightenment), but that it should also lead to improvements in social practices and society as a whole. However, the direction of the improvement must emerge from internal, self-formative governing processes, in which critical theorists must not be given any special powers of authority. This principle has been developed the most by Habermas and other critical theorists of the Frankfurt School. The concept of emancipation they developed describes the process through which individuals and groups become freed from repressive social and ideological conditions, in particular, those that place socially unnecessary restrictions upon the development and articulation of human consciousness (Alvesson & Willmott 1992:432). However, this principle is not limited to just one particular type of critical research. Bleicher (1980:233) says that critical hermeneutics is also "directed at the future and at changing reality rather than merely interpreting it." Likewise, some of Bourdieu's work was directed at improving opportunities for higher education in France (Harker, 1990).

2.2.3.6 The Principle of Improvements in Social Theories (Social Orientated)

This principle is concerned with the growth and improvement of theoretical knowledge. It advocates that critical researchers should establish their data generation and analyze with reference to essential concepts established by critical social theorists. This does not mean that these concepts should remain unchallenged or that new ones might not emerge (Adam, 2005:74). Rather, co-researchers should be subjected to change. Hence, all critical theorists assume that our social theories and concepts have changed over time and will continue to do so (Watson & Wat, 2011:73). This last principle suggests that critical researchers should be willing to subject their research project to self-critique to change challenges experienced in the communities for the better. This principle is supported by Nkoane (2015:99) when stating that, critical research needs not only study and understand society, but rather to evaluate and transform the society.

2.2.4 Rhetoric of CER to this study

The role of CER is to unmask the potential that is hidden by various misrepresentations of reality. One fundamental role of CER is to make meaning of the world, to a large extent, unconsciously or consciously built up from the language habits in the communities. Reality is, for one to make sense of the world around, one makes use of label that makes sense and has relevant meaning to their environment (Mahlomaholo, 2009:228). This implies that, as people are individuals and unique, each person's point of view is dependent on the way of seeing and doing things. In this research, my stance is that discourses will play a pivotal role based on the co-researchers' respective experiences, informed by their diverse social, political and cultural backgrounds. According to Ivey (1986:12), everyone is consciously or unconsciously knowledgeable of certain approaches of elucidation, even while that individual believes that s/he is neutral, no individual seems to be free to describe the world with absolute impartiality. When conducting research located within CER, a researcher must take into account subjectivities co-researchers bring into the discussions. The discussions could result in multiple subjectivities, and the individual owning them could decide which one s/he will have sanction on, either by the language used in the discourses or by the elements of CER, such as humanity, equity, social justice, liberation and empowerment (Alsup, 2006).

According to Esau (2012:35), critical emancipatory research engages co-researchers in the challenges with the aim to establish rational, impartial, democratic and fulfilling forms of education. All in all, it is an empowering process for co-researchers. It is 'activist' in that it involves co-researchers in taking action based on their critical and self-critical reflection, but it is judicious in that it creates change at the rate at which it is justified by reflection and practicable for the co-researchers in the process. Emancipatory research methods inherently appreciate that knowledge of others is dependent upon knowledge of self (Linda, Ber-Horenstein & Xiaoying, 2015:54). Co-researchers will be involved in identifying the problem, defining the problem, generating and analyzing the data, disseminating the findings through the aid of Participatory Action Research, which is adopted as the methodology in this study (Kawulich, 2012:13).

Words of co-researchers provide an insight into their experience of the world. It is through the confrontations of co-researchers that a researcher creates a 'space of authoring' (Nkoane, 2015:101) and leaves traces of discourses, positioning, and identities. When co-researchers share their personal practices, they make themselves, an objective for another and oneself. According to Pais, Fernades, Matos and Alves, (2007:5), Mathematics education has the purpose of helping lecturers and students to discover the Mathematics behind the more diverse situations, promoting the education of participative, critical and confident citizens. Emancipatory research is not only on how to empower people, but once people have decided to empower themselves, it then facilitates the process further. Oliver (1992:111) emphasizes this by stating that researchers have to learn how to put their knowledge and skills at the disposal of their research focuses. This then mean that social relations of research invention have to be changed, the researcher should view the world through the lens of the respective co-researchers.

2.2.5 Reflection on the use of CER

In this section, the researcher reflects on the use of CER, by highlighting the positives/strengths and weaknesses associated with the CER framework in research.

2.2.5.1 Strengths of CER

CER is an ideal framework in the sense that it attempts to stimulate social justice throughout the research process. It is permeable to this research as it guides the important and effective ways of creating conditions under which the distorted consciousness can be challenged and the refinement of positive academic identity be achieved (Mahlomaholo, 2009:224). Nkoane (2010:113) states that CER provides a much-needed change in the world of an unjust society. It conceptualizes the idea that power may be exercised by some and by total systems to control not only the actions, desires, goals, perceptions, behavioural dispositions and individual power of others, but to control their paradigms and epistemologies as well (Dube, 2016:49). In essence, this framework is critical in that it provides praxis and ideas on how socially oppressive structures must be challenged to enhance democratic participation. In the case of my study, the strength of CER will be a positive contribution to the challenges experienced by the co-researchers with the hope to bring back the drive of students to do Mathematics with enthusiasm and the identified gap of the relevancy of mathematical geometry to the students' daily lives could be bridged. This study seeks to bring about the desired empowerment for people whose cultural knowledge and background are vanishing. Through emancipation, students' belief that Mathematical Geometry is difficult and does not have a contribution or relation with their everyday lives can be eliminated.

With all these being said, the following subsection discusses the weakness of CER when utilized as a theoretical framework of a study.

2.2.5.2 Weakness of CER in research

According to Dube (2016:49), every theory has weaknesses associated with it, thus this section grounds readers on the drawbacks of using CER. Firstly, by nature, CER poses a threat to society because of its emphasis on a radical change of oppressive societal structures. The theory "is a dangerous activity for the ruling class in that it could lead to members of the subaltern classes as well as critical theoreticians to understand that a free and rationally self-organized mode of socialization had become possible" (Demirovic, 2013:2).CER often labels participants as belonging to a particular marginalized group; therefore, homogeneous notions of identity are superimposed (Scotland, 2012:14).

I am in agreement with Dube (2016:49) when stating that the major weakness of the theory is that people are identified as disadvantaged in society. It becomes hard to see how the theory relates to the students and or members of the community who are already advantaged. It is easy to separate what disadvantaged students from rural areas can get from the use of CER. Likewise, it is complex to similarly identify for students located in the cities and urban Areas. Despite the weaknesses cited, CER is a framework relevant to my study as discussed in the subsequent section.

2.2.5.3 Relevance of CER to this study

Critical Emancipatory Research centers around the view that reality is molded by culture, politics, economics, race, gender, ethnicity, and disability. Values and beliefs are considered to be important, notwithstanding that they diverge from one culture to culture (Kawulich, 2012:18). On the other hand, indigenous knowledge accentuates that reality is socially constructed and immerses to multiple realities, based on the associations humans have with each other and the world around them. Values of mutuality, respect and demonstration are accentuated.

Knowledge is regarded from individuals' diverse backgrounds' drawn from indigenous knowledge systems. In this research, the researcher and the co-researchers come together to identify potential problems, their underlying causes and possible interventions experienced in Mathematical geometry (Holter et al., 1993:301). The problem will be redefined after discourses with the researcher and the co-researchers and a mutual understanding is reached. Participatory action research seeks to improve practice through the application of the personal wisdom of the co-researchers (Grundy, 1982:357). CER has an agenda to critique and challenge, to transform and empower; it is geared towards social justice and enhances the principles of democracy.

CER's purpose is to challenge the relations of the dominance of western knowledge that has taken its tall in process of teaching and learning and emphasis on taking a phenomenon shift of incorporating indigenous knowledge in the teaching and learning of mathematical geometry (Eisenhart, 1991:39). CER is relevant to this study because it provides a theoretical basis for a view of planning that emphasizes on sharing of information amongst the co-researchers reaching consensus through dialogues in focus groups to improve relations, rather than an exercise of power domination (Dube & Hlalele, 2018:77). Regarding this, Walker (1990:61), says that emancipatory action research allows "lecturers' voices and those of their students as partners in the research initiative to be heard as producers of educational knowledge". Lecturers and students are not only concerned with changing and improving their practice in the classroom, but also with changing unequal relations in the wider social context.

2.3 RELATED LITERATURE

2.3.0 INTRODUCTION

This section presents the literature review for this study. It was done to fulfill the objective of the study. That is, it reviews the challenges prevailing in the teaching and learning of mathematical geometry, the strategies to respond to the challenges, conducive conditions, the threats and risk facing the implementation of the strategies and the evidence of success envisaged afterward.

2.3.1 Challenges prevailing in the teaching and learning of MG

Learning Geometry has been identified as an area of Mathematics that poses various problems for many students as they neglect to build up a satisfactory comprehension of geometrical ideas, and to exhibit thinking and critical thinking aptitudes (Mamali, 2015:1). Binti, Tay and Lian (2003:168) acknowledged problems of teaching and learning Geometry as a visualization amongst others. Mamali (2015:23) adds by stating that students have a negative frame of mind towards the geometry. Therefore, they wind up blending circles and lines and experience nervousness when expected to prove theorems.

A large portion of the studies center on the connection between students', Mathematics accomplishment and students' attitudes towards Mathematics. In Turkey, Aksu (1991:185) focused on the effects of students' attitudes towards Mathematics and it was reported that the teachers' attitude towards Geometry affects students' attitudes. As indicated by Nkopodi and Mosimege (2009:381), education in South Africa has been founded essentially on western qualities. This has contributed to the circumstance of having students from disadvantaged backgrounds being unable to see the association between the education they receive at school and their regular encounters on their everyday experiences as the teaching and learning of mathematical geometry in TVET Colleges is still dominated by teacher-centered and textbook oriented approach (Özerem, 2012:23). Teachers tend to introduce students to mathematical geometry facts and then drill them on concepts through deductive reasoning. Consequently, learners are seldom allowed to discover and conceptualize this concept and make it their own (Mullis, 2000:1).

For many African students, European knowledge constitutes a major barrier to education; in some cases, this also applies to educators. Moleko (2014:381) recognized the troubles experienced by numerous indigenous students in learning mathematical geometry are thought of as an argument of language contrasts and the ramifications of culture. Students find geometrical concepts abstract and difficult to understand. Students find geometrical ideas theoretical and hard to get it. This results in poor performance, which contributes to the declining interest in geometry (Bhagat & Chang, 2015:86). Amongst the challenges experienced are: Visualization, Attitude, Abstract presentation of concepts, omitting reasons when determining the angle in the theorems and students being unable to relate the Mathematical Geometry taught in the Classroom to everyday lives (Environment).

In the following subsection these challenges were addressed in terms of subsections and the initial challenge dealt with was visualization.

2.3.1.1 Visualization

Geometry learning, one of the cognitive levels related to it is the capacity to visualize. Numerous concepts in Geometry require students' capabilities to visually distinguish objects and identify their properties by contrasting them with their past encounters involving similar objects. These geometrical concepts additionally require visual elucidations; as many Geometry problems emanate from analysis and interpretation. Consequently, students who are unable to extract geometric information about three-dimensional solid objects drawn on paper will have some challenges in interpreting questions involving solid Geometric shapes. Some Mathematics lecturers suggest progressively recommend more visual activities in the classroom to enable students to comprehend geometric concepts (Guzman, 2008:5).

The subsequent subsection addresses the second challenge, namely, Attitude.

2.3.1.2 Attitude

The findings in the USA demonstrate that one of the most significant factors in developing students' Geometry capacity is the frame of mind (Attitude) of the lecturers towards teaching this concept and the students' belief in perceiving Mathematical geometry as Complex and difficult (Mamali,2015:26). He further stated that the discovery made was that students who have positive attitudes towards the concepts taught in the classroom have high achievement levels. Fennema and Romberg (1999:1) state that it is not only the students' beliefs about the levels of difficulty in mathematical geometry, but also the lecturers. Additionally, the lecturers' uncertainty of the students' capacity to do Geometry have an effect on how they teach and along these lines, on how students adapt. As indicated by Mamali (2015:24) there was a study conducted in Turkey by Bayram (2004:46) who established that teachers at lower grade levels from (Primary schools to Intermediates schools) tend to have less favourable attitudes towards Mathematics than high school Mathematics teachers. My experience in the teaching and learning of Mathematics has generally led me to be in agreement with these authors (Bayram, 2004; Mamali, 2015 & Fennema & Romberg, 1999) when arguing that, students tend to form lasting attitudes towards Mathematics during their middle school years. It is essential that their teachers strive to enforce a positive attitude towards Mathematics from a very early age.

2.3.1.3 Abstract presentation of concepts

By considering mathematical geometry as a discipline that represents objective facts, the discourses of teaching and knowledge remain unchallenged. This leads to prompting the oblivious activities of lecturers in Eastern Asia, utilizing an abstract teaching approach when teaching indigenous students, whose cultures and languages are not integrated within the practice of instruction (Leung, 2001:35). According to Appiahene, Opoku, Akweittey, Adoba and Kwarteng (2014:363) studies in Ghana have demonstrated that even teachers who have an in-depth knowledge of mathematical Geometry cannot integrate it in their teaching as they need fundamental aptitudes and basic skills of teaching this content. As a result of being unable to incorporate new developments and they resort to abstract teaching. Jones (2002:132) states that inquiries show that students cannot recognize various types and are unable to distinguish between different forms of mathematical reasoning, such as explanation, argument, verification, and proof. Chinn (2016:53) attests to this by highlighting that the problems in Mathematics are world-wide and are often subjected to deep entrenched beliefs, all children can rote learn, but need to comprehend what they have learned and this fills in as proof that there is a range of challenges in learning Maths, because of the heterogeneity of students and constellation of skills that Mathematics requires of these students.

Research demonstrates that there is contrast between the Geometry students know, their involvement in the classrooms, their critical thinking, problem solving, and discovery concerning what students learn in the classroom, but have not yet experienced tendency to mislead students into regarding classroom Mathematics as recalling equations and conditions without knowing the guidelines required (Klemm, 2007:3). Mamali (2015:28) states that ‘teaching for reasonable comprehension and conceptual understanding is difficult. Instead, lecturers in general, tend to give students mainly what they think is important for their examinations at the end of the year. According to Tay and Mensah-Wonkyi (2018:9), students' deficiency of interest and understanding of Geometry comes as a result of the lecturers' poor teaching skills and shortage of resources for presenting geometrical shapes to students. This condition produces students who can calculate but cannot solve everyday life problems that involve such concepts and mathematical skills (Dlamini,2017:211). According to Kutluca (2013:1513), it was evident in the West African Senior Secondary Certificate Examination (WASSCE) and international examinations and the Trends in International Mathematics and Science Study, [TIMSS] that Ghanaian students were unable to be competent in higher-order thinking geometric problems and consequently performed poorly in mathematics. The author elaborated by indicating that

Ghanaian students scored zero in advance and higher-level thinking in the content domains tested specifically in Geometry.

Likewise, research done in South Africa shows that students fail to make a discrepancy between the Geometry they know and experience in the classrooms and abstract geometry, the discipline of creativity, problem-solving, and discovery, about which they are told, but have not yet experienced (Klemm, 2007:3). I, therefore, deduce to these studies by observing that abstract routine of teaching makes students passive listeners, and deficient in geometrical analysis and reasoning. This approach to teaching and learning Geometry places more accentuation on how much a student can recall and less on how well the student can contemplate and reason, and it makes the teacher dictate the classroom and turns students to mere listeners (Department of Basic Education 2011).

The next subsection proceeds with the discussion by addressing the omission of geometric reasoning by students when determining angles in given geometric theorems.

2.3.1.4 Omitting reasons when determining the angle in the theorems

According to Kaino (2013:84), studies done in New Zealand demonstrated that in Alaska, traditional knowledge was not utilized or acknowledged in Mathematics curricula. Consequently, challenges experienced by lecturers were: students omitting reasons when determining angles in the various geometrical shapes, students showing minimum understanding of the difference between a theorem and its converse. Students not understanding when to use the theorem and when the converse would apply, consequently they tend to assume information such as perpendicular if not parallel lines, whist not given in the instruction. Students tend to use incorrect geometrical reasoning and confuse theorems, which is a result of being unable to analyze diagrams correctly, which is the case in South African curricula as stated in NCS (2017:171). Through consulting a number of literature, it has come to my attention that students cannot link correct mathematical reasoning to angles provided in questioning. If some do find the correct angles, they tend not to provide the relevant mathematical reasoning required, such as Supplementary angle, angle on a straight line, Corresponding angle , Angles subtended on the same Arc, angle subtended by Diameter and so forth; due to them being unable to explore their knowledge and understand to make connections between knowledge, concepts, and skills in the altered facets of geometry.

The next section acknowledges the inability of students to relate the MG taught in the classroom to their everyday lives as a challenge that contributes to the performance of students in the teaching and learning of MG.

2.3.1.5 Relating the Mathematical Geometry taught in the Classroom to students' everyday lives (Environment).

To impart mathematical geometry effectively to students of any age or ability, it is important to ensure that students understand the concepts they are learning and the steps that are involved in each proof, rather than students solely learning rules (Gordon & Browne:2014). More effective teaching approaches encourage students to recognize connections between different ways of representing indigenous knowledge and geometric mathematics (Jones, 2002:133). According to Deppe, Sonderegger, Stice, Clark and Streuling (1991:257) one of the problems encountered in the developed countries that were being addressed were that students do not explore the conceptual foundation and real-world relevance of Geometry information taught in the classrooms and they result in students experiencing high failure rates in Mathematics, as they are unable to relate to their environment to application of Mathematics, in particular geometry in their day-to-day living. According to Tsanwani (2009:23) blacks in the United States of America underachieved greatly in geometry and blamed their achievements on cultural-related factors as they were unable to see the usefulness of Geometry to their lives, both in the present and in the future. Likewise, ln South Africa, learners' performance in Mathematics is generally under expectation, even though students are considered to have passed Mathematics if they obtain 30% and this poor performance in Mathematics does not occur only in high schools or the Further Education and Training (FET) band, but it is dominant even in the General Education and Training (GET) band as well (Dlamini, 2017:20).

2.3.2 Strategies Responding to Challenges Identified

It is believed that indigenous knowledge can promote the teaching and learning of mathematical geometry in multicultural classrooms. In various tribes around the world, there exist indigenous knowledge that can be integrated into College curricula (Chained, 2013:02). The knowledge experienced in the traditional environments can serve as an important tool to bridge the gap of understanding the connection between the mathematical geometry taught in the classroom and their everyday life (Kaino, 2013:83; Mwakapenda, 2008:190). Such knowledge includes indigenous music, architecture, mural decorations, indigenous games, beadwork, weaving and social activities (Chahine, 2013:2). According to Özerem (2012:32), the major problems in mathematical geometry are inadequate thinking and reasoning abilities amongst others mentioned above. The under-listed are therefore the strategies that respond to the above-mentioned challenges of Visualization, Attitude, Abstract presentation of concepts, Omitting reasons when determining the angle in the theorems and students being unable to relate the Mathematical Geometry taught in the Classroom to everyday lives.

2.3.2.1 Visualization

Mathematical geometry would be taught at ease if geometry lessons could be carried out using hands-on activities (Chahine, 2013:12). By being able to "touch-see-and-do" and interacting with the objects in their learning, students can learn geometry more imaginatively and successfully (Tay, 2003:1). The National Council of Teachers of Mathematics has developed a stand statement, which provides a framework for the use of technology in Mathematical geometry teaching and learning (Mamali, 2015:14). The NCTM statement endorsed technology as a crucial tool for effective Mathematics learning to eliminate the challenge of visualization. Using technology appropriately can shelter both the scope of content and range of problem situations available to students'. NCTM recommended that students and teachers should have access to a diversity of instructional technology tools, teachers should be provided with appropriate professional development, the use of instructional technology was integrated across all curricula and courses, and that teachers made informed decisions about the use of technology in

Mathematics instruction (Johnson, 2000:1). Acknowledging and responding to learning in terms of visualization by students is a critical component of effective inquiry-oriented standards-based geometric instruction. Using technology appropriately can extend both the scope of content and range of problem situations available to learners'. According to Mamali (2015:36), the framework for utilizing technology in Mathematics teaching and learning was provided by the National Council of Teachers of Mathematics (NCTM). It also recommended that learners and teachers have access to a variety of instructional technology tools, teachers must be provided with appropriate professional development, the use of instructional technology be integrated across all curricula and courses at the Colleges, and that lecturers make informed decisions about the use of technology in the teaching and learning of Mathematical geometry to address the challenge of visualization of the set shapes and dimensions (Johnson, 2000:1).

2.3.2.2 Attitude

Findings from the Third International Mathematics and Science Study (TIMSS) (2002-2011) showed that many teachers in the United States and Canada focused more on the strategies and techniques used by Japanese teachers in teaching Geometry. TIMSS results acknowledged the improved performance of learners in Mathematics as a consequence of a deeper mathematical thinking by the Japanese learners. Japanese Mathematics teachers made use of a lesson study strategy, whereby a group of teachers developed an instructional approach of observing, analyzing and revising lesson plans that focus on the same objectives. After the teachers made use of the respective lesson topics, they observed the lesson using a common check list, discussed the lesson outcomes, they revised each lesson and documented the findings. Johnson (2000:1) also supported these findings by adding that a significant constituent of the Lesson Study process is that it supports the facilitation of teachers to work together to improve their interconnecting skills across grades.

2.3.2.3 Abstract presentation of concepts

One credible realistic instructional approach known as GeoGebra as opposed to the dominance of traditional methods in Mathematics instruction assisted Ghanarian students who had learning difficulties in Circle Theorems. According to Kutluca’s (2013:1514) study, GeoGebra instruction that was employed in the tentative group was a better approach that increased the Van Hiele geometry thinking levels of students, as opposed to the traditional approach of teaching geometric circles. He indicated that GeoGebra assisted students in producing their geometric shapes, testing and constructing their knowledge. GeoGebra, as both a learning and teaching instrument, also assisted teachers to modify their classrooms to an exploratory environment, whereby students were actively involved in the teaching process. More so, Jones (2002:133), emphasized that students be exposed to this instructional tool, were able to find geometry simplified, as it prompted peer interactions and students scuffled each other as a collective to understand geometry better. It is obvious from Kutluca's (2013:1514) study that a full utilization of GeoGebra in the classroom, will improve the teaching and learning of mathematical geometry. To teach mathematical geometry effectively to students of any age or ability, it is important to ensure that students understand the concepts they are learning and the steps that are involved in each proof, rather than students solely learning rules and through the aid of GeoGebra, this was easily attained (Gordon & Browne, 2014).

2.3.2.4 Omitting reasons when determining the angle in the theorems

A trace back of Geometry education revealed that in the previous years, traditional teaching methods were the only teaching methods utilized, hence the emergence of technology on curriculum as a new approach to the scientific study of how Geometry is learned, came as an alternative. According to Mamali (2015:37), essential to the reform effort was a standards-based approach to the "what and how" of Geometric teaching. Within the modern Mathematics approach, the emphasis was on problem-solving, geometrical reasoning, justifying ideas, making sense of complex circumstances and independently advocating new ideas. Students must be given prospects to solve complex problems, define and test Geometrical ideas in Mathematics and draw conclusions. I share the same sentiments with Battista (1999:80) when stating that learners must be able to peruse, compose and examine geometrical concepts in Mathematics, utilize demonstrations, drawings, and real-world objects, be given the opportunity to participate in formal geometrical and consistent contentions.

The driving force behind this standards-based approach to Geometry of instruction has been the measures created by the National Board of Instructors of Arithmetic (NCTM); to help, all students to have an opportunity to memorize and have the capacity to be competent in arithmetic (Dlamini, 2017:14). This implies that instructors ought to be careful of a child's environment and adjust their directions approach to instructing geometry by utilizing a more viable approach that draws on a student's insights, which is characterized as the understanding of shapes by depicting their characteristics and their relations to each other (Battista, 2007:12). These two components of geometric information play a critical part in students' capacity to get shapes and their properties through geometric thinking and visualizing the pictures when deciding points, their properties, and physical representations. Concurring with Battista (2007:843) well-executed lesson, where the teacher educates and represents the geometrical shapes utilizing characterized geometric thinking, the student would be able to acclimatize and assimilate those qualities and understand Geometry better.

According to Bahr, Bahr and De Garcia (2010:390), it is at the heart of all mathematical strands and comprises "the ability to think and reason by comparing, manipulating and transforming a mental picture viewed in the classroom, hence the knowledge of shapes should not revolve around merely knowing their names, but rather around thinking in geometric context and ultimately provisions of reasons that explain the relationships that exist. Teaching and learning instruction should be built on content knowledge that is appropriate for the various levels of knowledge, and activities should be designed to challenge learners at various levels of understanding and this will ultimately encourage students to formulate and engage in deductive reasoning (Tay & Mensah-Wonkyi, 2018:14).

2.3.2.5 Relating the Mathematical Geometry taught in the Classroom to students' everyday lives (Environment)

Appiahene, (2014:362) states that the importance to incorporate Mathematics in education has gained worldwide recognition, as it has a great potential of improving the level and quality of education completely. South Africa is a country of diverse culture, as manifested by the notion of "rainbow nation". Barnett and Pierce (1999:615) point out that culture is the aggregate of attitudes tradition, and ethical codes peculiar to the particular society. Internationally, authors like Appiahene, (2014:362) and Barnett, Maree (1997:145) and Pierce (1999:615) have written much about the relationship between culture, Geometry learning and teaching with authentication; there is a significant relationship between cultural environment and performance of students. This was supported by Maree (1997:145) who states that people's cultural background can influence aspects of geometry that different cultures may stress. Research in Geometry education has sought to understand how cultural differences affect learners' performance in Mathematics (Maree, 1997:145). Maree (1997:145) further states that people's cultural background can influence aspects of geometry that different cultures may stress and this may have an attribute towards students' performance. Analyses of studies on culture and Geometry revealed some general factors that could enhance students' geometry performance and these factors had to do with lecturers' design classrooms and the activities that will assist students to construct knowledge internally, rather than imposing knowledge on students (Mulaudzi, 2016:12). Lecturers should further provide students with concrete learning materials, such as indigenous teaching aids, assisting them to explore geometrical patterns and use them in their ways of understanding and rationalization of angles (Gordon & Browne, 2014). Mulaudzi (2016:12) proposes that students should interact with lecturers and the community continuously to construct knowledge that makes sense to them.

Science, Technology, Engineering and Mathematics (STEM) education is an interdisciplinary approach to teaching that allows students to create, build, understand,

and make connections to the world around them authentically (Sinay & Nahornick, 2016: 25). I tend to agree with Shaughnessy (2012:43) when explaining that STEM is becoming a driving force in educational development and gives students a way to use Mathematics in meaningful ways, the student enjoys gadgets and technology, which makes them enthusiastic.

2.3.3 Critical Conditions Necessary to enhance the Teaching and Learning of Geometry

To teach mathematical geometry effectively to students of any age or ability, it is important to ensure that students understand the concepts they are learning and the steps that are involved in each proof, rather than students solely learning rules (Gordon & Browne, 2014). More effective teaching approaches encourage students to recognize connections between different ways of representing indigenous knowledge and geometric mathematics (Jones, 2002:133). Lecturers should design classrooms and activities that assist students to construct knowledge internally, rather than imposing knowledge on students (Mulaudzi, 2016:12). Lecturers should further provide students with concrete learning materials such as indigenous teaching aids, assisting them to explore geometrical patterns and use them in their ways of understanding and rationalization of angles (Gordon & Browne, 2014). Mulaudzi (2016:12) proposes that students should interact with lecturers and classmates continuously in the classroom to construct knowledge that makes sense to them and this will be a positive feature of a democratic approach through which environmental education will emerge as students will become enthusiastic about learning. Given that these practices are a conducive condition for the teaching and learning of geometry, the lecturers' concerns are that, though this is an integrated and democratic approach, barriers still exist in the form of expectations that are driven by traditional, disciplinary and content-based, rather than process-basic approaches to schooling.

2.3.4 Threats and Risks Facing Strategies Address Challenges

The anticipated threats that could evade the successful integration of indigenous knowledge in the teaching and learning of mathematical geometry is poor management of the learning space, students inconsistently focusing on the set objectives and lack of motivation. Educators experience uncertainty as to what the usage of indigenous languages entails, a lack of sufficient sources such as indigenous teaching aids according to Metzger (2015:6). These can be overcome by supporting lecturers to design classrooms and the activities that assist students to construct knowledge internally, rather than imposing knowledge on students (Mulaudzi, 2016:12). Lecturers should further provide students with concrete learning materials such as indigenous teaching aids, assisting them to explore geometrical patterns and use them in their ways of understanding and rationalization of angles (Gordon & Browne, 2014). Mulaudzi (2016:12) proposes that students should interact with lecturers and classmates continuously in the classroom to critically construct knowledge that makes sense to them and their environment.

Lack of parental involvement in the teaching and learning of their children is regarded as a threat because parents are not able to be involved in issues related to the education of their children (Park & Holloway, 2013:105). This study is attempting to involve parents from the rural areas that were marginalized in education to be part of their children's learning process, to understand the challenges in which their children are facing as far as Mathematics is a concerned and work collaboratively with the lecturers in coming up with ways to eliminate them through focus group discussions. Parental engagement in children's learning is seen to be of great importance for children's achievement. The religious belief of parents is another factor that has also been shown to affect achievement (Goodall & Ghent, 2014:334).

Sarason (1993:1) sustains that if one wants to change the education of learners, one needs to first change the education of the teachers. According to Sarason (1993:1), it is necessary to prepare lecturers for what life is like in the classroom, college, higher education systems, and environment. The preserve and continuing education of teachers of Geometry should provide them with the opportunity to examine and revise their assumptions about how Geometry should be taught, and how learners learn geometry (National Council Teachers of Mathematics, 1989:160). Findings indicate that Geogebra software is a better option for schools in urban areas where the internet connection is a problem, which is not the case in Rural Areas (Tay & Mensah-Wonkyi, 2018:10). The rural-urban infrastructure disparities indicate that while urban areas can boast about electricity and telecommunications, rural areas remain unconnected, hence disadvantaged students schooling in the rural (Gulati, 2008:08). Meanwhile, the shortage of lecturers who know how to use computers and teach IT threatens the usage of technology in Mathematics to a larger extent.

Pais et al., (2007:19) states that critical emancipated Mathematics education might collide with the assessment system of the Department of Higher Education and Training, which will require lecturers to plan and implement the critically emancipated Mathematics tasks outside the Mathematics classroom before integrating it into formal curriculum, and this might be viewed as a threat because the classroom example and interaction experienced by indigenous students in a form of knowledge inquiries will not benefit them in terms of marks improvement.

2.3.5 Indicators of Success

According to Ferreira (1997:27) respect for diversity is encouraged, students should be active in directing their learning and work from their own experiences. Alves (2007:7) affirms that it is possible and desirable to develop with students' tasks of critical Mathematics education, those that make sense to students and suggests that this could be a way of promoting a bigger societal transformation. Research done by Tarım, 2003 as cited by Gulfer and Kamuran (2014:556) in Turkey shows that the effects of indigenous knowledge as compared to those of western learning indicates a positive increase in attitude towards Mathematics, alternative in South African Traditional Method of teaching Mathematics at TVET Colleges is still dominant, especially in rural areas. Additionally, a study was also conducted in Australia, and the findings showed that the use of the native knowledge, proved to be more effective in bringing out higher Mathematics achievement (Chigeza & Whitehouse, 2014:48).

The Tchokwe people in the Angola Tribe drew with their findings that, gratefulness of the materials learned stimulates interest amongst students to learn (Kiano, 2013:83). The above-mentioned studies have proven that the use of indigenous knowledge, elevated the students' self-esteem and eliminated their fears and inhibitions (Arzadon, 2010:13). I hope that this pedagogy will support the experiences and the processes used for the teaching and learning of mathematical geometry. I anticipate that lecturers and students authentically explore the integration of hand and mind tools that indigenous cultures employ on planning, conceptualizing, visualizing and in executing myriad activities as part of their daily lesson Chahine (2013:3), argues for a pedagogical approach that will support mathematical instructions developed with and for lecturers and students.

In Ghana, GeoGebra was one of the instructive innovation apparatuses utilized in science instruction and any other subject. The impact of innovation utilization in the Mathematics classrooms on students' execution has drawn the consideration of Mathematics teachers, to ought to utilize mechanical computer program in Mathematics classrooms. Anamuah-Mensah, Mereku and Asabere-Ameyaw (2004:216) view the Mathematical Association of Ghana (MAG), that it has made a surprising step towards the utilization of ICT within the educating and learning of Mathematics, which can be effective tool for social transformation. This program has made it possible for students to discover theorems of circle by dragging the point on the circumference of a circle with the mouse. GeoGebra appeared to have motivated learners to approach Mathematics with an experimental method (Hohenwarter & Fuchs, 2004). I tend to agree with Toy and Mensah-Wonkyi (2018:04) when stating that from the study of Bhagat and Chang (2015), educating and learning Mathematical Geometry with GeoGebra, made a difference in the students' progress. It assisted students to develop their reasoning, visualization skills and representation of mathematical concepts in diverse ways.

2.4 SUMMARY OF THIS CHAPTER

From the literature review done in this study, it can be seen that many components caused students to perform poorly in mathematics and at the same time many measures need to be done to correct the circumstances. Some literature reviewed in this chapter highlighted the cause of poor performance in mathematics generally, and in geometry in particular.

The following chapter deals with the research design and methodology used in conducting the study. All major procedures followed in carrying out this research are described lengthily in Chapter (three).

CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN FOR THE UTILISATION OF INDIGENOUS KNOWLEDGE AS AN APPROACH TO IMPROVE THE TEACHING AND LEARNING OF MATHEMATICAL GEOMETRY

3.0 INTRODUCTION

This study aims to enhance the teaching and learning of mathematical geometry at TVET College using the indigenous knowledge approach. To achieve this aim, this chapter discusses the research methodology followed, data generation instrumentation and the data analysis thereof. The methodology adopted by this study is Participatory Action Research (PAR). The chapter demonstrates how the phases and goals of PAR cycle were followed, from problem diagnosis coupled with SWOT analysis of the research site, establishment of a team of co-researchers, developing a plan for improvement, implementing the plan, evaluating and documenting the effects of the plan and reflecting on the effects of the plan for further planning and informed actions. It explains and justifies the data generation methods and finally explains the method that was used to analyze the data. Furthermore, the theoretical constructs developed in Chapter two (see section 2.2) are integrated into practice when trying to answer the following research question:

How can indigenous knowledge be used as an approach to enhance the teaching and learning of mathematical geometry at NQF level 4 at TVET College?

This chapter is divided into two sections. The first section explains, concisely, the theory of PAR (Research Methodology). It contextualizes PAR in terms of its origin and benefits to this study; the relationship between the researcher and the co-researchers; the key aspect of PAR and its application to this study and its suitability concerning CER, which is the theoretical framework adopted for this study. Whilst the second section is the core of the study, where I explain how data was generated with the co-researchers to validate the need for the proposed strategy (Research Design). The data generation instrument used in this study was Focus Group Discussions (FDG) through the utility of homogenous sampling as a convenient selection technique for the co-researchers, to clarify team formation (co-researchers), the description of the research site and ethical considerations were elaborated.

Furthermore, the second section is more practical. It discusses how the study made use of the phases and goals of the Gerald Susman's PAR cyclical, from problem identification coupled with SWOT analysis of the research site, establishing a team of co-researchers by providing the reader with the profiling of the co-researchers. This chapter also discusses the plan of action that was followed by the research team for the formulation of a pilot Practical Assessment Task (PAT) as an intervention approach to validate the authenticity of the proposed strategy, which formed part of the strategic plan to address the identified problem. Lastly, data analysis was discussed. These were done to respond to the aims, research question and objectives of this study and to enable coherence in the readers' mind. Objectives of the study, are hereby restated below:

- To determine challenges prevailing in the teaching and learning of mathematical geometry and each challenge was explored separately.
- To determine possible solutions to the identified challenges in the teaching and learning of mathematical geometry.
- To identify conditions conducive for the teaching and learning of mathematical geometry.
- To anticipate threats that could evade the successful integration of indigenous knowledge in the teaching and learning of mathematical geometry and determining how to prevent them.
- To indicate the evidence of success in the teaching and learning of mathematical geometry through integrating indigenous knowledge using the indigenous knowledge approach.

The next section unpacks PAR as the methodology of this study.

3.1. RESEARCH METHODOLOGY

In this section, PAR is an approach suitable for the study. It is discussed, including its origins and relevance to the study. To justify the need for the study, the benefits of PAR and its suitability to CER, the theoretical framework of this study are also discussed.

3.1.1 Participatory Action Research (PAR) as research methodology

Participatory Action Research (PAR) PAR is the research methodology employed to shape this study, a qualitative research design that incorporates understanding and consideration. PAR is considered to be democratic, equitable, liberating, and life-enhancing qualitative inquiry that remains distinct from other qualitative methodologies (Mcdolands, 2012:34). In this study, the researcher and co-researchers were equally involved in all the processes, decisions and information sharing throughout the research process containing the primary purpose of enhancing the teaching and learning of Mathematical Geometry as the ultimate goal.

PAR speaks to a combination of two customs, action research, and participatory research. This infers participatory research and action research have unmistakable origins. As indicated by Bhana (1999:228), participatory research (PR) has its commencements in the fields of education and community development, while action research (AR) emerged out of a need to change how modern organizations and different associations were overseen. Their distinctive origins could or may represent minor contrasts between these ways of dealing with research. Notwithstanding, Bhana (1999:228) states that the contrasts between the two methodologies have turned out to be insignificant, and that ebb and flow utilization supports the term participatory activity look into (PAR) for any sort of research which consolidates activity or potential cooperation. In support of this, Schwandt (1997:112) recognizes three attributes that seem to recognize participatory activity investigation from different types of social request: its participatory character, its popularity based motivation, and its intentions to create information that is both helpful and activity arranged. The utilization of PAR in this study made use of these attributes by giving the research team adequate participatory abilities, the discourses prompted the co-researchers to collaborate and interact as a collective, intending to follow the descriptive phases of Susman's PAR Cycle. Co-researchers were equitably involved in all dimensions of the research process. To fully conceptualize and theorize PAR, I focus on the origins of PAR as an approach to generating empirical data in the succeeding fragment.

3.1.2 Origins of PAR

The origin and development of PAR can be traced back to the work of Kurt Lewin in 1944. Deduced from Erdem and Glassman (2014:206), PAR is multidimensional and cannot be attributed to an individual or a group of researchers. PAR originated in countries that were previously colonized in the early 1960s and was inspired by the anti-colonial struggle, when researchers began to focus on how to change and better people's lives, fighting for survival and the researchers' stance was to value the co-researchers' knowledge (Hlalele & Tsotetsi, 2015:148), whilst its legacies can be followed back to Paulo Freire (1970), who believed that critical reflection was significant for individual and social change (Maguire, 1987; McIntyre, 2002; Selener, 1997). Azaiza, Lazarowitz and Zelniker (2010:271) affirm that PAR initially appeared around the 1960s and 1970s together with research studies that concentrated on underprivileged societies. As per Macdonald (2012:38), the participatory action research approach of Freire was concerned with empowering the poor and marginalized members of society about issues pertaining to literacy, land reform analysis, and the community at large. Freire (1970) was an adult educator and author of critical works of pedagogy who challenged social relationships in traditional education that were based on dominance and power (Freire, 1970). PAR is an approach embedded in the social sciences and was developed as a feature of a move away from customary, positivist science to progressing in the direction of perceiving and tending to complex human and social issues (Eruera, 2010:1).

According to McTaggart (1991:169), there is diversity in the meaning of PAR, which is understandable as "any literature search using the descriptors "participatory research", “action research”, and “participatory action research” identifies a confusing and meaningless diversity of approaches to research. PAR has been utilized in agriculture, industry, education, social work, and health (Gillis & Jackson, 2002; Koch, Kralik & Selim, 2002; Maguire, 1987; Selener, 1997). Due to the multiplicity of fields in which PAR has adopted, it can have different meanings and at times be contradictory. PAR was developed as a means for improving and informing social, economic, and cultural practice, which in principle is a group of activities whereby individuals with differing power, status, and influence, collaborate concerning a thematic analysis (McTaggart, 1991:169).

From a philosophical approach to research, Participatory action research has been known for its ability to recognize the importance of co-researchers in research conducted in all the four phases, namely: preparation, planning, reflecting and implementing, which are meant to nurture capacity, community development, empowerment, access, social justice, and participation (Anderson, McFarlane & Vollman, 2004:129). Macdonalds (2012:38) further added to this by incorporating the reflection of historical, political, economic, and geographic contexts to make sense of issues and experiences requiring action for changing or improving a situation.

Nonetheless, Whyte (1991:20) maintains that individuals in a community or association offer effective participation in collaboration with the professional researcher throughout the whole research process, from the initial designing to the presentation of results and the discussion of action implications. In PAR, co-researchers are not passive as is the case in other anticipated models of pure research, but enthusiastically engaging in the quest for information and ideas to guide their imminent actions. Maguire (1987:29) characterized PAR from a women's activist point of view in combining activities of social investigation, education, and activity in an aggregate procedure.

The social exploration activity of PAR incorporated a strategy for social exploration of problems, involving the participation of the oppressed and ordinary people in problem posing and solving. PAR is additionally seen as an educational process for the co-researchers and researcher, by analyzing basic reasons for the distinguished challenges through aggregate discourses and cooperation (Mcdonalds, 2012:39). Maguire (1987:29) emphasized that the action activity of PAR is a route for researchers and oppressed people to participate in solidarity to take collective action, both in the short and long term, for radical social change.

In summary, I contend that PAR finds space in this research where the teaching and learning of MG have shown through literature, that it does not address the social influences of the communities; it is accommodative, especially for indigenous knowledge which has been socially marginalized in the MG curriculum. It is therefore desirable to utilize PAR to rethink our current practices to incorporate indigenous knowledge that is pedagogically excluded from mainstream teachings of MG. The next section outlines the crucial aspects of PAR that could be of benefit to this study.

3.1.3. The benefits of PAR in the study

In this section, I conceptualize PAR further by interrogating it as a promoter of knowledge of indigenous people, as practical and collaborative and as an emancipating aspect. The next subsection discusses PAR as a promoter of knowledge from indigenous people.

3.1.3.1 PAR as a promoter of knowledge from indigenous people

One of the significant features of PAR is its native principle of benefiting the marginalized (Francis, 2012:149; Hoare, Robinson & Levy, 1993:43). It promotes recurring back power to the previously underprivileged, erecting knowledge and its usage to native people located in the communities. It therefore, contributes to the democratization of the research procedure and the development of social change (Hanrahan, 2005:22).

Similarly, Smith (1999:193) states that the activity of research is transformed when Indigenous people become the researchers and not merely the researched, as parents and other stakeholders are included in the research study. Their roles and influence towards social change will be vital because they are the bearers of the indigenous knowledge as they are the local people in the community and it is through their knowledge and experiences that the objectives of the study could be addressed (Dube, 2016:106). In addition, this study incorporate knowledge deduced from the co-researchers in focus group discussions to emancipate lecturers in important areas of IK, where they may have encountered or may lack orientation.

According to Gaffney (2008:10), PAR has also been used as technique for addressing the identified challenges through hand mind rid learning and recurring processes (Eruera, 2010:02). This process of Design change; Acting and observing the procedure and significance of change; Reflecting on these processes and concerns; and then re-planning, acting, and seeing and reflecting assists the researcher to address the challenges identified in the study. The usage of PAR in this study provides the team an opportunity to engage with one another in discourses with the vision to identify the problem, plan jointly on how best to tackle it, implement the suggested solutions and critically evaluate the impact of the proposed solutions as a group.

The focus was first on anticipating the challenge, then proceeding to action. During the reflective phase, the idea was to enhance involvement and cooperation, as well as to identify appropriate existing indigenous resources to address the social issue (Eberson et al., 2007:127; Eruera, 2010:02). The purpose of the reflection phase is to build on the identified relationships. This phase is followed by co-researchers actively exploring the challenge through researching the communities. This phase consists of implemented procedural decisions and the adoption of results as a consequence of gained clarity of the set objectives.

During the research phase, the aim was to identify the challenges collectively, generate possible strategies to try to eliminate these identified challenges (Eberson et al., 2007:127). The action phase serves as the recognition of the PAR tenets of action, development, and change (Eberson et al., 2007:127; Eruera, 2010:2). Based on a set of action plans, co-researchers gave the principal researcher a flat to go and implement the pilot assessment in the classroom with a collaborative purpose to allow students to work in groups and use the identified indigenous resources to attain the aim of this research. The process then proceeded to the phase of considering the possible challenges that may have emerged (Eberson et al., 2007:127; Eruera, 2010:2).

Expressed by these authors, Cochran, Cook, Garcia-Downing, Gover, Kendall, Marshall and McCubbin (2008:26), using indigenous ways of knowing in research is not different from the utilization of indigenous knowledge to better understand and know in order to comprehend the community at large, is significant. I am in agreement with Baum, MacDougall and Smith (2014:855) when stating that PAR enables the researcher to engage with community members and bring about real change to their quality of life by addressing the challenges experienced in the communities and working collaboratively with the co-researchers to solve the challenge. Indeed, PAR plays a vital role of promoting the indigenous knowledge currently prevailing in the communities. The next subsection discusses the next beneficiary role of PAR as practical and collaborative.

3.1.3.2 PAR as practical and collaborative

PAR is comprehended as a cooperative, which infers dissolving the traditional limitations which have been set between the researcher and the researched (Schroeder, 2013:106; Dickson, Fletcher & MacPhee, 2015:2). These limitations are dispensed through the accentuation of equivalent participation (Given, 2008:601). The functional and synergistic part of PAR draws in individuals to examine "social practices that connect them with others in social collaboration. It is a consistent procedure wherein individuals investigate their practices of correspondence, creation, and social association in a mission to improve their connection in the network" (McTaggart & Kemmis, 2007:282). It is comprehensive "at every stage, involving discussion, pooling skills and working together, and it is intended to result in some action, change or improvement on the issue being researched towards more socially and environmentally just outcomes" (Pain, Milledge & Whitman, 2015:625). It normally includes joint effort between various partners who have specific sets of aptitudes and information (Bouveng, Finn, Pain & Ngobe, 2013:29). Tshelane (2013:417) maintains that PAR is community-oriented solidarity to address the exact frameworks. It is a common and thoughtful research structure that stresses critical thinking, improving work rehearses and appreciating the exploration procedure and its effects.

Apart from being hands-on and cooperative, Harmon, McDaniel, Lanham, Leykim and Pugh (2009:8) express that PAR endeavours to address issues in a particular framework, centers around critical thinking, edifying work practices, and qualities of the examination procedure as an option in contrast to living arrangements. The effect of progress is tested and its importance to the network inspected. Accentuating cooperation inside the minimized or the abused networks, PAR attempts to address the "fundamental reasons for disparities while simultaneously concentrating on discovering answers for explicit network concerns" (Brydon-Miller & Williams, 2004:245). For this situation, the college and the community become the principal worry of the exploration procedure where collaborative and functional arrangements are sought. From this point of view, PAR is certifiably not only as a methodology, "but rather a pledge to collaboration and partnership throughout the problem-posing, knowledge creation, and action-taking cycles of a project" (Maguire & Miller, 2008:88). Because of these elements of PAR, of being practical and collaborative, co-researchers are able to interact with one another in an effective way that reflects elements of mutual understanding in trying to resolve the challenges confirmed by literature, which are prevailing in the teaching and learning of Mathematical geometry. That said, the next subsection discusses PAR as an emancipating aspect.

3.1.3.3 PAR as an emancipatory aspect

PAR from the emancipatory point, plans to give space to help individuals recoup and discharge themselves from the confinements of nonsensical, and sub-par social structures that cutoff their self-advancement and self-assurance (Kemmis & McTaggart, 2007:282 & Dube, 2016:110). Through PAR, lecturers are urged to work with their students and community partners from the identified population on how best their interaction in group discussions can contribute positively to the community (Apple 1995:87).

Similarly, the utilization of PAR in this study is aimed at finding practical applications for incorporating IK in the teaching and learning of mathematical geometry and viable solutions for the difficulties distinguished (Chapman & Dold, 2012:512). In its emancipatory research approach, relations have equal representation as opposed to hierarchies (Brown-Sica & Somerville, 2011:671), which contorts the embodiment of transformative research that plans to improve the life of the community members.

The emancipatory viewpoint of PAR "offers the possibility to create more equitable educational policies which allow for practices for educational reform from the bottom up" (Maguire & Miller, 2008:85). Leowenson, Laurell, Hogstedt, D'Ambruoso and Shroff (2014:18) expressed that produced learning reflects and solidifies control relations and struggle and thus, impact social and power relations. To put it plainly, Reason (2004:16) states that PAR as an emancipatory procedure is critical to free and recuperate voices that have been consigned to the fringe even in research. I concur with Elicondo, Alberto, Zavala, Alvarado, Suazo and Veronica (2013:425) when they state that the enthusiasm of the emancipatory part of PAR is to perceive the psychological, good, political and social truth of the considerable number of members of the examination, with the point of concentrating on the comprehension of the gathering to incite an efficient change that indeed PAR contains emancipatory aspects. Not only these mentioned aspects of PAR show its value in this study, but also its key aspects and their application to this study are discussed in the next section.

3.1.4The key aspects of PAR and their application to this study

In this section, the key aspects of PAR and their application to the study are discussed.

Kemmis (2006:270-271) shows three noteworthy and urgent viewpoints about PAR. Initially, its significant points of view tend to genuine issues as recognized by co-researchers in a form of ideas, hypothesis and practice (Eruera, 2010:1; Sanginga, Kamugisha & Martin, 2010:696). Furthermore, PAR's approach incorporates the community, wherein the co-researchers are situated in. The consideration of retired Mathematics Lecturers as guardians and different accomplices in advanced education, in the focus groups, help in the facilitation of professional dialogues amongst co-researchers and the discovered knowledge in regards to the difficulties they experience, the qualities, shortcomings and thinking of indigenous ways on the most proficient method to conquer those difficulties, are of worth and have an incredible commitment for the set objectives (Eberson, Eloff & Ferreira, 2007:126; Eruera, 2010:1; Sanginga et al., 2010:696). Thirdly, PAR investigates the constitution of training in a profound, rich manner that will motivate informed correspondence concerning different ways of practices that could be comprehended, from the various purposes of perspectives (Tsotetsi, 2013:143). Thus, PAR involves those who are affected by the challenges from the beginning, through the discussions and meetings, to generate data (Eruera, 2010:09). Savin-Baden and Wimpenny (2007:335) state that strategies employed within a PAR process to achieve a meaningful change involve engaging with a group of co-researchers in a series of self-reflective cycles that include: planning a change with the co-researchers; acting and observing the process and the consequences of change; reflecting on these processes and consequences; and further cycles of planning and reflecting. This study made use of this self–reflective cycle to provide the team an opportunity to engage with one another in discourses with the vision to identify the problem, plan jointly on how best to tackle it, implement the suggested solutions and critically evaluate the impact of the proposed solutions as a group. The next section describes the research design of this study.

3.2 RESEARCH DESIGN

In this section, the research design is described, to show how the study was planned and structured to gather the data.

In every research, there are systematic processes to be followed when generating, analyzing and interpreting data to increase our understanding of the phenomenon in which we are interested (Baloyi-Mothibeli, 2018:76). The research design is defined by Creswell (2009:107) as a set of guidelines and instruments to be followed in addressing the research problem. A research design embodies the disposition that a clear account of how data is generated and analyzed (Van Wyk, 2005:82). According to Kumar (2014:122), a research design is an operational plan that specifies what and how different methods and procedures are to be applied during the research process.

Furthermore, Kumar (2014:123) affirmed that a research design is an arrangement whereby the researcher chooses how to impart to other choices in regards to what study configuration is proposed to be utilized, how information is gathered from co-researchers, how the co-researchers are selected, how the data gathered is analyzed and how the findings are conveyed. A research design for this study which gives a clear structure on how the study unfolds through a qualitative research phenomenon. On the other hand, Research methodology refers to various techniques, methods, and procedures that were used in the process of implementing research design or research methods (Creswell, 2009:18). Qualitative data was used to generate data through Focus Group Discussions. I tend to agree with Creswell (2009:16), when stating that the purpose of qualitative research is to try to gather full information in genuine settings, to develop an understanding of the concepts discussed and transcribed by the researcher as this is exactly what this study aims at doing. As a result of this purpose, the next section describes the research site where the study gained permission to be conducted.

3.2.1 Description of Research Site

The research was conducted in the TVET sector of education of the Department of Higher Education and Training, TVET College. This college is situated in the rural Areas of the Free State Province, well known as a rural homeland in the Free State.

This TVET College is a Technical Vocational Education and Training Institution operating under the custody of the Department of Higher Education and Training. The College is accredited by Umalusi and several Sectors of Education and Training Authorities (SETAs). The specific focus of the TVET College is to address the skills shortages in South Africa; by offering relevant and responsive vocational and occupational programs. The Pay–Offline of this College is Great Place, Great Choice for Lifelong Learning has been chosen because it perfectly represents what the College is about. The vision of the TVET College builds a society that has the technological competencies to be both self-supportive and globally competitive.

This College has a reputation for attracting students mainly from disadvantaged or marginalized families. The College consists of Eight Campuses. The TVET College offers two programs which are the National Certificate Vocational (NCV) and the National Technical Diploma (NATED)/Report 191 program. National Certificate Vocational (NCV) is a qualification offered at levels 2, 3 and 4 of the National Qualifications Framework (NQF) and it is designed to provide both the theory and practice, whereas the National Technical Diploma (NATED)/Report 191 programs, also known as an alternative post-school program, is available in engineering, business and utility studies and is offered at a full-time or part-time basis. The practical component of this study is based on the performance of students taking Mathematics as one of the fundamental subjects at NQF level 4, under the NCV program, with its aim of enhancing the teaching and learning of Mathematical Geometry using the indigenous knowledge available in the surrounding communities of this College. This was informed by what the next section entails when elaborating on the selection of co-researchers.

3.2.2 The Selection of Co-researchers

A sample is the number of co-researchers who are selected from the population and from whom data is generated (Mamali, 2015:58). To select the co-researchers, a homogeneous sampling technique was adopted because all the stakeholders involved in the problem identification were homogenous to the community of mathematics geometry. This technique, however, was a form of co-researchers' selection technique that is best suitable for Focus Group Discussions (FGD), because it entails homogeneous group or group of people who are directly affected by the issue at hand (Patton, 1990:173). Meanwhile, all the co-researchers were considered proficient, well-informed, knowledgeable and have experience of the concept at hand (Etikan, Musa & Alkassim, 2016:2). The study dealt with co-researchers who knew the significance of convenience, willingness to participate and the ability to communicate experiences and opinions in an articulate, expressive, and reflective manner. In this study, the homogeneous sampling technique enables focus group discussion to run constructively to bring together people of similar backgrounds and experiences to participate in group discussions that attend to the issues that affect their homogeneity. The next section outlines the composition of the research team.

3.2.3 The Composition of the Research Team (RT)

The team of co-researchers, Mathematics lecturers, students and HODs drawn from four different campuses of the TVET College, with pseudo-names, Campus A, Campus B, Campus C and Campus D, based on their level of experience in offering Mathematics, the total number of co-researchers was 10, namely: 2 HODs, 2 Maths Lecturers, 1 Former Lecturer, 1 Mathematics specialist, 1 Senior lecturer, 1 Mathematics Tutor, and 2 Mathematics students. The selection of these co-researchers was done in consideration of the PAR's broader mandate of guiding practitioner inquiry dialogue that bears collaborative social change aspects through involving those with a stake in the change (Brydon-Miller & Maguire, 2009:88). Eruera (2010:1) states that the PAR approach requires active research participation and ownership by people who are motivated to identify and solve the issues that concern them. In the same vein, Eruera (2010:3) suggests that these individuals ought to be engaged with every one of the stages of the research process aimed at addressing the identified challenges. In line with this recommendation, the co-researchers in this study were persons who were mostly concerned with the challenge at hand.

Co-researcher	Involvement	Experience
Head of Department	They know the challenges that students encounter in class. They are familiar with the challenges that students in Mathematics classrooms encounter in the process of teaching and learning MG.	They have extensive teaching experience (10 – 15 years in the field).

Mathematics Lecturers	They are on the ground level as they meet and teach students daily. They are familiar with the challenges that students in Mathematics classrooms encounter in the process of teaching and learning Mathematics. They also know what is needed to find possible solutions.	They have extensive teaching experience (3 – 5 years at most) in the teaching of Mathematics.
Former Teacher (is this person former teacher or lecturer? You used both terms interchangeably, hence I ended up opting for former lecture instead of former teacher)	She was previously employed as a Mathematics educator, later appointed as the head of the Mathematics department. She is now working as a lecturer at the College.	This person is experienced in what is happening inside Mathematics classrooms. She taught Mathematics for more than 12 years.
Mathematics specialist	He is knowledgeable in Mathematics content. He taught, trained and oversees the teaching and learning of Mathematics. He was familiar with the challenges that lecturers and students encounter in a Mathematics classroom.	This person has extensive teaching experience (10 years at most) in the teaching of Mathematics.

Senior lecturer	The person is directly in contact with the lecturers. He is familiar with the challenges that students in Mathematics classrooms encounter in the process of teaching and learning MG. He also knows what is needed to eliminate the challenges.	This person has extensive teaching experience (5 – 7 years at most) in the teaching of Mathematics.
Mathematics students and Tutor.	These are students who enrolled at NQF level 4 in the current year. They are selected due to the reason that they are the ones facing the challenges of teaching and learning daily. They are in a better position to explain their experiences in terms of the teaching and learning of MG.	Enrolled for three years program in NCV.

Table 3.2.3.1: Co-researchers Profiles

3.2.4 The researcher and co-researchers' relationship

To increase understanding in the connection between the researcher and the co-researchers, Nkoane (2015:99) states that in PAR, both the researcher and the co-researchers are submerged like discussions and convergences as translated from their informed position and experiences. The issue of power relations in research is equally distributed. It involves absolute inundation of both the researcher and the co-researchers as they are equivalent accomplices in the research process, with the goal that all faculties of observation and comprehension are at the same time required to have the option to understand the myriad of signals and images originating from various points of view as could be allowed (Mahlomaholo, 2010:36).

It is through this sort of research approach that qualities, for example, majority rules system, social equity, maintainable occupation and strengthening of consigned or minimized individuals could be figured out. It is tied in with comprehending other individuals' translations and understanding their reality educated by their encounters. In discourses, the specialist is not coding and computing the number of words verbally expressed by co-scientists as a reason for reaching research inferences or importance making (Mahlomaholo & Nkoane, 2002:93). The analyst and the co-scientists are keen on changing their social stations to cultivate and propel majority rule government, freedom, value and social equity in a way that meets the methodological desires for both the specialist and the co-analysts.

According to Pais, Fernades, Matos and Alves, (2007:5), Mathematics education has the purpose of helping lecturers and students to uncover the mathematical geometry behind more diverse situations, promoting the education of participative, critical and confident citizens. The issue then for the emancipatory look into worldview is not just on the best way to engage individuals yet, when individuals have chosen to enable themselves accurately what research would then be able to do is to encourage this procedure. This does then, imply that the social relations of research-creation do need to be on a very basic level changed; scientists need to figure out how to put their insight and aptitudes at the transfer of their examination subjects, for them to use in the manner in which they pick, the specialist should see the world through the eyes of the co-analysts (Oliver, 1992:111). Hence, it is important that, during the discourse, the team should be allowed to engage in discussions that assist them to come up with the solution to the problem facing the team without fear. The next section gives processes and phases that were followed to gather data.

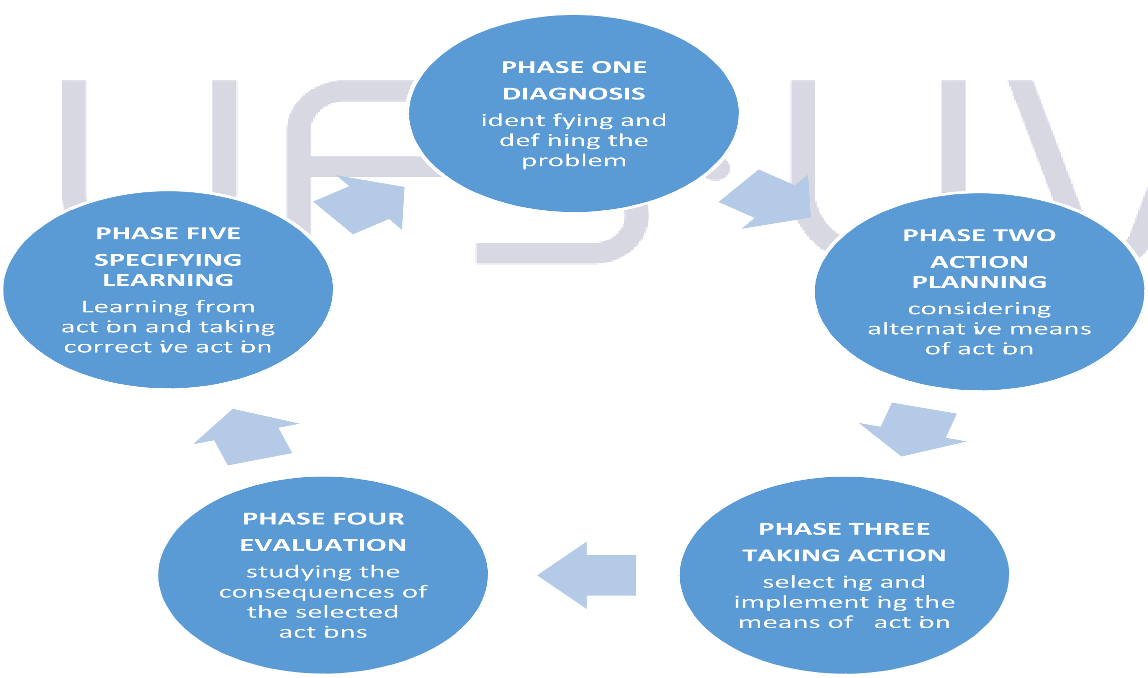
3.3 DATA GENERATION PROCEDURES

This section describes the instrument that was used to generate data being Focus Group Discussion. Focus Group Discussions (FGD) was implemented according to the schedule for discussions with the similar aim of gathering data to respond to the set objectives.

3.3.1 FGD as a Research instrument

To generate data in this study, discussions were done in a form of focus groups, as they are considered as a socially orientated process and a "form of group interview that capitalizes on communication between the research co-researchers to generate data" (Kitzinger, 1995:299). During focus group sessions, the researcher created a supportive environment in which discussion and differing points of view were encouraged (Marshall & Rossman, 2006). Ideally, in PAR, all co-researchers' viewpoints are recognized and valued, as all co-researchers have an opportunity to communicate (Jacobs, 2016:49). Hence, this makes FGD more productive as a method to implement the principles of PAR concerning my study.

Through collaboration among the researcher and the co-researchers, the topic(s) for discussion during the FDG, the team agreed to use Gerald Susman's (1983) PAR model framework to shape the research process.



3.3.1.1 Source: Gerald Susman's PAR Model (1983)

This author described the PAR cycle in five subsequent phases. The process began with the diagnosing, action planning, taking action, evaluating and specifying learning (see figure 3.3.1.1). This PAR approach is a cyclic collaborative research process that involves co-researchers to be active throughout the entire research process (Greenwood & Levin, 1998; McNiff & Whitehead, 2006). Gillis and Jackson (2002:235) noted that even though the topic of discussion is left up to the focus group, the facilitator provided the structure, as the FGD enabled me to implement the principles of PAR where everyone was given equal opportunities to participate with no power differentials. This model enabled the discussion to have descriptive themes in trying to respond to the research question and objective of the study.

The next section discusses data generation in terms of FGD using the phases as a guideline or theme for each meeting.

3.3.2. Phases and process of data generation

This section describes how the research team worked together to generate data through the implementation of the PAR cycle using Susman's phases as guiding themes for each meeting. Invitation letters to attend the first gathering were sent to all stakeholders, who all confirmed attendance. The first meeting was considered as the briefing and planning meeting for the succeeding ones, whereby the team agreed to make use of the five subsequent meetings looking at the PAR cycle and its unique respective phases.

The subsequent sections below show these phases and also gives a detailed narration on how each phase and their unique goals were dealt with in singled out meetings. The phases described below highlight the topic that the team dealt with towards the formulation of an approach aiming at responding to the problems encountered in the teaching and learning of MG.

3.3.2.1 Briefing and planning meeting

The purpose of this meeting was to brief the research team about this research project, whereby the principal researcher conveyed the overall outline of the study to the research team (see figure 3.2.2 below) using a PowerPoint presentation.

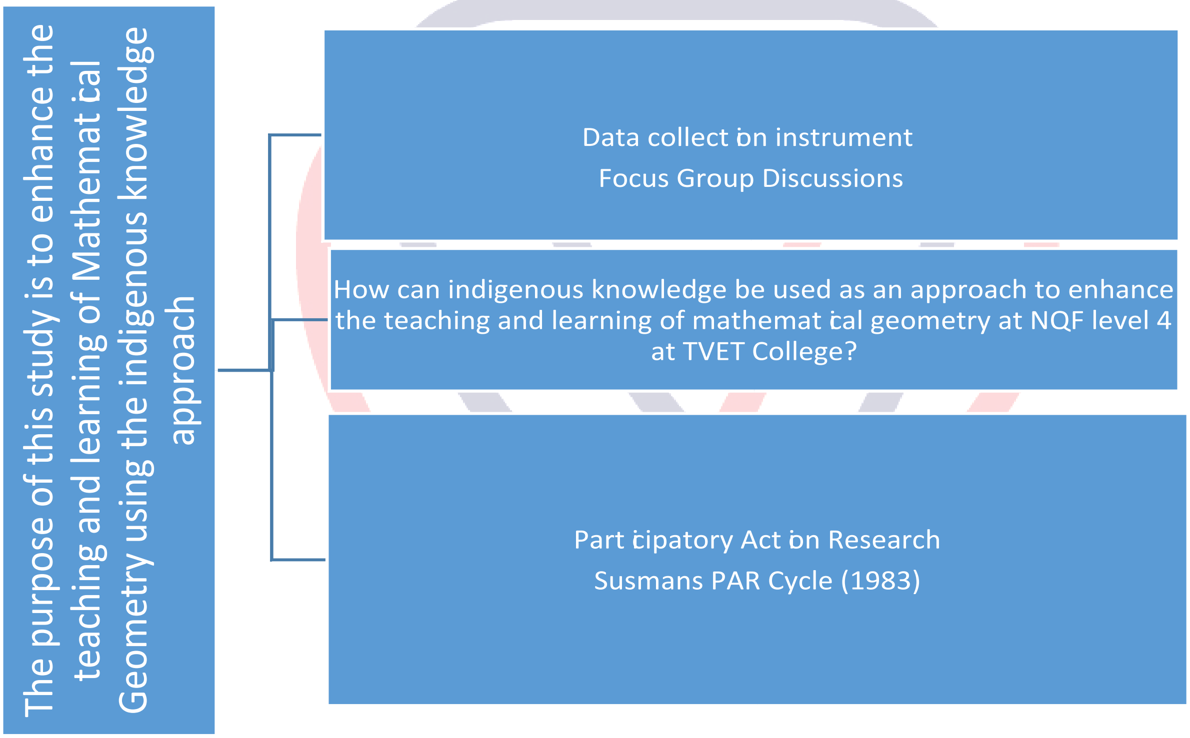


Figure 3.3.2.1.1The overall outline of the study

The study outline was about the title of the study, the data generation instrument (FGD), the research question and the principal researcher further unpacked on the usage of PAR as the methodology and or approach guiding this research. I explained that this approach involves interaction from all stakeholders. We had an information session that involved discussing how the phases of the PAR cycle would be used as a guiding approach to gathering data, to give a sense of what was expected from us as a research team. It was agreed by the research team that everyone understood the research processes. As the discussion commenced, it was agreed by the research team that a voice recorder is used throughout the discussion, to ensure that all the discussions are captured correctly, so that the important points are not missed. It was also agreed upon by the team that the recording instrument will be kept safe until the end of the study. Consequently, the date and the agenda of the next meeting were set and agreed upon by everyone present. The agenda of the next meeting was drawn by the research team as a collective being the first phase of the PAR cycle. The next section clarifies the first phase of the PAR cycle as unfolded during the data generation process.

3.3.2.2 Phase one: diagnosis.

This section discusses the proceedings of the second meeting which was the beginning of the PAR cycle, diagnosis.

The purpose of this meeting was for the research team to diagnose the challenges experienced in the teaching and learning of MG, providing a clear understanding of the problem at hand. This meeting was differentiated into two phases, whereby the first session was about the discussion of SWOT analysis. This analysis was done to assist the team to identify the strengths and weaknesses of the research site. It also assisted in identifying the opportunities and threats of the college in which the study is conducted. SWOT analysis is a traditional form of brainstorming as it is defined as a commonly used tool for strategic planning (Phadermrod, Croeder & Wills, 2019:194). The table below indicates the components of SWOT analysis thereof.

Strengths	Opportunities
It was found that the strength of the college for this research was that co-researchers to have the opportunity to, co-researchers were given a fair chance to and participate collaboratively throughout the research process, the team was able to contribute collectively in the formulation of the Practical Assessment Task (PAT) which served as	Support from the students' support services (SSS) was found to be the greatest opportunity. The SSS introduced an academic support gesture, whereby the Mathematics students were allocated a tutor to assist students in areas where the students experience problems for days of the week (Monday to Thursday). This

an example of the integration of indigenous knowledge in the classroom through in an assessment format, do reflection on the student performance in this task, implement the suggestions, plan or re-plan for improvements. The profound component of this task was to enhance students' geometric reasoning of theorems which was identified as a challenge. This task aimed at assisting students to master geometric theorems as they were unable to determine geometric angles in such theorems under the MG concept. The study had dedicated lecturers who were working hard in an environment with limited resources.	initiative assisted dedicated students to a greater extent because the students were able to work cooperatively and assist each other in groups having more time to tackle these grey areas. The tutor focused more on the areas where students did not perform well to assist the students to perform better in Mathematics and increase the college certification rate at NQF level 4 (NCV).
Weaknesses	Threats
Lecturers in the college are lacking resource those that will smoothly enhance the teaching and learning of MG, this leads to lecturers opting for the abstract presentation of the concept and rely on textbooks as the only source of information. This consequently leads to an absence of practical assessments that will allow students to work cooperatively doing tangible hand-activities. Lecturers are not attending content related	The College is situated in the rural areas of the Free State province and this comes with the disadvantages of lack of innovative initiatives from the lecturers' side to thoroughly plan and prepare lessons that are enticing and arouse the interest of students in the Mathematics classrooms.

workshop whereby, they can be thoroughly equipped with skills on how to tackle concept which is most problematic to the students.	

Table 3.3.2.2.1 SWOT analysis components

After this brainstorming session, co-researchers gain comfort to participate freely as their views and inputs were noted timeously. They were able to identify and voice their ideas confidently and work as a team during this phase of discussion. The authenticity of this was promulgated in Brydon-Miller and Maguire's (2009:79) statement, which stated that the intentional focus of PAR is a collaborative, action for social change, that allows the co-researchers' educational inquiry to shift from an individual perspective to a collective endeavour, consistently aiming at transformative personal, organizational, and structural change. The proceedings of the meeting led to the second session of the meeting, whereby the research team diagnosed the challenges prevailing in the teaching and learning of mathematical geometry at various campuses, but specifically at NQF level 4. Amongst the other challenges mentioned by the co-researchers were, lack of Visualization by students, misconception or shortage of this skill could hamper the students' ability to recall various geometric shapes and their properties and this leads to students having a negative attitude towards this concept as a whole. Abstract presentation of concepts, omitting reasons when determining the angle in the theorems and students being unable to relate the Mathematical Geometry taught in the classroom to everyday lives. The team was able to see the need to enhance the teaching and learning of MG and its benefits thereof. This was supported by the fact that the performance of students in MG affects the certification rate of the College at large. From the deliberation, it was agreed that the agenda of the next meeting was to do action planning. The subsequent phase describes the Action Planning of the proposed approach in detail.

3.3.2.3 Phase two: Action Planning

In this section, the research team discussed the possible approaches that can be utilized to integrate indigenous knowledge in the teaching and learning of MG. In this meeting, the research team proceeded with their discussion on brainstorming the possible solutions on how the identified challenges could be addressed to enhance the teaching and learning of MG. The following are the suggestible solutions according to the discussions which were mentioned, formulation of strategy to improve visualization skills, student interaction to enforce positive attitude and beliefs in the teaching and learning of MG, lecturers collaboration and indigenous teaching aids as means to eliminate abstract presentation of MG concept, strategy to improve students' understanding of mathematical geometry vocabulary and practical assessments as a strategy to assist students to relate the Mathematical Geometry taught in the classroom to their everyday lives.

In realizing what the research team wanted to achieve, the team proposed a strategic plan on investigating how the integration of indigenous knowledge in the teaching and learning of mathematical geometry can be actively explored.

Table 3.3.2.3.1: Formulation of Practical Assessment Task and learning materials needed

Areas of priority	Activities	Target	Resources needed	Duration	Monitoring
Empowering lecturers on creating PAT	Creating a Practical	Lecturers	Computer/laptops		Senior
					Lecturers

that foster maximum student interaction	Assessment task (PAT)		NQF level 4 Subject Guideline NQF level 4 Assessment Guideline Mathematics NQF level 4 textbook	Approximately 2hrs 30 minutes	HOD Moderated PAT
Demonstrating understanding of the properties of these theorems	Student creating an A3 poster responding to the PAT	Students	A3 chat Coloured Cultural beads Needle Cotton White clothes Paper glue Scissor	2hrs per day for 5 days	Rubric (see Appendix I[2])
Demonstrating understanding of how the concept relates to the students' daily lives	Presentations	Lecturers Students	PAT Question Paper (See Appendix I[1])	50 minutes	Feedback sessions with the NQF level 4 students Rubric

Evidence of improvement in student's geometric reasoning	The types of geometric theorems constructed	Students	Revision using previous question papers (formal assessment tasks)	20 minutes	Students' performance on formal Assessment tasks
Evidence of parental involvement	Research the historical implication of beads	Students	A3 Chat Poster	10 minutes	The poster (see Appendix I[3]) will serve as evidence
	A3 Poster Presentation				students' enthusiasm will serve as evidence that research was done
					Rubric
					Feedback session with level 4 students

In alignment with Chahine (2013:02), the role of discovery and practice and the use of concrete indigenous teaching materials must be considered when developing a solution directed at improving mathematical geometry achievement. A Practical Assessment Task accompanied by the Rubric as a marking guideline was formulated by co-researchers as a pilot test (see Appendix I[1]& Appendix I[2]). This was done in the alignment of Brydon-Miller and Maguire (2009:85) allusion that, PAR offers the possibility for creating more equitable educational policies and more empowering and inclusive practices for educational reform from the bottom up. The instructions of this task were that students should work in pairs to construct Geometric Circle Theorems using the type of indigenous artifacts known as beads. The duration of this assessment task was 5 days (2 hours per day) to finalize the task. The marks allocation of this task was 50 marks. This PAT was categorized into two sections, the first section is whereby students had to do the geometric construction and the second section was whereby students had to do some research. It was agreed by the research team that the next phase would take place in the classroom between the principal researcher and the students and that the next meeting of the research team would be the discussion of phase four (evaluation), in a form of feedback. The subsequent phase describes the taking action part of how the proposed approach was implemented.

3.3.2.4 Phase three: Taking Action

This phase took place in the classroom, whereby the Mathematics NQF level 4 students were given this PAT as the implementation stage of the cycle. The purpose of this phase was to put the plan into action and to also assess conditions that could be conducive to the successful implementation of this approach. From the deliberations, it was acknowledged that, conditions that will ensure the strategy is implemented successfully are, proper context setting, availability of resources to properly plan the activities, active involvement of students leads to long-term retention and improved application of MG concepts, involvement of parents in the teaching and learning of mathematical geometry and motivation of lecturers and students.

It was also picked up from the previous discussions that the conducive conditions go hand in hand with the possible threats that may hamper the successful integration of indigenous knowledge in the teaching and learning of mathematical geometry. The co-researchers' concerns were that though these integration barriers may still exist in the form of threats, namely, poor management of the learning space, lecturer resistance to technology in the classroom, students inconsistently focusing on the set objectives, lack of parental involvement in the teaching and learning of MG and demotivated lecturers and student lecturers for the teaching and learning of MG.

3.3.2.5 Phase four: Evaluation

This phase took place in the classroom, whereby students presented their PAT evidence (see figure 3.3.2.5.1) to the principal researcher. Students managed to do a poster that was used during the 5 minutes' presentation that incorporated circle theorem geometry. Supported by Ouyang and Stanley (2015:166), the utilization of teaching aids in the classroom enables lecturers to bridge the gap between theory and practice and stimulate students' interest, and as it also assists the lecturer to assess pre-existing knowledge of students spontaneously.

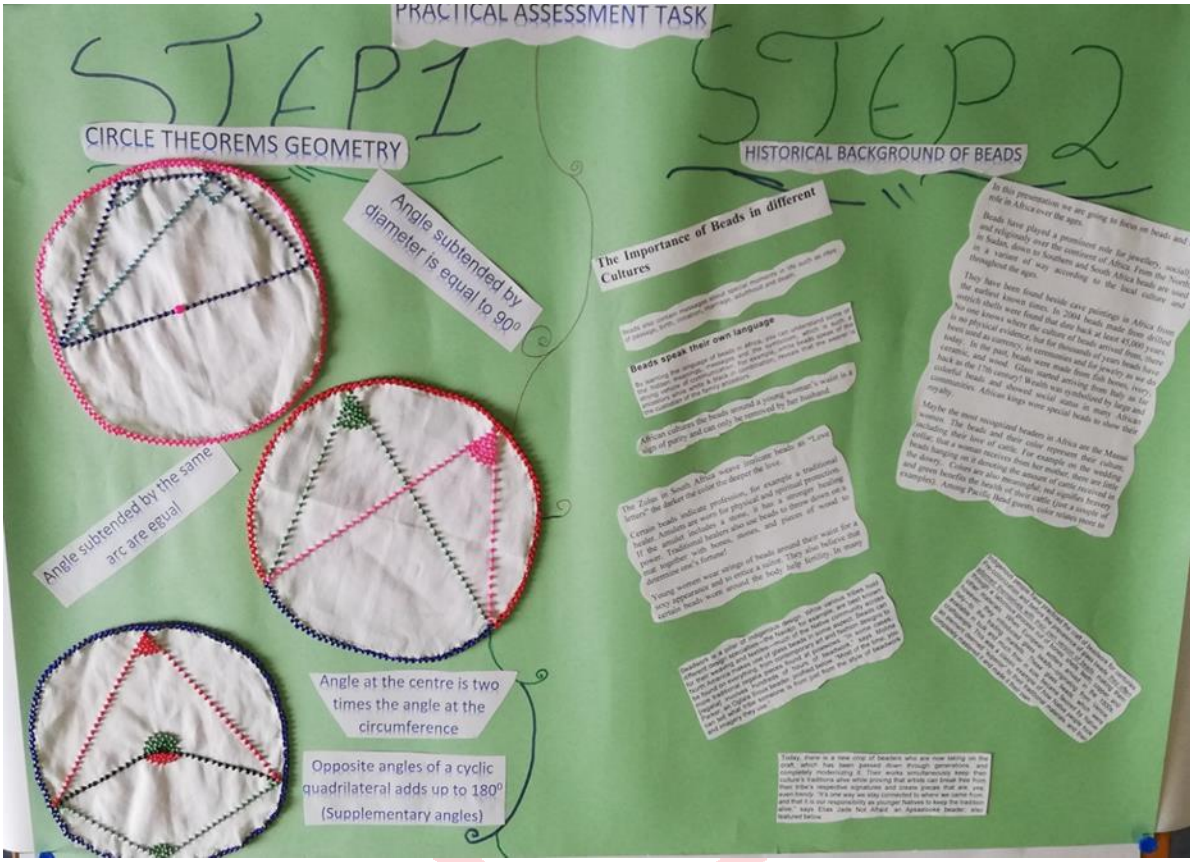


Figure 3.3.2.5.1: Practical Assessment Task Evidence

Visible in the figure above is an A3 poster that displays the students' PAT evidence. The poster is divided into two sections, the first one being beaded geometric theorems and the second one being the historical background of beads as per what the students have researched in their local respective communities. Specifying the learning was scheduled to be discussed in the form of a feedback of the evidence from the students in the last reflection meeting. The agenda of the next meeting (phase five) was planned in such a way that the principal researcher should give feedback to the research team based on the findings of the deliberations of this phase.

3.3.2.6 Phase five: Specifying the learning

The goal of this phase was to reflect on the PAT. The reflection was based on the evidence of assessment (see figure 3.3.2.5.1) coupled with the classroom presentation that was done by the students and their discoveries thereof. The principal researcher also clarified how parental involvement was identified during the students' presentation. The students made mention that whilst they were doing their research in the communities, their parents advised the students that the beaded theorems are time-consuming and that it was advisable that students make use of the white cloth instead of using white beads to resemble a paper. The co-researchers seemed to be in agreement with the advice and this was evidence that the strategy is indeed an achievable activity on the side of the students and that it enables parents' involvement in the teaching and learning of students following that PAR is a deeply relational approach to knowledge creation and social change (Brydon-Miller & Maguire, 2009:87).

Moreover, judging from what the principal researcher had brought in to the gathering, the research team found it proper to add to these developments by also identifying and discussing, the indicators that will serve as evidence that the strategy was successfully implemented. It was also indicated by the co-researchers that the successful implementation of the proposed approach can be determined in numerous ways. Amongst them, those that take priority are, student enrolment in Mathematics, parental Involvement in Education, Student achievement in the Certification Rate at exit level NQF level 4 and improved teaching skills and Mathematical Proficiency. This feedback was done to ensure all the valuable aspects of the study are covered and monitored correctly, thus the study was focused throughout. The next section presents the method that was employed by this study to analyze the gathered data.

3.4 METHOD OF DATA ANALYSIS

The data analysis in this qualitative research was done using a thematic analysis approach. According to Ainscough, Smith, Greenwell, and Horeb (2018:506), thematic analysis is a technique for identifying, analyzing, and reporting themes within data that was deductive, whereby themes were organized according to predefined criteria. The recorded data was textually transcribed and ready for analysis. Then, these transcripts were reduced into themes through the process of coding and condensing the codes and finally representing the data as co-researchers' direct quotations.

Thematic Analysis is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a set data (Howitt & Cramer, 2008:341). It is a method that works both to reflect reality and to unpick or unravel the surface of reality (Braun & Clark, 2006). By focusing on meaning across the generated data, it allows the researcher to see and make sense of collective or shared meanings and experiences discussed (Yardley, 2000:220). Identifying unique and characteristic meanings and experiences found only within a single data item is not the focus of TA. This method, then, is a way of identifying what is common to the way a topic is talked or written about, and of making sense of those commonalities.

3.4.1 How to do thematic analysis

In this study, Braun and Clarke's six phases of thematic analysis were adopted to create a sense of the study. These steps were conjointly conjoined by Wolcott's (2008) to give meaning to the data description, analysis, and interpretation. However, once the theoretical saturation is reached, the researcher attempts to sort, categorize and organize the generated data and finally interpret them according to the prescription of Braun and Clarke (2006). According to Nowell, Norris, White and Moules (2017:04), these phases are: acquaintance of data by the researcher yourself with your data, generating initial codes throughout the transcript, searching for themes, reviewing and evaluation of themes, defining and refining themes and producing the analysis as highlighted and discussed below:

3.4.1.1 Phase 1: Acquaintance of data by the researcher your data

According to Braun and Clarke (2006), the primary step requires the researchers to read over the data to urge a general understanding of what the data entails. When the researcher engages in analysis, he or she has to generate data personally. If you generated it through interactive means, prior knowledge must be taken into consideration when the researcher does data analysis. Notwithstanding that, the researcher should immerse himself or herself in the data to the extent that the researcher is familiar with the depth and breadth of the content (Whites, Oelke & Friensen, 2012:249). This level of immersion usually involves that the researcher should read the data more than once, with the anticipation of an active search for meanings, patterns and so on. Nowell et al., (2017:04) emphasize that it is ideal that the researcher read through the entire data before he or she begins coding, as the ideas and identification of possible patterns will be shaped as the researcher reads through repeatedly.

3.4.1.2 Phase 2: generating initial codes throughout the transcript

The second phase includes the researcher creating detailed notes concerning ideas found in the co-researchers' responses, which creates an initial coding structure for as many alternative fascinating options as possible (Thorne, 2000:69). According to the clarity provided by Nowell et al., (2017:5), as a result of time constraints, we combined these first two steps into one. Phase 2 begins when the researcher has read and familiarized himself or herself with the data, and has generated an initial list of ideas about what is in the data and what is interesting about them. This phase then involves the ensemble of initial codes from the data. The researcher can code the data by writing notes on the texts analyzing, using highlighters or coloured pens to designate potential patterns, or by using post-it notes to categorize segments of data.

3.4.1.3 Phase 3: searching for themes

Phase 3 begins once all data have been initially coded and collated. The researcher has a list of the various codes that were identified across the gathered data (Ando, Cousins & Young, 2014:4). This phase re-focuses the analysis at the broader level of themes. Instead of codes, it involves sorting the various codes into potential themes and ordering all the relevant coded data extracts within the identified themes (Aronson,1995). Here the researcher starts to analyze the codes, and check if there is a possibility of associating these codes whilst taking into consideration the level of heterogeneity of the codes to embrace themes.

3.4.1.4 Phase 4: reviewing and evaluation of themes

According to Braun and Clarke (2006), the fourth step reviews how the data fit into identified themes. It begins when the researcher creates a set of themes, and it involves the alteration of those themes (Vaismoradi, Jones, Turunen & Snelgrove, 2016:101). During this phase, it becomes evident that some themes may not be themes, while others might collapse into each other, such as two separate themes and form one theme. Other themes might need to be broken down into separate themes. Additionally, the researcher should also take into consideration, Patton's (1990) dual criteria for judging categories in terms of their internal homogeneity and external heterogeneity. There should be clear and identifiable distinctions between themes, in a sense that the data within themes should adhere together meaningfully (Yardley,2000).

3.4.1.5 Phase 5: defining and refining themes

This phase is effected when the researcher has a satisfactory thematic map of data for the ultimate modifications (Ando et al., 2014:4). At this point, the researcher defines and further refines the themes which will be utilized for analysis, and analyze the data within them. Vaismoradi et al., (2015:102) clarify that to define and refine themes means to identify the essence of what each theme is about, as well as the themes overall, and determining what aspect of the data each theme captures. It is important not to try and get a theme to do too much, or to be too diverse and complex (Bazeley, 2009:13).

3.4.1.6 Phase 6: producing the report

According to Nowell, Norris, Whites, and Moules (2017:5), this phase is the initial phase where the researcher has already identified the themes and embarks on the final analysis. The stage of the write-up of this kind of analysis also takes place, where the researcher will be including data extracts that provide a concise, coherent, logical, non-repetitive, and interesting account of the data within and across themes. The researcher's write up must provide sufficient evidence of the themes within the data, that is, enough data extracts to demonstrate the commonness of the theme (Braun & Clarke, 2006). To facilitate this process, themes were assembled to help envisage the relationships between the different ideas communicated in the data. Linking the themes which indicate individual responses included more than once and those in which a link could be easily inferred between two or more themes.

From the above, it is clear that TA complements CER and PAR in that it provides opportunities for the views expressed in the FGD to be interpreted and analyzed in different dimensions and contexts, and to take into account factors that inform the co-researchers' cognitive levels of thinking, reasoning and doing things. The subsequent section discusses the relevance of PAR in this study.

3.5 THE RELEVANCE OF PAR IN THE STUDY

Discussions to enhance the teaching and learning of mathematical geometry was done with the aid of the objectives of the study as outlined above. The discussion was amongst the selected co-researchers of the study. The principles of PAR guided the discussion throughout, co-researchers participated by embracing the research principles of participation and reflection, empowering and emancipation as a team with a solidified aim to incorporate indigenous knowledge that is present in the communities in the teaching and learning of MG. The three features of PAR were applied, namely; a segment possession of the research process, analysis of the teaching and learning of MG at the TVET college, and the integration of indigenous knowledge in the teaching and learning process of MG (Jeffrey, Kiskotagan, Poudrier, Shea & Tomas, 2013:4). PAR allowed co-researchers in the study to segment possession of the research process in identifying the challenges experienced in the teaching and learning of MG, and co-researchers explored the possible means in which indigenous knowledge can be integrated into the teaching and learning of MG.

Amongst others, this study was determined to familiarize and emancipate co-researchers in the research processes as they are directly affected by the identified challenges. During the first discussion meeting, the research team (co-researchers) took ownership of the study by actively participating in the discussions, were enthusiastic to critically identify and address issues of concern to the teaching and learning of MG. The co-researchers also came up with alternative ways of the teaching and learning of MG. Local and indigenous knowledge of the rural teaching and learning were accepted when PAR methodology was used. PAR supported the researcher to gather data whilst adhering to the code of ethics of the University of the Free State. The researcher was able to monitor the discussion to ensure that the objectives of the study were thoroughly explored. One of the objectives of PAR is to provide the opportunity for co-researchers to take an active role and develop emancipatory skills (Jacobs, 2016:48). Hlalele and Tsotetsi (2015:148) stated that PAR centers on collaborative relationships and taking action to make social change by building the capacity of local communities to participate in the research. PAR in this study allowed participation of co-researchers in a democratic way to develop practical knowledge in the pursuit of worthwhile human purposes (Reason & Bradbury, 2001:1) because the settings of the discussions allowed the co-researchers to apply their knowledge based on their educational experiences and background concerning the college community.

During the five-phases of discussions, co-researchers cooperated to their greater abilities to achieve outcomes of the study considering the epistemology of PAR which states that knowledge is rooted in the experiences and lives of individuals and that knowledge is created through collaboration between the researcher and co-researchers (Bergold, & Thomas, 2012; Borg, Karisson, Kim & McCormack, 2012; Minkler, 2000; Savin-Baden & Wimpenny, 2007). The study acknowledged a proposition of organized social action to the change in Mathematics classrooms. As co-researchers engaged in the discussions, challenges in teaching and learning of MG were identified, proceeding with the SWOT analysis and then the team came up with possible solutions to the challenges, conditions for the successful integration of indigenous knowledge in MG were outlined, threats that would impede the progress were also stipulated and the last phase of the discussions centered around the evidence of success. This process was in accordance with the findings of Jabos (2016:49) when stating that researchers should work collaboratively with co-researchers to co-generate knowledge which addresses the identified problem. PAR as a method synthesizing local experience and organizing shared collective analyses of the relationships between problems and their causes (Tolsdorf & Markić, 2018:96). The study acknowledged co-researchers' local experiences of the lecturers and students. This acknowledgment is further argued in the next section where the suitability of PAR and CER in this study is evaluated.

3.6 THE SUITABILITY OF PAR AND CER FOR THIS STUDY

According to Tsotetsi and Mahlomaholo (2015:49), the impacts of CER are visible when it is coupled with PAR. PAR can generate local and useful information and record it in an accessible form (Kemmis 2006:471). PAR complements CER by generating knowledge enriched by different perceptions of co-researchers (Kemmis 2006:461), creating space for co-researchers' educational empowerment to change their lives. Consequently, the knowledge created is understood and owned by the people from whom it is derived (Ehrhart, 2012; Kemmis, 2006:463).

PAR can address the research objectives and more extensive issues of social equity, incorporation, and strengthening of the minority and regularly minimized networks and it connects well with CER, which advances the motivation for values and social equity, harmony, opportunity and expectation (Mahlomaholo, 2009:226). The combination of the two will assist me as a researcher to immerse myself in these qualities. I concur with Tshelane (2013:416) that PAR is an advanced strategy for conducting research. However, a direction to inquire is established in emancipatory developments, and it draws, in the co-researchers, so that their voices can be heard and regarded. The Study frees co-researchers by bearing them a chance to voice their perspectives on an issue that is influencing them, as of now and that will likewise influence them in the near future. The emancipatory point of CER (the hypothetical system for the study) combined with the characteristics of PAR are accomplished when individuals who never had a voice, can take a stand in opposition to issues which influence them once a day, through the way toward teaching and learning of MG.

In this study, PAR was seen as a proper match for CER. This combination allows the team (Principal researcher and the co-researchers) to yield rich indigenous knowledge epitomized in the communities and incorporate it in Mathematics classrooms. It would empower the voices of parents and communities in which the college is situated to be heard and captured. I, likewise considered PAR to be suitable for its significant inconsistency in the society in which the study intends are attempted. Following the rules of CER, of liberation, I assume that the utilization of PAR is beneficial to this study. I envision that PAR can make space for the unheard voices to be heard. PAR empowers people to assume liability for their very own development and history (Eruera, 2010:1; Kemmis, 2006:467). I trust these components could be actualized in this study as this will enable me to address the research question of this study. The next section gives a lengthy description of how approval was received from the relevant offices and authorities.

3.7 ETHICAL CONSIDERATIONS

This section discusses the ethical considerations that had to be given priority when conducting this study before data could be generated.

All ethical considerations were observed. Permission to commence with the study was sought from the Deputy Principal: Academic Affairs, Director of the TVET College in the Free State Department of Higher Education and training before data generation began. The second permission was granted by the General/Human Research Ethics Committee (GHREC) of the University of the Free State through this approval number **UFS-HSD2019/0040/0207**. This research was based on mutual trust, acceptance, cooperation, promises and well-accepted conventions and expectations between all stakeholders involved in the research. The co-researchers were assured of their freedom and confidentiality to participate and their right to withdraw from the study at any point should they wish to do so (McMillan & Schumacher, 2010:250). Participation was voluntary and the basic human rights of co-researchers were protected at all times during the research (McDonald, 2012:45). Co-researches were identified and informed of the nature and purpose of the research, as well as the procedures to be used and its benefits. The consent forms regarding the field and type of research to be conducted were made available to co-researchers for completion and signing. These forms stipulated the co-researchers' right to withdraw and anonymity was assured. Co-researchers in the study remained anonymous and were treated with respect.

Besides, PAR consists of a reflection element whereby, a group of people identifies a common concern (Eruera, 2010:2) and in this study, the co-researchers were not pressurized and were assured that the discourses will be fair, free and open. The potential benefits for the co-researchers were a pedagogical shift of moving from abstract methods of teaching and learning towards the authentic utilizing of the indigenous knowledge learning approach that will be informed by having emancipated learner-centered mathematical geometry lessons. This will allow students to respect cultural heritage and encourage them to know that all people are capable of doing mathematical geometry in their unique perspectives.

The researcher must accept responsibility for maintaining confidentiality throughout the research process (Baum et al., 2006:6). The researcher remained responsible for the ethical quality of the study. Anonymity is to be kept as the names of the co-researchers and the school where the research is conducted cannot be revealed. According to O'Brien in McDonald (2012:46), the ethical principles of PAR are clear that all decisions regarding the direction of the research and probable outcomes are collective. Research findings and results are open and available to the public in a written form. The researcher must be explicit about the nature of the research process from the beginning, including all personal preferences and interests, while ensuring that there is equal access to information generated by the process for all co-researchers. I, therefore, anticipated having good working relationships through careful discussion and planning, as well as initiating how best this can maximize the potential benefits of the study. McDonald (2012:47) further attested that the researcher and the coordinating group discussion create a process that maximizes the opportunity for involvement of all co-researchers. The next section is the summary of chapter three that explains what is discussed in this chapter.

3.8 CHAPTER SUMMARY

This chapter addressed the research methodology and design. A detailed description of PAR as a research methodology in terms of its origin and benefits to this study was explored; the relationship between the researcher and the co-researchers; the key aspect of PAR and its application to this study and the suitability of PAR in relation to CER, which is the theoretical framework adopted for this study. Furthermore, ethical consideration was also addressed and co-researchers were sensitized of their rights and processes of confidentiality. The research design was outlined through the unpacking of how the FDG was utilized as a method of generating data, the selection of co-researchers and a description of the research site was clarified. TA as a method of analyzing data was described in detail. Lastly, the relevance of PAR in this study was given to serve as a conclusion thereof. The next chapter presents the data presentation, analysis, and interpretation of findings of data generated from the focus group discussions.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION OF FINDINGS

4.0 INTRODUCTION

This chapter focuses on data presentation, analysis and interpretation of findings. This study aims to enhance the teaching and learning of Mathematical Geometry using the indigenous knowledge approach. In this study, Indigenization was regarded as an act of adapting and transforming the educational landscape to incorporate indigenous knowledge into mathematical geometry lessons, as a way of teaching relevant concepts and ideas. Indigenization encourages a culturally responsive curriculum that addresses the needs, knowledge, and cultures of local communities. To achieve this aim, this chapter focuses on data presentation, analysis, and discussion of the data. The data presented in this chapter emanated from the deliberations that occurred in focus group discussions which were done in alignment with participatory action research (PAR) cycle, as a methodology for generating data and critical emancipatory research as a lens in which the study is viewed in. The generated data attempted to respond to the aim and objectives of the study and it was interrogated in the six steps of thematic analysis. This generated data builds on the constructs discussed in chapter three and the analysis of the main constructs of the five objectives, namely:

- To determine challenges prevailing in the teaching and learning of mathematical geometry and each challenge was explored separately.
- To determine possible solutions to the identified challenges in the teaching and learning of mathematical geometry.
- To identify conditions conducive to the teaching and learning of mathematical geometry.

- To anticipate threats that could evade the successful integration of indigenous knowledge in the teaching and learning of mathematical geometry.

- To indicate the evidence of success in the teaching and learning of mathematical geometry through integrating indigenous knowledge using the indigenous knowledge approach.

The analysis and interpretation of the findings was done with the aid of the transcripts of the discussions. Each of the five objectives was further divided into appropriate subheadings that are chosen and formulated in correspondence with the respective constructs that define the various sub aspects of the objectives arrived at in chapter two. Each subheading was discussed by referring to co-researchers' past and present experiences in the teaching and learning of MG, while making reference to literature compiled by the Principal researcher.

During the diagnosis phase meeting, we engaged in discourse to determine whether a common problem exists among the co-researchers, SWOT analysis (strengths, weaknesses, opportunities, threats) was conducted, whereby each co-researcher was assigned a task to come up with a plan on how indigenous knowledge can be incorporated in the MG lesson or assessment with the main aim of encouraging students' interaction and hands on activities that employ indigenous artifacts. The data presented here was generated through face-to-face deliberations, recordings, audio transcription and reflections of the pilot assessment task (PAT) formulated by the research team. In substantiating the discussions, each phase was thoroughly ironed out, where co-researchers presented the evidence of their side of the arguments in the form of spoken words, whereby some co-researchers even went to the extent of painting verbal pictures and scenarios. The extracts captured in this chapter are direct quotations of the utterances made by the co-researchers as audio transcriptions were not edited. The co-researchers were indicated by means of abbreviated pseudo-names, such as Head of Department one, and two (HOD 1, 2); Maths Specialist one (MS1); Maths Senior Lecture(MSL); Maths Lecturer one and two (ML1 & 2); Former Lecturer(FL); Student Tutor (ST) and Student one and two (S1 & 2), bearing in mind the fundamental principle of PAR, that of empowerment and emancipation also supported by Wicks and Reason (2009:246). All the co-researchers were equivalent and their inputs were not regarded based on these pseudo profiles. These extracts were analyzed against the literature referred to, as well as in the contexts of CER as the theoretical framework of the study to show the role of power differences. The next section unpacks on the identified challenges prevailing in the teaching and learning of MG.

4.1 THE DETERMINATION OF THE CHALLENGES PREVAILING IN THE TEACHING AND LEARNING OF MG

This section analyzed and discussed data based on the understanding of the challenges faced by the lecturers and the performance of students regarding the teaching and learning of Mathematical Geometry in the NVC program at NQF level 4 in the College. The research team diagnosed the challenges experienced in the teaching and learning environment that simultaneously addressed the first objective. These challenges were picked up to be, Lack of Visualization Skills, Attitude and Beliefs, Abstract presentation of concepts, students omitting reasons when determining the angle in the theorems and students being unable to relate the Mathematical Geometry taught in the classroom to their everyday lives. As such, the subsequent section outlines these challenges in subheadings in line with the constructs set in chapter 2 (see section 2.3.1).

4.1.1 Lack of Visualization Skills

The first challenge that was discovered during the FGD meeting was a lack of Visualization skills by students. According to literature, visualization of the Geometrical shapes and or figures (making mental pictures and drawings) also has the potential to lead to the selection of appropriate operations and the attainment of the correct solution(s) to the problem (Moleko, 2018:129). Supported by Teahen (2015:28), when maintaining that without the ability to visualize, students may find it difficult to tackle geometry problems. During our discussion, it was revealed that visualization of the shapes and or figures is important in clarifying the properties of the shapes, thus making it easier for students to recognize how they must go about answering the questions. Although the co-researchers believed that visualization is important when dealing with this Mathematics concept, they acknowledged that it is a skill that most students lack and it was through these statements that this problem does not lie with the students only, but with the lecturers as well. See the below statement:

MS1: "*Pictures are very important in imprinting knowledge in one's mind. Students Inability to identify various orientations of Geometric figures affect their Performance in the sense that they cannot interpret questions on their own."*

HOD 1*: "Lecturers do not have enough resources to teach MG in the classroom. MG is a practical topic hence lecturers and student have to always engage in visual and tactical style of teaching and learning when dealing with this concept."*

HOD 2: *"Student is often unable to comprehend the purpose of geometry, as a result of being unable to visualize as lecturers tend not to bring teaching aids that allows the student to see the various shapes as the lecturer tend to verbally present the shape to the students and due to the student's inability to create pictures in their minds they tend to experience difficulties in geometry."*

The above extracts seem to be in line with the research findings of Yilmaz and Argum (2018:53) when emphasizing that visualization has a strong complementary role in the teaching and learning of MG. Thus, the extracts indicate that students are lacking the skill to visualize mathematical geometry shapes (internal visualization). According to MS1: "Pictures are very important in imprinting knowledge in one's mind". This statement shows the importance of visualization in the teaching and learning of MG and it outlines the fact that in absentia, HOD 2 stresses the important role of Mathematics Lecturers that they have to play in retrieving this skill as stated: "due to the students in or minimum evidence of students' ability to create pictures in their minds leads to them experience difficulties in geometry". HOD 2 gave a clear explanation of what contributes to the student performance in MG. Not only these statements, but the literature also highlights that lack of this skill is a challenge (see Section 2.3.1.1) of this study. However, HOD 1 has revealed the reason for this challenge when stating that "Lecturers do not have enough resources to teach MG in the classroom". According to this statement, MG is a practical topic, hence lecturers and students have to always engage in a visual and tactical style of teaching and learning when dealing with this concept. MG necessitates Lectures to bring teaching aids or to a larger extent encourage students to interact with each other through the engagement of practical activities that will assist students to recall MG shapes and their properties respectively, as a result of being physically exposed to them.

From these statements uttered, it is also clear that the failure to internally visualize MG shapes and or figures makes it difficult for students to understand the various properties associated with these shapes and or figures respectively and this consequently, leads to students mixing up the important and relevant information expected to be presented during assessments and not perform well in the Mathematical concept in general. The below statement also shed more light in my argument:

S1:*"Some of us learn and understand better if we see pictures or diagrams. Lack of resources or various types of teaching aids is one of the factors that contribute to the challenge of visualization as a lecturer is only dependent on the figure provided in the textbook."*

This statement is supported by the utterance of HOD 1 and HOD 2 above that resources play a very important role when coming to present abstract Mathematics concepts like geometry. Lecturers' teaching methods and the lesson preparation have a great contribution in as far as using teaching methods that encourage student participation and those that trigger their enthusiasm in the classroom. In section (2.2.3.4), the Principle of Individual Emancipation support a process of critical self-reflection and associated self-transformation. Lecturers should support and scaffold their students' enthusiasm in this concept. The textbook is not the only source of information. This indicates, to a certain extent, that the lecturers do not make an effort in their teaching to teach in a manner that promotes students' visualization skills. To further expose the visualization problem, the below conversation becomes key:

HOD3: *"Most of the lecturers see geometry as an abstract concept and they have no enthusiastic when coming to the dissemination of this concept in* *class and this tend to demotivate students towards the concept in general and this leads to the student not even attempting to visualize the mathematical shapes used in this topic."*

Analysis of the above extracts shows that students are unable to visualize problems, geometric figures and or shapes. Furthermore, the lecturers make no effort to promote visualization skills in students. The teaching of MG is presented in a mere traditional manner, whereby students are given problems and are expected to provide answers only. Students are not asked to apply their prior knowledge; prior knowledge is not even elicited from the students. Thus, this kind of practice reflects convergent right-answer thinking and predictability, which does not contribute positively towards students' growth and cognitive levels of thinking enhancement in the MG concept. PAR in this regard contributes to the democratization of the research procedure and the development of social change (see section 3.1.3.1) as it allowed the co-researchers to describe the challenges in a democratic way, being free to air their views from their perspective. This facilitated a deeper meaning of what was deemed to be the challenge and its causes. Moreover, CER endorses the notion that the problem must be understood for sound solutions to be devised for a problem to be addressed (see section 2.2.5). With this in mind, my personal interpretation from the conversation above is that students' inability to visualize the MG shapes and or figures is a challenge that needs to be addressed. The next subsection adds to this by describing the next challenge retrieved from the discussions as attitude and beliefs.

4.1.2 Attitude and beliefs

The other challenge that emanated from the discussions is that Negative attitude and beliefs is a worrying factor in the teaching and learning of MG, as it affects the performance of the in Mathematics in totality. According to McLeod (1992:575), factors such as attitudes and beliefs play an important role in Geometry achievement. If the attitude of the students towards Geometry is positive, students will perform well. According to Stuart (2000:330), students' and lecturers' attitudes toward geometry should be positive to influence students' confidence in Geometry. In section (2.3.1.2), literature has shown that students who have positive attitudes towards their lecturers have high achievement levels. According to Fennma and Romberg (1999:1), it is not only the lecturers' beliefs about geometry and its usefulness that are important, but also that the lecturers' beliefs about their students' ability to do Geometry have an influence on how it is taught and subsequently, on how students understand it. This was also attested by the co-researchers' statements during our discussion in vehement terms in the extracts below:

FL:*"Most of the students show a negative attitude and lack of interest towards MG as compared to other mathematical concepts. Student find MG as a demanding concept that requires visualization and analytical skills which to them it is a challenge all together."*

ML1:*"Students lack confidence in MG and this, in turn, makes them suffer from anxiety, this makes them not focus in class and ultimately miss out on the knowledge taught per lesson. This as a result of anxiety student ends up having an attitude towards MG."*

S1:*"Students attitude when coming to mathematics as a subject is very different as compared to other learning areas, reason being MG need time for practice, re-doing what was done in class alone in your own spare time and this is what tends to bore most students hence many opt to go do mathematical literacy instead."*

After listening carefully to what FL, ML1 and S1 said, I deduced that students have an attitude towards Mathematics subject as a whole. They have the belief that this subject is difficult. Students tend to treat Mathematics with the same attitude as other learning areas, not looking at the fact that this learning area requires different angles of practice. Judging from personal experience, mathematical geometry is a learning area that requires students to invest more time in it. As a result, the students tend to opt from doing Mathematics and resort to mathematical literacy as they find it demanding (FL).

In support of the above utterances, literature reveals that lecturer attitude and belief plays a vital role in learning institutions (Castro, Expósito-Casas, López-Martín, Lizasoain, Navarro, Asencio & Gaviria, 2016:175). For instance, most of the time, if lecturers dislike a specific content, their students will also dislike that particular content, and vice versa. In support of the above statement, I have personally experienced this. If lecturers do not feel comfortable with specific content, they do not emphasize it when teaching it, nor make an effort to teach it in a stimulating manner. They just cover the specific content because they must provide evidence to the higher authorities (e.g. HoD, subject advisors, etc.) that the topic has been dealt with. In some extreme instances, they choose not to teach the content at all. In this context, CER plays a pertinent role in interrogating forms of power and knowledge in teaching and learning pedagogies, challenging the assumptions that Mathematics is difficult, whereby the potential of students is often taken for granted (Dube, 2016:31). This type of practice deprives students of the opportunity to comprehensively learn mathematical geometry, as it is one of the problematic concepts. However, this places students at the "receiving end". In other words, the students are in a position where they cannot control the content they are presented with or how the content should be presented or taught to them.

In ML1's utterances, a student does not have confidence when doing MG. They tend to have anxiety that contributes negatively towards their level of focus and paying attention to what is thought or learned in the classroom. It is common knowledge that people often refrain from doing "things" they are not confident to do, especially when they have to do these things in the presence of others, whom they regard to know more than they do. The act of refraining from participating in-class activities in this instance may also be attributed to the fact that those who lack the confidence to do certain things in the presence of the others, may be one of the contributing factors of anxiety. In addressing this challenge, the collaborative aspect of PAR recommends social association amongst students (see section 3.1.3.2). The opposite of this perception holds – if a person is confident about doing something, then the person will be able to do it with ease in front of others, without fear of being ridiculed. My analysis is that, students who participate freely in-class activities, as indicated by ML1 have a better chance of following and easily assimilating the content taught and consequently, students who are not partaking in classroom activities, ultimately miss out on what is taught. As a result of a lack of confidence and anxiety, most students do not do what they have learned in class at their own space (Not Practicing). My analytical reflection of the above discussion is that, indeed lack of positive attitude and belief is a challenge in the teaching and learning of MG. The following subsection also elaborates on the other challenge that contributes to the hindrance of students not performing up to expectation in MG, which is abstract presentation of concepts.

4.1.3 Abstract presentation of concepts

The third challenge that was discussed in the FGD meeting sessions was that of abstract presentation of concepts. It was raised by co-researchers that most lecturers believe that Mathematical instruments, calculators and textbooks are the only relevant materials used in the teaching and learning of geometrical concepts. This idea was crystallized in literature According to Nel, Nel and Hugo (2016:46), students grasp concepts better when they see, hear and touch, when there is a mixture of visuals and tangible interactions. These students support materials to create a classroom which is dull, lacking an element of various teaching methods as deduced from the following statements:

ML2:*" The teaching of Mathematics in general at TVET Colleges is still done in an abstract way of teaching, whereby lecturers fail to conceptualize . concepts as lecturers tend not to aim at delivering this concept of MG in a simplified manner."*

S1:"*An abstract lesson gives room for passive learning to take place and as a result route learning becomes dominant in the classroom. As a student we are ignorant and if the lesson is not triggering our curiosity and inquisitions we tend to memorize."*

Teaching methods need to encompass the encouragement of the development and the use of conjecturing, deductive reasoning and proof, as well as developing skills of applying Geometry through modeling and problem-solving in a range of contexts (see 2.3.1.3). The above quotations imply the teaching of Mathematics seems to be more lecturer-centered in the sense that the lecturer dominates the classroom proceedings by relying on the traditional method of teaching, i.e. the lecture method or the chalk, textbook and talk method. This method of teaching is based on the direct transmission of knowledge from the lecturer to the students. Students' learning styles are often not accommodated by this method. Part of this is evidenced in the statements below:

HOD 2:" *Sometimes presentations of concepts such as MG is a challenging issue on its own. Our textbooks nowadays have a few examples that one can refer to when preparing for an MG lesson."*

HOD1: " *It has come to my attention that lecturers do not do MG practical rather they focus on the audiological part of it, which reduces the concentration span of students to other topics."*

My analysis of HOD 1 and 2's utterances is that abstract presentation of concepts creates students who are passive recipients of knowledge in class, consequently resulting in rote learning. The co-researchers seemed to agree that this teaching method limits students to only know what is in the textbook. It does not prompt students to interact in problems of the real world that incorporate cultural artifacts as suffixes in HOD 2's statements that the examples in the textbook are limited. Supported by literature is that additional resources are needed for content presentation and lesson preparation (Baloyi-Mothibeli, 2018:86). From the discussion of this challenge, I conclude that this approach does not regard students as co-creators of knowledge in the learning process and it elaborates a need for lecturers to assume the role of a guide and facilitator in the learning process, which is in disagreements with the principles of CER. This does not imply that I am against the lecturers at the college, but it is my understanding that a classroom consists of different students from different background to whom a variety of learning styles should be a priority for lecturers when preparing lessons. The ideal for student-centered teaching is also based on different learning styles exhibited by the students that gel well with the mandate of CER, theory, and practice in pursuit of finding a practical solution (see section 2.2, Noel, 2016:12). In acknowledgement of the discussion, deliberation and the co-researchers' utterances, it is evident that abstract presentation of concepts is a challenge.

The subsequent subdivision discusses the other challenge as being students omitting reasons when determining angles in circle theorems.

4.1.4 Students Omitting geometric reasons when determining the angle in the Circle theorems

The fourth challenge that was pointed out by co-researchers in the FGD is that of students omitting geometric reasoning when determining angles in the circle theorems. According to literature, there should be a distinction between the student's prior knowledge of MG, the MG experience in the classrooms and abstract geometry, with regards to the discipline of creativity, problem-solving, and discovery, about which they are told, but have not yet experienced (Klemm, 2007:3). During the deliberations, co-researchers indicated that students' performance indicates that they failed to recognize when valid inferences should be made from logical implications under different circumstances. In addition, Baloyi-Mothibeli (2018:104) argues that students are faced with a common cognitive challenge in their reasoning with logical implications in both the arbitrary and mathematical geometry context. Both types of tasks required them to justify logical implications, either arbitrary or mathematically meaningful, based on consideration. This was further emphasized in the statements below.

FL:*"Majority of students can determine angles but they find it difficult to give reasons for their answers. This is due to a lot of geometric terminologies, lack of logic in solving MG questions. This as a consequence of students not being exposed to proper key vocabulary term in lower grades."*

HOD 3: *"On the other hand Language is a barrier. One can recall that schools situated In the Rural Areas communities, English is done as a First additional Language, so if student do not understand the terms or key vocabulary used in these concepts, they tend to mix things up a provide correct angles with no accompanying mathematical reasoning."*

HOD 1:*"Students struggling with recalling the reasons because of a language barrier the lecturer does not provide the student with acceptable reasoning from the exam guidelines at times."*

What the above statements communicate in general is that students encounter problems when using a 1st additional language to learn Mathematics in general, Geometry in particular. The use of English as a medium of instruction in the South African classroom in black schools is one of the reasons for poor performance in Geometry. The issue concerning first language problems has a bearing on learning Geometry by the inductive approach, since it involves reading and understanding instructions. The utterance of HOD 1, "Language is a barrier" clearly elaborates a challenge faced with students in as far as mathematical reasoning is concerned. Students need to understand what does the word Supplementary, Tangent, Circumference, Centre of a circle, etc. mean, for students to be in a position of analyzing the relationship that exists between angle and their surrounding figures and or shapes. Hunter (1990:34) believes that language-related obstacles that hinder maximum performance in Geometry might be as a result of non-usage of ordinary English and the language of Mathematics. Referring to the FL's statement, "students not being exposed to proper key vocabulary terms in lower grades". The lecturer must structure their lesson in such a way that students get a clear picture of what is being taught. For example, an Arc of a circle, the lecturer has to unpack what an arc is…. How it can be recognized on a given cyclic quadrilateral through the usage of ordinary English at the beginning of the lesson. The usage of the Key Vocabulary list, as stressed by HOD3 in support of HOD 1's utterances of the contribution of the geographical orientation of students in the Language of learning and teaching (LoLT).

ML1*:"If a lecturer use an abstract method of presenting concepts, student tend to use a Rote learning and just memorize the theorems, once the theorem orientation changes, it becomes difficult for the student to can identify some angle as they know them but the theorem changed."*

HOD 2:"*Student not providing reasons when determining angle is an indication that the a student is not yet competent in the MG concept. This is because of reasoning skills are not enhanced through-out the lesson, as theorems are answered in routine procedural steps (Well Known Steps) and the reasoning part of the the answer is informed by student turning a blind eye on the set mark allocation of a given question."*

Moleko (2014:88) asserts that without student participation, it can be difficult for lecturers to track the student's progress and identify areas of difficulty or any misconceptions that might be experienced by students. The statement uttered by ML 1 coupled with HOD 2, cautions lecturers to timeously track and ensure that students are following through-out the lesson, which may, in turn, enhance students' participation in class. This is in line with the CER principle of inclusivity and active participation in the sense that people should not be limited in participating actively and fully. Thus, any form of obstacle which may keep the students from participating should be dealt with and eliminated. In this case, the use of English, even though it comes with many benefits, where it limits participation and becomes a "barrier" towards the learning, needs to be dealt with using proper channels. Not only this, but the succeeding subsection discusses the other challenge of students being unable to relate the MG taught in the classroom to their everyday lives.

4.1.5 Students being unable to relate the Mathematical Geometry taught in the classroom to their everyday lives

The research team identified the fifth challenge as the inability of students to relate the MG taught in the classroom to their everyday lives. This involves the engagement of students in activities that are designed to bring the abstract mathematical geometry concepts home. The team was in agreement with literature when stating that indigenous knowledge, in general, can be used to promote and concretize the teaching of Mathematics content in a multicultural classroom, for enjoyment and for the promotion of Mathematics (Moloi, 2014:187; Nkopodi & Mosimege, 2009:377). With this approach to teaching and learning of MG, students will be able to retain what they learn in the classroom and recognize the impact of what they learn at the institution as confirmed by the comments below.

HOD 2: *"It is due to the abstractness of MG that student is unable to see the link between what is taught in the classroom and what they see or do in the real-life situation. Students' homes and environment play an important role in the development of knowledge (Cognitive levels of thinking)."*

ML1: *"Lecturers appear to have more trust in the textbook and has resorted to its utility holistically. Teaching aids have always been the best demonstrator of what the* *content entails. These aids can assist to close the gap that seems to be existing as far as linking the environment to the classroom content."*

FL: *"As a nation, we proclaimed our independence as total liberation from the chains of the colonial power, but yet the liberation of the people's mentality is still a big challenge and the curriculum taught in the institutions is still culturally oppressed."*

S2:"*When teaching MG, Lecturers tend not to use practical examples that are applicable to our local homes (geographical Area), like the various types of roofing present in their communities to demonstrate the different types of angles, examples that are in our real-life situations."*

According to Mudaly (2018:68), Western knowledge is seen to be superior and universal and the erasure of intellectual and cultural contributions of non-western societies to the world at large. There is this dominant belief that the re-appropriation of indigenous knowledge that has been relegated to the realms of irrelevancy through the process of recognizing that only Western and European knowledge is both useful and germane, is essential to the decolonizing process and this is what FL's statement indicates. Lack of resources, such as basket weaving techniques, arithmetic and local languages, children's self-made toys, Sona drawings, traditional architecture, traditional games whereby lecturers only rely on textbook as the only source of information is evidence enough that there is a need for indigenous knowledge to be incorporated into the teaching and learning of mathematical geometry. The need for lecturers to bring indigenous teaching aids to the classroom cannot be overemphasized as deduced from ML1's statement: "Teaching aids have always been the best demonstrator of what the content entails".

In relation to these utterances, experience has taught me that students are diverse and they learn using different learning styles. It is therefore crucial that a lecturer prepares each lesson with this knowledge in mind. These different teaching and learning styles can be visibly demonstrated using different types of resources that require thorough preparation. My understanding of these deliberations is that, it is through proper understanding of the concept thought that students will be able to take what they have learned in the classroom home and relate it to their everyday lives. On the other hand, the usage of such teaching aids can follow the example done by S2 above. This is in line with CER principle of human lives improvement (Dube, 2016:30). These teaching aids or resources can be outsourced in the local communities with the help of the parents and various stakeholders. In responding to these identified challenges, the principal researcher found it proper to also skeleton the possible solutions to the identified challenges in the subsequent section.

4.2 POSSIBLE SOLUTIONS TO THE IDENTIFIED CHALLENGES IN THE TEACHING AND LEARNING OF MATHEMATICAL GEOMETRY

This section deals with the solutions proposed by the research team towards solving the problems identified (See section 4.2). There are some factors that influence effectiveness of lecturers in the classroom. Factors such as, how the lecturer prepares for the lessons, the teaching strategies they employ, beliefs about teaching, the indigenous teaching aids or resources utilized in the lesson and the general classroom process that provides an immediate learning environment in the teaching and learning of Mathematical Geometry (Baloyi-Mothibeli, 2018:119). Teaching strategies can be classified in various cultural ways: for example, lecturer-centered or student-centered. According to this study, lecturer-centered strategies are those in which the lecturer has direct control over everything in the classroom, while student-centered strategies are those strategies that allow students to take an active role in the learning process. The following are the suggestible solutions according to the data generated: a strategy to improve visualization skills, student interaction to enforce positive attitude and beliefs in the teaching and learning of MG, lecturer collaboration and indigenous teaching aids as means to eliminate abstract presentation of MG concept, strategy to improve students' understanding of mathematical geometry vocabulary and practical assessments as a strategy to assist students to relate the mathematical geometry taught in the classroom to their everyday lives. The next subsections outline these solutions in line with the constructs set in chapter 2 (see section 2.3.2).

4.2.1 A Strategy to improve Visualization Skills

The first solution that was discussed as possible strategies to improve students' visualization skills in the teaching and learning of MG was Concrete Pictorial Abstract (CPA) and technological aspects in a form of indigenous artifacts. With reference to literature, Mathematical visualization is the process of creating images or constructing mental representations and using such local images effectively for mathematical discovery and understanding (Scriven & Paul, 2005:2). Scriven et al., (2005:2) notes that critical thinking is a mode of thinking about subject content or problems in which the thinker enhances the quality of their thinking by skillfully taking charge of the structures inherent in thinking and striking intellectual standards upon them. Furthermore, Campbell et al., (1995:177) further encourage the development of culturally related visual images and intuitive skills in all the developmental processes. Not only that, but the data generated during the team discussion also reflects the above suggestion by the literature. Some of the co-researchers said the following:

HOD 1: *"Since we are in the 21st century, this generation of students are more interested in technology, Imagine if MG was to be taught using technology, as opposed to the old school way? If the technology that incorporates local knowledge was to be integrated into the teaching and learning of MG? this would assist in eliminating the abstractness of the concept Geometry. For example, teach students using software that contains familiar material such as making use of videos of indigenous things for Geometry lessons and learn from those contents in the videos. Even us as lecturers we could prepare our lessons in a more interactive way like using power point presentations that contains those familiar indigenous local materials. That could increase the interest of students in attending classes".*

HOD 2: *"Lecturers must use different teaching methods. The issue of resources is very crucial when it comes to Mathematics because if a lecturer relies on textbooks Only that results in a problem. Alternative teaching methods such as Concrete Pictorial Abstract (CPA) method that employs indigenous Teaching Aids."*

In line with the above statement, it indicates a solution derived from both the students and the lecturers' side of teaching and learning. I agree with HOD 1's statement that times have changed and development is taking place continuously. This generation of students is digitally inclined. For lecturers to entice the interest of students in MG as a concept, amongst the indigenous teaching aids or resources we can utilize in the lessons, technology takes the first seat.

My reflection of these statements is that, resources can assist lecturers to present the various geometric shapes and or figures, visibly display their properties using cultural artifacts and display the connection thereof. These could be done in a simplified manner, such as using power point slides to display the indigenous information that is no longer prevailing in the communities that will serve a great contribution to the teaching and learning of MG, coupled with the CPA method mentioned by HOD 2. From the textbooks, Geometry is abstract, but it could be easier for students if a lecturer could apply the CPA method. As uttered by HOD 2: "…Since there is an issue of load shedding, it suffices for one to resort for a different teaching method in the classroom…" Supported by literature, Leong, Ho and Cheng (2015:2) state that majority of students prefer visual learning style, which utilizes characteristics maximized by concrete pictorial and abstract approach (CPA). The co-researchers agree with Presmeg (2014:2) when avowing that all mathematical problems involve geometric reasoning. Therefore, the presence of indigenous visual images is important in developing students' visualization skills. Sabean and Bavaria (2005:1) suggested that the development of practical meaning for geometrical concepts can be enhanced using indigenous teaching aids and this statement is supported by Mertens (2009:12) when stating that knowledge constructed from the reference of those most affected by the issue is very important (see 2.2.3). I therefore summarize this section by noting that the strategy firmly believes that indigenous teaching aids are significant and relevant in improving students' visualization skills. The next subsection discusses students’ interaction in the classroom as a means to enforce positive attitude and beliefs in the teaching and learning of MG.

4.2.2 Students' interaction to enforce positive attitude and beliefs in the teaching and learning of MG

The other possible solution that was identified is that, students' interaction through the aid of lecturers and parents' facilitation can assist in elimination of negative attitude and beliefs in the MG concept. The team emphasized in agreement that students' attitude in the classroom is vital. This was argued by Makina (2010:24), when stating that students are not born with the power to think critically, nor do they develop this ability naturally. Attitude and beliefs are learned and assimilated abilities and their development needs to be facilitated. In support of Makina's claim, Campbell, Watson and Collis (1995:177) encourage lecturers to guide and develop the students' interaction so that they can become mathematically competent and critical students. This was also highlighted in the below extract from the co-researchers' statements:

ML2:"There is a saying that says attitude determines altitude. Therefore, attitude is very important and the lecturers should love the subjects that they teach. This is because, if lecturers love their subjects, they will go the extra mile and see to it that the students understand. Remember that these students come from families whereby they are being told by their parents that they also failed to master Mathematics and they gave up along the way. Students come with that mentality in the classroom but we as lecturers should remove that perception in students. We should also try to check the concept and relate it to other subjects and real-life situations. In that way, students will have an interest in learning."

According to ML2, this challenge of attitude is not only on the side of the students, but with the lecturers and parents as well. This is based on the analysis of this statement: "students come from families whereby they are being told by their parents that they also failed to master Mathematics and they gave up along the way". Parents' support plays an important role when coming to scaffolding the way students perceive MG. The usage of various indigenous teaching aids will assist in appetizing the student interest in the classroom and reduce the anxiety of doing Mathematics as a Learning Area. ML 2 also gives clarity that in order for all the stakeholders involved to beat this challenge, students should be made aware that most of the concepts covered in Mathematics have a relation with other learning areas and that, if they master these concepts, such as MG, in learning areas such as Physical Science, their cognitive levels will be enhanced and they will be competent in tackling them. Also, confidence in learners is vital. This is mentioned in the below statement by one of the co-researchers:

MT:"*Peer teaching in a form of tutorial sessions in which students will interact with their peers who had passed that level with good marks previously. This will assist in enhancing the student's confidence as group interaction will be encouraged in these sessions."*

The principle of individual emancipation (in section 2.2.3.4) reflected in MTs' extract when stating that peer teaching can also assist in building students' confidence as a classroom consist of various students from different backgrounds. Some are outspoken, some are shy and in order for the lecturer to reach out to them, they should encourage students to interact with each other and build on their level of understanding in a form of tutorial sessions. It is supported by Tshelane (2015:28) when clarifying that CER believes in transformation for the better, a diminishing of the "human condition or emancipation and it does so by providing a better self-understanding of the social agents who aims at transformation". Thus, using this type of teaching interaction will not only help students in their academic performance, but also forge a meaningful connection between the students, tutors and other stakeholders. Therefore, it seems that the utilization of indigenous teaching aids will help students understand mathematical concepts and process them easily. Such self-disclosure can lead to more opportunities for lecturers to provide a variety of meaningful assistance to all students with different cognitive levels. My analysis in this regard is that, attitudes and beliefs about Mathematics are dependent on: the students' level of interest and enjoyment in the learning of Mathematics; the appreciation of the beauty and power of Mathematics; confidence in using Mathematics; and perseverance in solving problems. It has come to my attention when analyzing the mood of the discussion that in trying to develop positive attitudes to the subject in totality, it is a mutual responsibility for both lecturers and students to make the learning of mathematical geometry fun and meaningful. Sabean and Bavaria (2005:1) examined research, which suggested that such a solution must be a balance between the enhancement of students' learning skills, relate practical activities with prior knowledge and new concepts to be learned. This method of discovery of new concepts will facilitate a deeper understanding of geometrical connections to assist both the lecturers and students to have a positive attitude towards MG. In support of the deliberations, Makina (2010:24) reported that students' interactions should be applied continuously, as the long-term use of indigenous teaching aids will increase geometric achievement and improve students' attitudes towards Geometry. The above discussion indicates the significance of maximizing students' interaction in the classroom through the usage of peer teaching, as this will help uplift students' attitudes and anxiety in gaining self-confidence in their learning process.

4.2.3 Lecturer collaboration and indigenous teaching aids as means to eliminate abstract presentation of MG concept

Lecturer collaboration and the usage of indigenous teaching aids were identified by the team as possible solutions to eliminate abstract presentation of concepts. In the new Mathematics approach, the focus is on geometrical reasoning, justifying ideas, making sense of complex situations and independently learning new ideas. The deliberations amongst co-researchers led to the conclusion that students should be provided with opportunities to solve complex problems, formulate and test Geometrical ideas in Mathematics and draw individual conclusions. In support of this discussion is literature that stated that students should be able to interpret, analyze and discuss geometrical concepts in Mathematics, use demonstrations, drawings, and real-world objects, and participate in formal geometrical and logical arguments (Rensburg, 2013:156). The need for these is shown in the statements below:

S1: *"Patience is one aspect that is needed to be exercised by both lecturers and students to solve the prevailing challenges."*

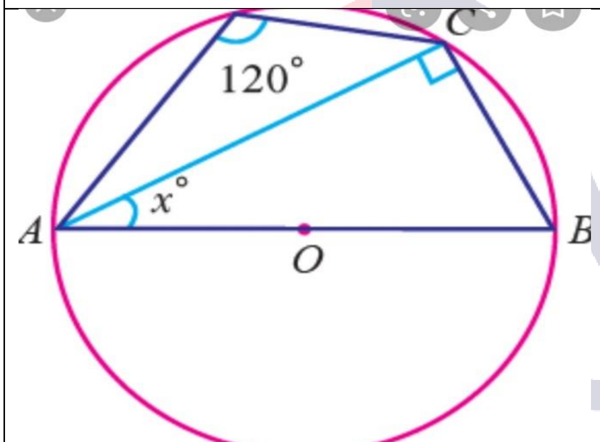
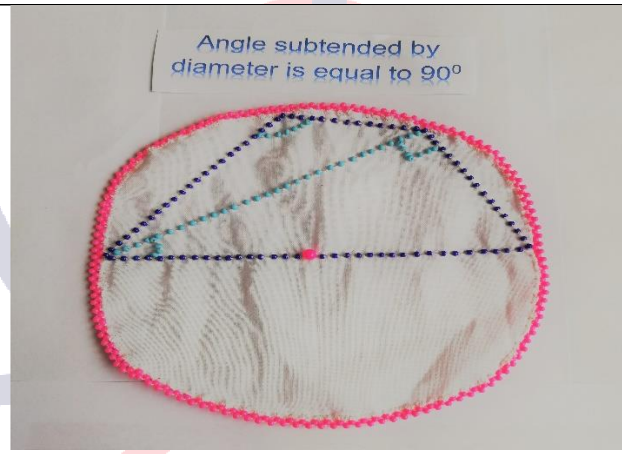
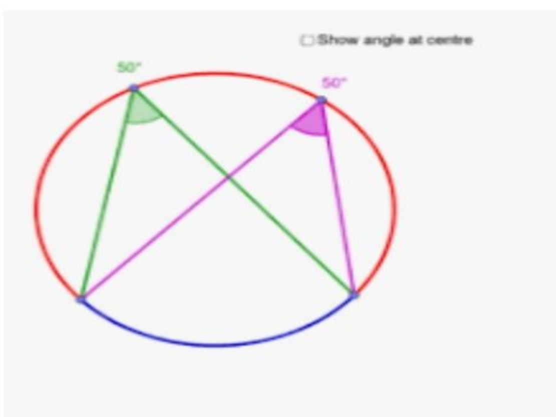
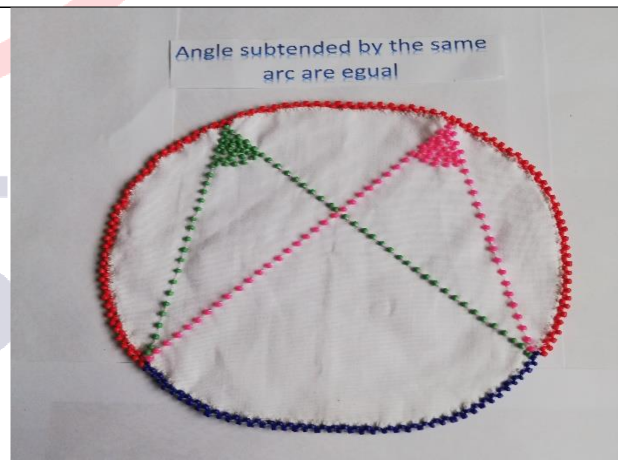
S2: *"Team teaching in a form of rallies can assist us as students."*

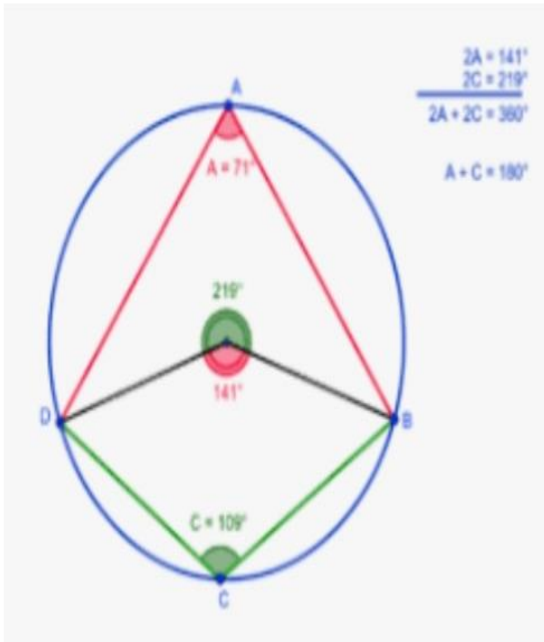
The above responses are prompted by the usage of traditional teaching methods. To indicate above, lecturers lack patience and in turn, tend to treat concepts abstractly. The proposal is that, lecturers need to come together and come up with ways to simplify this abstract concept and make use of team teaching. This method of teaching will assist the students to learn from a different school of thought and this will also assist the lecturers to learn from each other when presenting complex concepts like MG. By so doing, lecturers will be aligning themselves with the CER principle of collaborative working, where they will be sharing good practice whilst building and empowering each other. Teamwork among the Mathematics lecturers to assist one another, will also encourage the HODs to support this motion to be explored on an ongoing basis. In addition, PAR encourages translation of multiple diverse perspectives, skills and experiences inherent in the education community, and this ensures the success of this collaboration strategy (Hlalele & Tsotetsi, 2015:143). This is indicated in the below statement from the co-researchers:

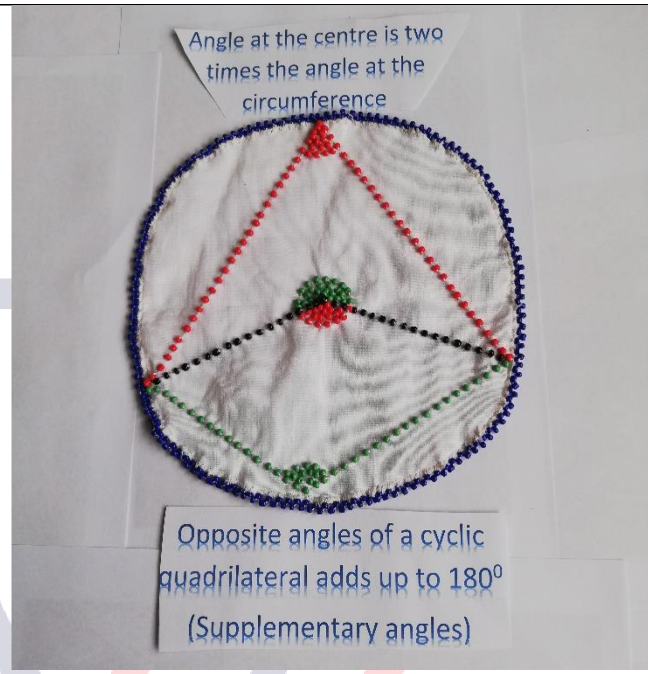
HOD 2: *"Lecturers must use different teaching resources such as indigenous teaching Aids. The issue of familiar or local resources is very crucial when it comes to Mathematics because if a lecturer relies on textbooks only that results in a problem."*

Indigenous teaching resources cannot be overemphasized. As uttered by HOD 2 earlier, lecturers should seek new, familiar and or local researches and approaches to tackle the issue of mathematics geometry and how Geometry can be taught to assist students in learning MG in and outside the classroom settings. Confirmed by the statement above is that, the mathematical geometric concept should be demonstrated and understood in material form as a reflection of reality and not only as drawings on paper or chalkboard.

An informal practical approach to Geometry that is intuitive and experimental has to give students imagery and dynamics through the design and construction of indigenous artifacts. This involve students interacting with the lecturer, sharing ideas amongst themselves and hence, assimilating MG meaning through new concepts introduced to them in the classroom in a bi-directional manner: for example, during the Action plan phase (See section 3.3.2.3). A Practical Assessment Task (see Appendix I[1]) was formulated by co-researchers with the aim to give students an opportunity to do research based on Circle Theorem Geometry, whereby students had to work in pairs to construct these theorems accompanied by geometric reasoning using beads as one form of indigenous teaching aids and the outcomes were thus, as follows in the figure below:

Circle Theorem Geometry	Indigenized Circle Theorem Geometry
	
	





Source: Van Rensburg (2013:156)

Figure 4.1, Circle Theorem Geometry

In the figure above, students managed to acquire geometric experience cooperatively. They were able to apply their experience to appropriate situations. In the table above, the first column consists of Circle Theorem Geometry as indicated in the Future manager (Van Rensburg, 2013:156) and the second column consists of indigenized Circle Theorem Geometry constructed by students in responding to the instructions of the PAT. This practical assessment of designing and constructing indigenized geometric theorems using beads seemed to have encouraged students to develop and explore their creativity and to exercise their spatial sense. I therefore analyzed from the deliberations that specific learning strategies and styles should be timeously encouraged by the lecturer to students. Thus, Students should be allowed to demonstrate their abilities to interact with new knowledge and invent their ways of doing Mathematics using learning strategies that suit their needs. This is in line with the research findings of Mamali (2015:111), when stating that hands-on activities will provide students with the opportunity to investigate, build and take apart, create and make drawings, and observe about shapes in the world around them.

In juxtaposition, these utterances have led me to conclude that the College should largely provide a platform where students can interact with each other using indigenous teaching aids in the teaching and learning process. As supported by Mamali (2015:111), group interactions method is one of the most effective learning and effective methods of in increasing students' achievement in Mathematical Geometry. In analyzing all these undertakings, my interpretation is that the learning process should therefore not be structured to lead to a set of procedures or methods that only the teacher approves of. The above discussion indicates the essentiality to ensure that lecturers should collaborate in team teaching endeavors that will make use of various indigenous teaching aids to do away with abstract presentation of MG at the College settings. Adding to the solution is the next subsection that discusses a strategy to improve students' understanding of MG vocabulary.

4.2.4 A Strategy to Improve students' understanding of MG Vocabulary

The other solutions that responded to the need to address the challenges in the teaching and learning of MG, is the utilization of the key vocabulary list at the beginning of each lesson as a strategy to improve students' understanding of MG terminology. The mathematical vocabulary plays a significant role in enhancing students' understanding of mathematical geometry content. The language of Mathematics has its vocabulary. Therefore, a lack of understanding of the mathematical vocabulary and register can potentially present challenges towards successfully solving word problems, causing misapplication of opposite mathematical operations. In line with this, the co-researcher pointed out that:

FL:"*Language is very important, that is why I think when you teach students you should speak in a language that accommodates all of them by using materials such as Key Vocabulary List at the beginning of each lesson.*"

The extracts advice that there should be careful reviewing of the construction of words and lecturers should try to by all means possible to prepare lessons in such a way that explains the ambiguous words thoroughly to the students through the usage of various teaching methods and aids to provide thorough clarity. This boils back to the type of lecturer and lecturers' stand in front of the students. The type that teaches the students with the utmost aim of empowering them using the formal or hidden curriculum.

The above utterance by FL indicates that each lesson should ensure that students are clear about the mathematical vocabulary used in each mathematical concept thought. This will assist students to not become confused and do away with mixing up reasons used in geometric theorem. Therefore, students will be able to conceptualize the theorem and solve it procedurally. On the same note, it should be understood in this context that language has to be represented in a manner that would make the given problem clear and simple to understand and respond to. This practice is in line with the CER principle of inclusivity to ensure that all the students understand the content, regardless of the difference in linguistic proficiencies.

FL's statement indicates that tension still prevails in terms of which language(s) should be used to teach students in a class. Some lecturers still embrace the sole use of English, while others recommend the use of both English and the students' home languages. However, the lecturers are aware that English is still widely recognized as the language of communication by many people from different backgrounds and different settings, including educational settings. This is supported by the MSL's statement below.

MSL:*"It starts with the language. Which means we as the nation is well known that the language of learning and teaching in the classroom (Lolt) is English and if we as lecturers can stick to it from lower grades till college level the problem of omitting reason can be eliminated."*

In line with this sentiment, literature also confirms this as Essien (2013:5) noted that fluency in English is usually perceived as an "emblem of educatedness". A similar perception can also be identified in our societies, in which some people are regarded as highly educated and given respect because they are fluent in English. If students are not exposed to an adequate level of the LoLT during their early years, they seldom tend to fall behind and do not perform as expected (Machaba, 2013:31). However, the sole use of English may be a disadvantage to some students, in particular, those who are located in the rural areas, since most of them are still learning English and cannot speak it fluently. On the other hand, depending too much on the use of students' home languages could have a negative impact on the students' ability to express themselves fluently in English, hence the above encouragement that, if lecturers can stick to it from lower grades, it will assist lecturers to scaffold students at the college to retain knowledge on how to maintain high capacity for logical thoughts, reflections, explanation, and justification. This is the kind of emancipatory research method that should allow students to inherit and appreciate English as a knowledge of others (Western) which is dependent upon knowledge of self. From the above, it is clear that mathematical vocabulary plays a significant role in the teaching and learning of MG. It is essential to ensure that lecturers make use of the Key Vocabulary List as an assistive tool to help students understand the Language of teaching and learning (LoLT) in MG. This said, leads the reader to the upcoming subsection of the study that deals with discussion around the usage of practical assessments as a strategy to assist students to relate the MG taught in the classroom to their everyday lives.

4.2.5 PRACTICAL ASSESSMENTS AS A STRATEGY TO ASSIST STUDENTS TO RELATE THE MATHEMATICAL GEOMETRY TAUGHT IN THE CLASSROOM TO THEIR EVERYDAY LIVES (ENVIRONMENT)

An additional possible solution suggested by the research team in responding to the need to address the challenges identified is the integration of Practical Assessments into the College Mathematics curriculum to assist students to learn and understand mathematical concepts through doing hands-on activities. In other words, a productive disposition is reached when students see sense in Mathematics. This is also supported in the literature by stating that, the useful outlook of Mathematics is reached when students start to perceive Mathematics as useful and worthy of studying (Maharaj et al., 2015). This can be enhanced by the usage of practical assessments as alluded in the below statements from the co-researchers:

MSL: *"Students need to identify the concepts done in class in their real life situations to use their different methods of understanding this concept. Practical visible examples and tangible cultural activities such as bead-work can make students* *understand this concept better and easier."*

According to MSL's utterances, lecturers need to develop complementary teaching methods that enable students to understand mathematical geometry using their traditional and cultural materials to retrieve hidden moments of geometrical thinking. This will assist them to make a connection between the MG taught in the classroom and their everyday lives, similar to what was done in the PAT, whereby students were supposed to construct geometric circle theorems using indigenous teaching aids in a form of beads. This is coupled with the historical presentation that students had to do in class (See Figure 2 below). This example is a resemblance of what can be characterized in many geometrical forms and patterns of traditional objects like baskets, mats, pots, houses, fish traps, etc.

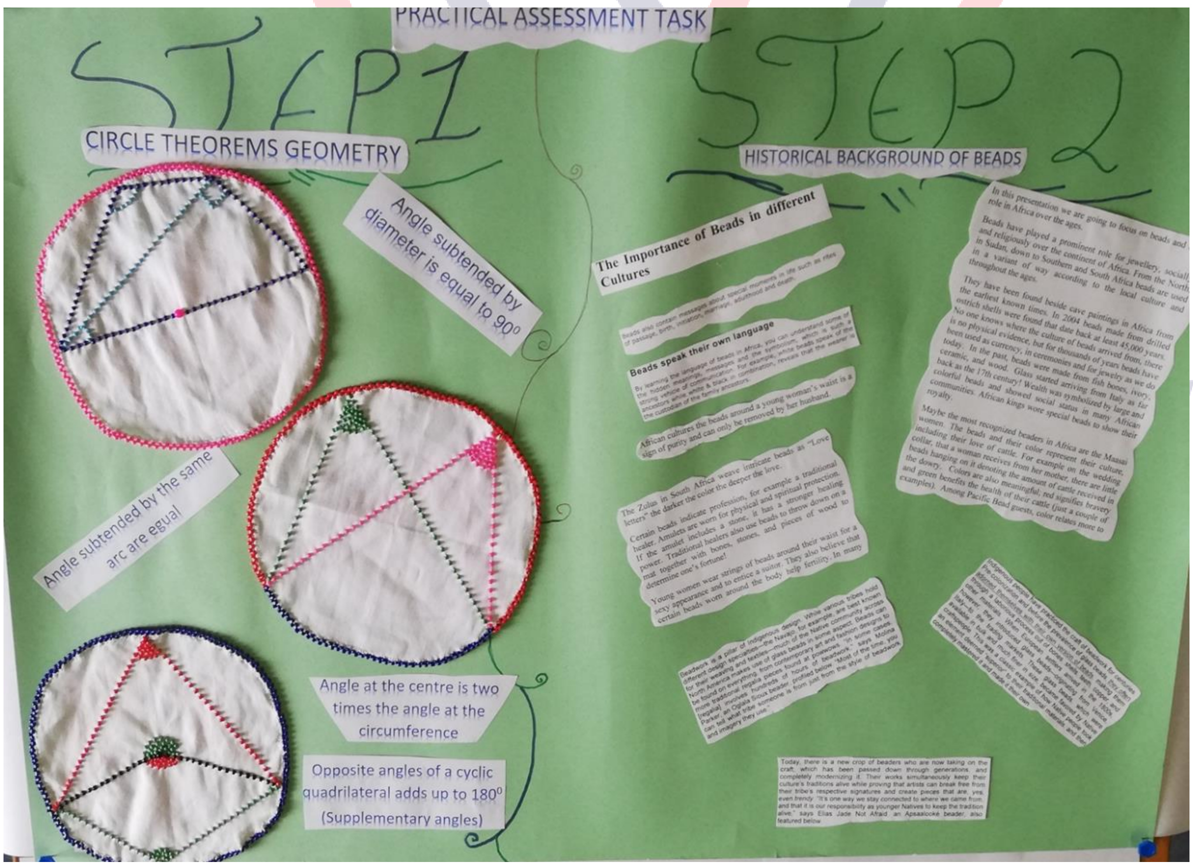


Figure 4.2, Practical Assessment Task Evidence

The introduction of practical and visible examples in the teaching and learning of mathematical geometry can bear positive results, as these traditional artifacts reflect accumulated experience and wisdom. They not only constitute biological and physical knowledge about the materials that are used, but also mathematical knowledge about the properties and relations of circles, angles, rectangles, squares, regular pentagons and hexagons, cones, pyramids, cylinders, and others. According to the MSL's statement, for students to perform well in mathematical geometry, lecturers have to use the real-life problems that can be solved mathematically. Suh (2007:57) supports MSL by stating that giving students more real-life problems will make them start noticing mathematical moments in their own lives. This will result in students bringing their mathematical problems to share. In such cases, students develop a skill of problem posing, as well as problem solving. That is, students learn how to formulate a problem and solve it through the use of apparatus that can manage the classroom. A project like building a sports ground at school can lead students into exploring measurement of area and perimeter, which is an example of geometric shape exploration (see Mahlomaholo, 2009:224 section 2.2.6.1). CER has its effective ways of creating conditions under which the distorted consciousness can be challenged and the cultivation of a positive academic identity. It was deduced from the students that through the acknowledgment of the different lines present in the Circle Geometric Theorems, it leads to a clear understanding of the various angles subtended by each, such as the radius, diameter, Arc and Chord. These lines bear priorities such as a radius of a circle bears equal angle, diameter subtend 90^0, whereas, Arcs and Chords subtends equal angles.

My analysis from the above accomplishments is that, learning is a social activity. This implies that, learning is closely associated with our connection to the environment, which is the students' everyday lives, lecturers, peers, family, as well as casual acquaintances. This is why lecturers need to teach the students in such a way that students can see and identify the connections between what they learn in the classroom and what they encounter on daily basis. The above discussion indicates the significance of using tangible and practical assessments that will incorporate local knowledge to enable students to relate the mathematical geometry they learn in the classroom to their everyday lives.

Moreover, these possible solutions can serve as important elements that can eradicate the challenges prevailing in the teaching and learning of MG, though the accomplishments of these solutions is dependent on critical conditions that need to be availed as a form of smoothening the implementation of such. Hence, the next section gives a lengthy discussion of these required conditions.

4.3 CRITICAL CONDITIONS NECESSARY TO ENHANCE THE TEACHING AND LEARNING OF GEOMETRY

The following section addresses the conditions proposed by the research team for the successful teaching and learning of MG.

The success and the implementation of the above solutions is dependent on a number of factors. These factors according to data, will ensure uninterrupted and smooth implementation of the solutions. These factors are: Proper contextual settings, Availability of resources to properly plan the activities, Active involvement of students leads to long-term retention and improved application of MG concepts, Involvement of parents in the teaching and learning of mathematical geometry and Motivation of lecturers and students. This section outlines these critical conditions in line with the constructs set in chapter 2.3.3. The next subsection discusses proper contextual settings as a crucial condition required for the successful implementation of the approach.

4.3.1 Proper contextual settings

The first conducive condition is proper contextual setting in the Mathematics classroom. Students, by virtue of being used to their passive role in the classroom and because of their reliance on the lecturer, may not automatically understand the purpose and value of active learning (Mulaudzi, 2016:12). It will, therefore, be important for the lecturer to create an enabling atmosphere explaining at the beginning what the students are expected to learn, what roles they will be expected to play during active learning exercises and how the overall experience in an active learning environment will be of value to them.

During the deliberation of data generation in alignment with the principles of PAR, MS 1 had this to say about proper contextual settings:

MS1:*"Preparation from both side the lecturer and the students is an important aspect In as far as lesson delivery is a concern. Lecturers should plan and prepare lesson thoroughly so that students can also do their part and be able to participate in class."*

The above utterances are in line with Vollma, Anderson and McFarlane's (2004:129) argument when stating that PAR has been known for its ability to recognize the importance of the four faces of research: preparation, planning, reflecting and implementing, which are meant to nurture capacity, community development, empowerment, access and many others. All these elements are reflected in MS 1's utterances. I also believe that preparation and planning are critical components of effective teaching. My analysis is that a good lecturer should always ensure that a positive learning environment is cultivated at all times. I also note that a fruitful lesson reflects the element of future lesson anticipation and accountability becomes a team effort from students and the lecturers' side. Therefore, ensuring this becomes a good condition that will enhance the solutions propounded above, and lecturer lesson to preparation should be monitored continuously. This said, leads the reader to the acknowledgment of availability of resources to properly plan the classroom activities, which is discussed in the subsequent subsection.

4.3.2 Availability of resources to properly plan the classroom activities

Another condition for successful implementation of the strategy lies on the availability of resources to properly plan the classroom activities. Once a proper context has been set for the implementation of active learning, attention should be focused on planning suitable activities, ensuring that the activities will encourage students' participation. Activities should illustrate a specific concept in such a manner that students can relate their experience in the activity to that particular concept (see Gordon & Browne, 2014. section 2.3.3). According to Özerem (2012:32), problems encountered in mathematical geometry are inadequate thinking and reasoning abilities. The role of the lecturer is very crucial to overcome this problem. The lecturer should explain to students in detail regarding what they should be careful of in image-based questions. Teaching should be done using visual indigenous teaching aids and this is supported by Chahine (2013:2) in section 2.3.3.

As the discussions unfolded on the possible conditions which can enable successful implementation of a strategy that responds to the MG challenges, HOD 2 and S 1 noted the following:

HOD 2:*"Lecturers need to make use of indigenous teaching aids, tangible resources so that they can be able to see what we are talking about."*

S1:*"Assessments used when assessing understanding it is important that the questions in the assessments are similar to those examples done in class."*

According to HOD 2's statement, lecturers need to bring, for example, circles of the different sizes, strings and rulers or tapes to determine, to enforce a migration from using concrete, abstract than the pictorial teaching approach with an interest of manifesting pride and respect to the cultural heritage. Gerdes (1986:26) suggested that a cultural-mathematical reaffirmation plays a part in the cultural rebirth: "It is necessary to encourage an understanding the students have been capable of developing their way (mathematical creativity) of understanding mathematical geometry considering their diversity in learning. It is within this awareness that lecturers should try different strategies to have new coming generations gathering cultural self-confidence in learning Mathematics as a whole. This will assist in the elimination of what Ozerem (2013:32) stated (see 4.4.2). It will also make lessons more interesting and increase student engagement in their learning process. In support of the DOE, Jojo (2015:48) defines Mathematics as a human activity that involves observing, representing and investigating patterns and quantitative relationships in (i) physical and social phenomena and (ii) between the mathematical objects themselves, and these human activities can be attained through this condition. I also agree that meeting this condition becomes necessary for the successful implementation of the proposed solutions. The next subsection discusses active involvement of students for long-term retention and improved application of MG concepts as a condition necessary for the implementation of the approach.

4.3.3 Consistent usage of indigenous language in the teaching and learning of MG can lead to long-term retention and improved application of MG concepts

The other condition of the successful implementation of the approach that responds to the problems faced in the teaching and learning of MG is engagement of students in activities that are designed to bring the abstract Mathematics concepts home and help them to develop a better understanding and the meaning of MG concept. The research team members nevertheless felt that there is a need for students to experience how hands-on activities can enhance their enthusiasm in the Mathematics classroom. Adding to the discussions, the co-researcher commented as follows:

HOD 1: *"The use of home languages as resources to support teaching and learning is important. It is important to advise lecturers to strive for a balance between the use of English, which is the LoLT, and the use of students' indigenous languages in a multilingual mathematics classrooms."*

According to HOD 1, home language can assist students to be at ease when communicating with others. Mulaudzi (2016:12) proposes that there should be continuous interactions between students and lecturers in the classroom in order for students to construct knowledge that makes sense to them and their environment (see section 2.3.3), and this could be attained if lecturers could follow HOD 1's statement and put it into practicality. Language is a problem and to overcome this, code-switching in Mathematics classrooms is essential. Lecturers may still see the traditional teaching method as an effective way to transmit large amounts of information and to stick to the lesson plan and this makes it difficult for them to foster students' interaction as they tend to be reluctant to change towards active learning. This is why lecturers should allow the students to come with suggestions on how they can be actively engaged in the classroom, as that will create a sense of ownership of the active learning framework that is proposed (Yazadjian & Kolkhost, 2007:165).

My analysis is that, if lecturers are to adapt to always encouraging active learning amongst students in the classroom, this will allow students to take control of their learning process. Moreover, this will empower students to be at the center of their learning process, as stipulated by the methodology employed in this study. This analysis was done through looking at how PAR complements CER because it makes "recommendations for improvements, social justice, empowerment, and emancipation" (Basit, 2010:15). Students' interaction is indeed a vital aspect of the enhancement of students' performance in MG at NQF level 4. In the next subsection, involvement of parents in the teaching and learning of MG is discussed together with its essential features that clarify it as a conducive condition for the success of the approach.

4.3.4 Involvement of parents in the teaching and learning of mathematical geometry

This is the other condition of successful implementation of the approach that responds to the challenges identified. Research has shown that most of the students' best performers at learning institutions are backed by parents' participation and a high level of effort in the learning process of their children. Seeing parents involved in the education of their children is a good thing because it improves academic performance. Students become more focused in their work (Kwatubana & Makhalemele, 2015:315). This motivates students not to give up easily when they do not understand MG and will not bunk classes because they know that their parents are always monitoring them and keep track of their attendance (Lemmer, 2007:320). Students whose parents are involved are active and ready to learn, they learn to be punctual from a young age, and they learn to be persistent as the parents would be continuously inquiring about their progress. This is also supported by the co-researcher below:

ML1: *"As part of the planning process, lecturers and parents need to work together in Preparing students and determine how they wish to engage as peers in the content of MG."*

According to ML1's utterances, parents can assist their students and the College in a variety of ways, such as waking the students up to be at the College on time, track their daily awareness to follow what they are taught in the classroom daily and help push students on doing homework.

In arguing for the co-researchers' utterances, I concur with Sapungan and Sapungan (2014:45) when stating that a strong collaboration of parents with school authorities can lead to an increased improvement in both the physical and academic performance of the school. Hence, this becomes a necessary condition for school administrators to encourage parents to get involved and make a contribution towards helping the College achieve its mission and goals.

4.3.5 Motivation of lecturers and students

Another condition is motivation of lecturers and students. Literature also supports this condition as Avery (2013:29) describes a rural school as a school in an extremely remote place, as well as adjacent. Working in a remote place makes lecturers reluctant to go and work in the area. Not only lecturers, but students as well. It was discussed by the team that proper forms of motivation can develop a meaningful and respectful relationship between all the stakeholders involved and create conducive conditions for the implementation of the solutions. This is shown in the below co-researchers' statement:

MSL:"Availability of teaching resources or materials those that can appeal to tactile, auditory and visual students."

S2:*"Acknowledgment of student's efforts in a form of praise can encourage students to try harder."*

Praises of students according to S2 for any effort that any stakeholder brings to the table count a lot in encouraging and developing the students. Both the students and lecturers are human beings and they need efforts that can reinforce mindset to be fixed on a set goal and objectives. Students have the ability and know more than they are showing. It is a team responsibility to retrieve the knowledge and channel it in the right direction and this can be mastered through correct planning and interventions as addressed in S2's extract. MSL's utterances point in the direction of resources. There is a saying that says "any amount of work on the lecturer's part can change the outcome on the students understanding". My analysis is that the ability for lecturers to do thorough preparations and plan accordingly is dependent on the support from the management in as far as availability of educational resources is concerned. My personal experience has taught me that motivation can come in many angles, verbally, in a form of support and availability of what is needed for the set outcomes to be reached. This is why encouragement is a very important aspect of the teaching and learning of MG. The following section addresses the threats associated with the teaching and learning of MG raised during the process of generating empirical data.

4.4 THREATS THAT COULD EVADE THE SUCCESSFUL INTEGRATION OF INDIGENOUS KNOWLEDGE IN THE TEACHING AND LEARNING OF MG AND DETERMINING HOW TO PREVENT THEM

Given the challenges, solutions to the challenges and conditions of success using indigenous knowledge as an approach to the enhancement of the teaching and learning of geometry, the co-researchers' concerns are that integration of barriers still exist in the form of threats, such as Poor management of the learning space, lecturer resistance to technology in the classroom, students inconsistently focusing on the set objectives, lack of parental involvement in the teaching and learning of MG and demotivated lecturers and student lecturers for the teaching and learning of MG. These threats are discussed below in terms of subsections that are in line with the constructs set in chapter 2.3.4.

4.4.1 Poor management of the learning space

One of the threats that could abolish any attempt of resolving the challenges identified is poor management of the learning space. Effective lecturers of MG know the appropriate method of teaching that is applicable to determine how their students can successfully learn this concept. Such lecturers recognize that for students to effectively use mathematical geometry, they need to understand the concepts presented, as well as become fluent with the skill taught. It is through the ongoing and increasingly complex application of concepts and skills that students become secure and competent in their use. Effective lecturers of Mathematics are knowledgeable in the theory of learning of this learning area and in the absence of this knowledge, lecturers tend not to know how to manage the learning space of their students in general (see section 2.3.4, Mulaudzi (2016:12), this is supported by the following co-researcher's utterance:

MS2: "*Time- management is very important. Though classroom interactions should be encouraged, lecturers should be time cautious as the periods of all the learning areas at the college are equivalent and the use of teaching aids might need more time to disseminate the content to students whilst facilitating learning.*"

In a nutshell, MS2 states that an effective Mathematics lecturer should be time conscious and quick to build a picture of what is expected to be known in a reasonable amount of time. They have to be in a position to can progressively provide their students opportunities to demonstrate what they have learned in each lesson. Poor management of the learning space and time were identified as a threat to the successful implementation of the strategy in the teaching and learning of MG. Discussed in the next subsection is the resistance of lecturers to the usage of technology in the classroom.

4.4.2 Lecturer Resistance to Technology in the Classroom

To be a lecturer is a deeply personal experience, and when lecturers feel as though they have lost the ability to teach in a manner that best suit them, it can be frustrating and discouraging. No single educational resource will be perfect for every lecturer, and educators should have the ability to select a technology that they feel most comfortable with. By allowing lecturers more freedom of choice, they will retain a very important sense of classroom control. This was also confirmed by the co-researchers' comments below:

HOD 2: "Unavailability of teaching materials, whereby the lecturer only depend on the prescribed textbook as the only source of information."

According to HOD 2, a shortage of resources prompts lecturers to only depend on the textbook. The most common reason mentioned by lecturers for not actively integrating new technologies is that many lecturers are satisfied with their current lesson plans and textbook as the only source of information as stipulated in HOD 2's utterances. Lecturers' desire for their students to learn effectively drives classroom instruction, and if current lesson plans meet the needs of students, there is very little motivation for the teacher to alter them. The comment below is in support of the above extract:

HOD 1: *"Students of the 21-century love technology, therefore, lecturers should make use of such in the classroom can prompt a deeper interest of the students and to increase the students' level of curiosity."*

Educators spend countless hours creating lesson plans that will hold attention and make learning exciting. Lecturers must first learn the technology well enough to utilize it in a classroom setting before deciding how to integrate the technology with classroom objectives and curriculum. Taking the words directly from what HOD 1 said, a lecturer's time is extremely valuable, and it should come as no surprise that time is one of the most commonly cited barriers to integrating new technologies in the classroom. There are numerous reasons why lecturers opt not to use technology in the classroom, ignoring the fact that technology is a solution for many challenges experienced by lecturers at the college. I agree with this by emphasizing that lecturers should be thoroughly trained and well developed inevitably to bring about the increased adoption of classroom technology to a large scale. Limited teaching resources in the teaching and learning of MG was identified as a threat to the successful implementation of the strategy. In the subsequent subsection, students inconsistently focusing on the set objectives is discussed in-depth as an element that threatens the proposed approach.

4.4.3 Students inconsistently focusing on the set objectives

Another threat is that of students being in dire need of a consistent classroom environment. To achieve this goal, the students and teachers must work together towards common and collective goals. Students must be willing to work with and assist other students in a class. The struggle should be acceptable and encouraged as part of the learning process indicated in the statement below:

FL: *"Lack of participation in the may limit class interaction and also cause students to miss out on the benefits of student-centered undertakings, which include being exposed to multiple ways of analyzing, interpreting and solving MG problems."*

From the above statement, one could deduce that being in a classroom without knowing the direction for learning is similar to taking a purposeless trip to an unfamiliar city. My analysis is that lecturers should set lesson objectives to ensure that students' learning journeys are purposeful. When lecturers identify and communicate clear learning objectives, they send the message that there is a focus for the learning activities to the students' attention as it is required based on FL's utterances. As I interrogate this, I agree that clear learning objectives reassure students of the need to focus and they provide lecturers with a focal point for planning instructions. In other words, feedback can assist in solidifying students' understanding of the content at hand and known specific lesson objectives will in this way help students improve their performance. Lecturers need to identify success criteria for learning objectives, so that students know when they have achieved those objectives (Hattie & Timperley, 2007). Similarly, feedback should be provided for tasks that are related to the learning objectives. This way, students will consistently focus on the set objectives. Inconsistency of students on the set lesson objectives, which results in a lack of participation by students in the teaching and learning of MG was identified as a threat to the successful implementation of the strategy. This said, led the discussion to the succeeding subsection of lack of parental involvement in the teaching and learning of MG as a threat to the proposed approach.

4.4.4 Lack of parental involvement in the teaching and learning of MG

Lack of parental involvement in school activities was indicated as a threat to lecturer preparation for sustainable rural learning ecologies because parents are not able to be involved in issues related to the education of their children (Park & Holloway, 2013:105).

Parental engagement in the students' learning is seen to be of great importance for students' achievement. The co-researcher's statement below concurs as follows:

S2:"*Lack of parental support at home, this, in turn, gives rise to students not practicing mathematics when at home, because when we seek assistance at home, we tend to get negative responses from our parents."*

The above statement indicates a downfall of not having parents as a supporting stakeholder in the students' learning journey. It has been evident that some parents are not involved in their children's learning process because they are unable to read and write and they can only communicate in their mother tongue (Lemmer, 2007:220). Nonetheless, the support in the areas of discipline, monitoring and scaffolding the students will be as much a benefit as their input in accordance with the learning area content. The research findings of (Baloyi-Mothibeli, 2018:140) confirmed that parents' involvement in the school is related to students' achievement.

Lemmer and Meier (2015:1) continue the argument by claiming that positive involvement by parents in schooling leads to learners improving their academic achievement. In support of this discussion is that when students were engaged in the PAT activity, they received assistance from their parents. From the discussion, it was revealed that even though some parents did not go to school or left school at the early grades, they were familiar with this concept of circle geometry. Evidence for that is, parents advised students to do these beaded theorems using a white cloth as opposed to the initial idea of using beads alone to complete theorem. It was deduced from the parents that they gathered their experience of circles when they were building their Mekgoro houses (cylindrical indigenous houses built with mud) which used to be in a form of a circle. The parents made the students aware that for them to check whether their Mekgoro houses were circular in shape, they would count their footsteps from the center to the sidewalls and by all means, those footsteps had to be equal on either side. In a Eurocentric term, this notion is referred to as determining the radius of the circle. My analysis of these students' findings is that absence or minimum involvement of parents in the teaching and learning of MG is indeed a threat to the successful implementation of the strategy proposed, because parents bear the most of the indigenous knowledge that students have to regain. The next section discusses demotivation of lecturers and students in the teaching and learning of MG as a crippling factor in the implementation of the approach.

4.4.5 Demotivated lecturers and students in the teaching and learning of MG

Students' motivation is powerfully influenced by the characteristics of the classroom learning environment (Greene, Miller, Crowson, Duke & Akey, 2004; Pintrich & Schunk, 1996; Sansone & Morgan, 1992), including elements of lecturer and peer support (Greene et al., 2004), and the teacher's interpersonal style of interaction and communication (Black & Deci, 2000; Deci & Ryan, 2002). Some lecturers lack confidence to teach in rural schools (see section 2.3.4, Lekhu, 2013:13). This is my argument that it has contributed to students being demotivated and vise-versa. This is reflected in the below statement from the co-researchers:

MSL: *"Students not being self-motivated, comes as a result of them being unable to have the correct revision method and studying skills those that give them a drive to practice Mathematics daily."*

S1:*"Students tend to fear seeking help from fellow students and end up losing on crucial information by not taking ownership of their learning process."*

According to S1, taking responsibility involves students taking ownership (partial or total) of many processes that have traditionally belonged to the lecturers, such as seeking help from both the lecturer and fellow candidates and taking ownership of their learning process. Lecturers often do not know how to encourage students. Lecturers should have followed up measures on how to reach the students' utmost levels of understanding, and check as to whether the methods they utilized are best suitable for their students or not. S1 pointed out that "Students tend to fear seeking help from fellow student", because of the level of negativity that prevails amongst students.

My analysis is that lecturers should do more in class is to give allowance for students' autonomy. Give students time to interact and do peer teaching and not give up on low-expectation students. Giving everybody equal opportunity is important because the classroom atmosphere also influences the development of every student. According to MSL, lecturers should not give students the impression that Mathematics is just a subject that has little to do with life in general. I also emphasize that lecturers should be conscious of their students' level of motivation and enthusiasm in their everyday lessons. This will surely assist both students and lecturers to flourish and enjoy mathematical geometry. Minimum self-esteem and lack of confidence from the side of both the lecturers and students in the teaching and learning of MG was identified as a threat to the successful implementation of the strategy. The subsequent section focuses on the indicators of success as evidence that the approach was successfully implemented.

4.5 INDICATORS OF SUCCESS IN THE TEACHING AND LEARNING OF MG THROUGH INTEGRATING INDIGENOUS KNOWLEDGE

This section outlines the success indicators that the strategy was successfully implemented. The discussion is done in line with the objectives of this study, as outlined in Chapter 1. The successful implementation of the proposed approach can be determined in numerous ways, and those that take priority are: Student enrollment in Mathematics, parental Involvement in Education, Students' achievement in the Certification Rate at exit level NQF level 4 and improved teaching skills and Mathematical Proficiency. This section outlines these indicators of success as subsections that are in line with the constructs set in chapter 2.3.5.

4.5.1 Students' enrollment in Mathematics

An indicator of success for this research will be when students' enrollment in Mathematics increases. In South Africa, Mathematics is perceived as a difficult subject, accessible only to the few. Adults frequently claim dislike or incompetence towards this learning area, while many students choose not to pursue Mathematics post-compulsory education. Recent studies (Sterling, 2004, de Villiers, 2010) indicate that there is a critical shortage of people qualified in Mathematics in South Africa, as a result of students opting to enroll in mathematical literacy. This results in a low intake of the students who are interested in studying Mathematics (Spaull, 2012). In addition, there is the recent decline in recruitment into higher education courses in Mathematics, science, technology and engineering, noted in South Africa where negative views of Mathematics are often cited as contributory factors (Fry, 2006). This is consequently seen as a filter that hinders students from pursuing their career aspirations in Mathematics and science-related fields. It is in line with this literature that the following comments were made by the co-researchers during the reflection session:

FT: "*Students interest in the concept will increase in terms of positive attitude and high cognitive levels."*

ML1*: "More enrollment of students in Mathematics will be seen."*

Deduced from FT utterances is that positive elements that will indicate that the strategy proposed is effective are that students will show more interest in MG. Students interested in the MG will be viewed by the student to have a positive attitude in the classroom, showing high levels of enthusiastic and the will to participate with one another. From a cognitive point of view, FT refers to students' deeper knowledge and understanding in MG, beliefs, and other cognitive representations while from an effective domain it refers to a student's attitudes, feelings and emotions about MG. in supporting FT's utterances, ML1 adds by saying that the benefits of students positive attitude and increased cognitive levels will be consequently viewed when during registrations, more students willingly enroll for mathematics as opposed to mathematical Literacy.

4.5.2 Parental Involvement in students' Education

Another indicator of success for this research will be parental involvement in the students' education. According to Garcia and Thornton (2014:1), current research shows that the involvement of the family in learning helps to improve students' performance, reduce absenteeism and restore parents' confidence in their children's education. Students with parents or caregivers who are involved in students' education, earn higher grades and test scores, have better social skills and show improved behaviour. This is something that we as a community and the world at large require, as it would highly contribute to reducing crime and poverty. Ideally, it would help to have a greater percentage of parental involvement in their children's education.

HOD 2: *"Strong collaboration of parents with college authorities can lead to increased improvement in both physical and academic performance of the college."*

According to HOD 2's statement, Parent-lecturer partnerships can make a tremendous impact on students' education. This is supported by Lamas and Tuazon (2016:59)'s words stating that parents become comfortable when the education system requires their involvement in learning institutions. Seeing parents involved in the education of their children is a good thing because it improves academic performance. Students become more focused in their work (Kwatubana & Makhalemele, 2015:315). This statement is supported by the MS 1's statement below:

MS1: *"Student motivation in terms of performance will increase as this will be visible in the increase in their pass percentages."*

According to MS 1's utterances, parents' involvement can motivate students not to give up easily when they do not understand a particular topic and will not bunk classes because they know that their parents are always monitoring their school attendance. Students whose parents are involved are active and ready to learn. They learn to be punctual and persistent as the parents would be continuously inquiring about their progress and they would not want to disappoint them. I therefore interpret the above utterances by stating that taking responsibility becomes a part of the nature of such students as they plan and can do their work according to their schedule, which is the quality of being organized is an element of motivation. As a result of these, students' pass percentages will accumulate. Parents-lecturers' collaboration can ensure that students succeed academically. As a consequence, this indicator complements the succeeding subsection of students' achievement in the Certification Rate at exit level NQF level 4 as an indication that the proposed approach has been successfully implemented.

4.5.3 Student achievement in the Certification Rate at exit level NQF level 4

There is a great need in South Africa for students, especially those who leave the formal schooling system before completing their National Senior Certificates, to be adequately prepared for the workplace. This need must also be coupled with the need for a skilled labour force to help the country attain its economic growth targets and to be globally competitive in terms of products and services. Consequently, a vocational learning pathway has been developed for students who do not wish to continue with general academic learning at TVET College level. This learning pathway, consisting of three qualifications in the FET band, will provide students with Communication, Numeracy and Life Skills and broad vocation competencies with specialization in a particular vocational area, which will enable them to be better prepared for the world of work and for further learning in their chosen vocational field, at either further education or higher education level. In line with this, the co-researchers highlighted some of the successes related to enhancing the teaching and learning of MG, which are as follows:

ML 2: *"Students will be able to link the mathematics they learn in the classroom to their everyday environment".*

HOD 1: *"Lecturers will prepare lessons which are interactive and those that make use of indigenous teaching Aids".*

MSL:*"The certification rate at NQF level 4 will increase because most of the student tends to do well in other learning areas and remain with mathematics as this consequently affects the College certification rate."*

According to HOD1, it is the lecturer's responsibility to do thorough preparation for each lesson, making use of relevant indigenous teaching aids that will promote students' interaction an assist them to make a connection between what is taught and its relation to their environment. The three co-researchers' statements are closely related as the other component is highly dependent on the other for its succession to be effected. Ideally, students should complete all three qualifications in the pathway that is the

National Certificate: Vocational at Levels 2, 3 and 4, as the qualifications have been planned successively so that students will be best prepared for the world of work and together, they present a coherent set of skills, knowledge, and competencies. Nevertheless, the National Certificate: Vocational, Level 4 serves as the exit level for the NCV program and taking the purpose of preparing students, the certification rate at this level is a concern, hence an increase in the pass rate for students who enroll in Mathematics will be a positive contribution to the certification rate of this program, especially in the IT, Engineering, and Finance, economics and accounting fields as stipulated in MSL's utterances.

4.5.4 Improved teaching skills and Mathematical Proficiency

Another indicator of success for this research will be improved teaching skills and Mathematical Proficiency. According to the discussions, Mathematical proficiency is key in developing a strong mathematical community in the classroom. Mathematical Proficiency can retrieve students' self-esteem, an increase in the student pass percentages and positive social behaviour. Amongst other benefits indicated by literature, co-researchers have highlighted a few below:

MT:"*Lecturers will make use of Conceptual and pictorial teaching methods those that display indigenous teaching aids as more means to make students relate to their learning process.*"

S1: *"Classroom students' interaction will be actively enthusiasm and students will display an Increase levels in confidence and participation."*

Deduced from MT's statement, Conceptual and pictorial teaching method will not only allow students to see just how mathematical geometry curriculum is broken down, but also on how each area concept in Mathematics is related to students' everyday lives, through linking indigenous teaching aids in each lesson. My analysis is that, if students' mathematical proficiency is developed, lecturers will have a clear vision of the goals of instruction and what proficiency means for the specific mathematical content they are teaching and which indigenous teaching aid is relevant for which learning style. In addition, S1 also attests to this by emphasizing enthusiasm. S1 points out the benefits of students' interaction in as far as confidence-building and students' participation are concerned. It is through the identification of the above-stated indicators of success that the implementation of the strategy in the teaching and learning of MG will be measured and confirmed.

5. CONCLUSION

The first section of this chapter highlighted the challenges experienced in the teaching and learning of mathematical geometry. In response to the challenges, the second section discussed the strategies that were put in place to address those challenges. Conducive conditions for the implementation, the threats which could hamper the operation of the strategy and steps taken to counteract them were also discussed. The last section provided evidence that will be visible as a result of the positive indicators that this approach was implemented. Deduced from the discussion is that CER concurs with the methodology approach (PAR), where the ultimate desire was recognition of the co-researchers, not as instruments to be used to fulfill the agenda of the research, but to collectively interact and find the best possible practices that respond to social pathologies for the strategy of this study. In the next chapter, the focus is on the findings, conclusion, and recommendations.

CHAPTER FIVE

FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.0 INTRODUCTION

This chapter provides summary of the findings of the study. The findings are organized in accordance with the objectives of the study. It further presents the findings in the light of the literature review, challenges, solutions, favourable conditions for the applicability of the approach and threats that could potentially threaten its operation in relation to the evidence of its applicability. This chapter also presents the conclusion of the study alongside recommendations. The recommendations were made in regard to each finding on how students' performance in this concept can be improved through incorporating IK for the enhancement of the teaching and learning of Mathematical Geometry at TVET College.

5.1 FINDINGS OF THE STUDY

The findings of this study aim at responding to the aforementioned research question and comprehensively demonstrate how IK is intended to be integrated into the teaching and learning of MG, through which its outcomes were presented in chapter three and chapter four (see Figure 3.3.2.1, 4.1 & 4.2). These findings are based on the literature review presented in Chapter two and the empirical data that had been gathered and was presented in Chapter four. They are categorized according to the research objectives which were further divided into appropriate subsections that were chosen and formulated in correspondence with the respective constructs to the objectives of this study.

The next section discusses findings pertaining challenges prevailing in the teaching and learning of mathematical geometry.

5.1.1 Findings pertaining challenges prevailing in the teaching and learning of mathematical geometry

In this section, each challenge was explored separately. In addressing this first objective, the following findings pertaining challenges were identified: Visualization skills and inadequate Resources, Negative Attitude and Disbelief towards MG, Abstract presentation of concepts, student omitting reasons when determining angle in the theorems and students being unable to relate the Mathematical Geometry taught in the classroom to their everyday lives.

The next subsection focuses on visualization skills and inadequate resources as a challenge in the teaching and learning of MG.

5.1.1.1 Visualization skills and inadequate Resources

The analyzed data indicated that visualization and inadequate resources are some of the challenges whereby students are unable to identify various orientations of Geometric figures, which affect their performance in a sense that they cannot interpret questions on their own. Through the discussions, it was discovered that the problem does not only emanate from students, but it also comes as a consequence of lecturers not having enough resources to teach MG in the classroom. Students are often unable to comprehend the purpose of geometry, as a result of being unable to visualize, since the lack of resources leads to lecturers not being able to bring teaching aids. Resources in the College are inadequate. Students struggle to identify various orientations of geometric figures as their visualizing skills are not retrieved, they are not involved in their learning process, there is no variety of teaching styles that would cater for students' diversity when coming to learning, understanding and grasping concept because of the lack resources (see section 4.1.1). Lack of teaching media in the college contributes to students' performance. This is in agreement with Omodan, Ekundayo and Bamikole (2018:111), that teachers ‘control of intellectual assimilation in classroom is significant to student academic performance’. Not only that, but Moloi (2013:125) also attests to these findings when stating that in a classroom situation, the teaching and learning of Mathematics is not aligned to African cultures. There are artificial barriers that exist between culture and Mathematics. This means that the adequate provision of educational facilities such as teaching resources are significant in positive direction to student academic performance. Mathematics students in this case are not exempted (Omodan, Kolawole & Fakunle, 2016:66). The findings revealed that not only visualisation (see 2.3.1.1) in general is a challenge in MG, but it is a challenge prompted by inadequate resources.

With this said, I now move on to the discussion on the following subsection on findings pertaining negative attitude and disbelief towards MG.

5.1.1.2 Negative attitude and disbelief towards MG

The study found that most of the students show negative attitude and lack of interest towards MG, whereby students find MG as a demanding concept that requires visualization and analytical skills, which to them it is a challenge. The co-researchers made allusion that negative attitude results in students having lack of confidence in MG and this in turn, makes them to suffer from anxiety. In support of these findings, Mutodi and Ngirande (2014:344) stated that personal beliefs affect the person’s interest in MG, efficiency in performing Mathematics tasks, motivation and pleasure with MG, attribution of causes to academic success or failure, and self-concept as belonging to a certain social group. In absentia of these important elements, students end up not being able to focus in class and ultimately, miss out on the knowledge taught in the classroom.

The attitude of students towards learning Geometry is very poor, which consequently leads to students suffering from anxiety when learning MG or dealing with assessments that include the concept of MG. There is also lack of willingness and readiness to learn because students believe that Mathematics is difficult and has no relation to their everyday lives. Students’ attitudes towards Geometry, either positively or negatively, influence students’ confidence in Geometry (see section 4.2.2). According to McLeod

(1992:575), factors such as attitudes and beliefs play an important role in Geometry achievement. If the attitude of the students towards Geometry is positive, students will perform well. In fact, students' who have the interest and ability in Geometry perform better than those who have no interest. From this study, it was clear that students have negative attitude towards Mathematics. Moreover, it was also discovered that the attitude does not only lie with the students alone, but with the parents, peers, lecturers and other stakeholders to a certain extent. This affects the level of guidance and support that lecturers and parents should avail, so as to scaffold the students' belief and encouragement to want to know and do more. Additionally, the findings were in agreement with literature that attitude (see 2.3.1.2) is a challenge in MG, but the study revealed that attitude is prompted by the general level of disbelief in MG as a concept. This said, leads the study to discuss in the succeeding subsection, abstract presentation of concepts in a Mathematics classroom.

5.1.1.3 Abstract presentation of concepts

Analysis on the challenges revealed that most of the teaching of Mathematics at the TVET College is still done in an abstract way. Lecturers fail to conceptualize abstract concepts as they tend not to aim at delivering this concept of MG in a simplified manner. This kind of teaching leaves room for passive learning to take place and eventually, students opt for rote learning and memorize important aspects of this concept, as the textbooks only have few examples. Sharing the same sentiments with the co-researchers is Moloi (2013:125) when stating that most of the lecturers are using Mathematics textbooks, which are written in European languages, style and illustration. Therefore, some of the examples given in the textbooks are not easy to understand because the context in which they are written is unfamiliar to both the lecturer and the student and this type of teaching is the one referred to as abstract presentation of concepts. Learning MG can be challenging as this concept is abstract in general, especially if the lecturer who is the manager of the classroom is still using the traditional resources, such as textbooks and chalkboard to teach mathematical geometry (see section 4.2.3). Chinn (2016:53) attests to the findings by highlighting that the problems in Mathematical Geometry are world-wide and are often subjected to deep entrenched beliefs. All children can rote learn, but lack of understanding what they have learned serves as proof that there is a spectrum of difficulties in learning Mathematics, due to the heterogeneity of students and constellation of skills that Mathematics requires of these students. These findings seem to be in agreement with the reviewed literature (see section 2.3.1.3) that indeed abstract presentation of concepts is a challenge that contributes to students' performance in MG.

Not only this, but students omitting reasons when determining angles in the circle theorem was also discussed in the next subsection as a contributing challenge in the teaching and learning of MG.

5.1.1.4 Omitting reasons when determining angle in the circle theorems

With regards to students omitting reasons when determining angle in the theorems, the study found that majority of students can determine angles, but they find it difficult to give reasons for their answers because of the challenge of lack of geometric terminology understanding. This challenge is experienced as a result of language barrier, whereby students tend to mix things up and provide correct angles with no accompanying Mathematical reasoning. In support of the findings, Schweifurt (2013:20) indicates that current teachings in MG is couched within outdated teacher-centered approaches which do not allow creativity and independence of students. Teacher-centered approaches to the learning of MG are widespread, leaving little room for more student-centered approaches (Armitage, 2010:4; Laughlin, 1987:479). Furthermore, there is limited use of teaching media and tools, and very high dependency on the textbook approach, which is most often a single view or a general statement giving only general guidelines, in violation of the lecturer's roles in the classroom, of being a leader and providing pastoral care (Qhosola, 2016:05). These findings were supported by literature in section (2.3.1.4). Hence, it is vital that lecturers make use of various forms of teaching aids, and recommended in this study are those that incorporate indigenous knowledge. This is supported by the next subsection of students being unable to relate the MG taught in the classroom to their everyday lives as a challenge discussed beneath.

5.1.1.5 Students being unable to relate the Mathematical Geometry taught in the Classroom to everyday lives.

The study revealed that it is due to the abstractness of MG that students are unable to see the link between the “what is taught in the classroom and what they see or do in the real life situation”. Lecturers appear to have more trust in the textbook and have resorted to its utility holistically. Lecturers tend not to use practical examples that are applicable to the local homes (geographical area), like the various types of roofing present in their communities to demonstrate the different types of angles. In fact, the teaching and learning of MG seems to be far removed from the daily lives of the students (Qhosola, 2016:5). Moreover, there seems to be inadequate feedback on assessment, in such a way that it limits students’ ability to identify and also alter their gaps (Boyce, 2004:569; McPhail, 2001:475). Attesting to the findings is Thomas, Menon, Boruff, Rodriguez and Ahmed (2014:55) who state that learning is a result of the individual’s interaction with the environment, and that knowledge is constructed as the students make sense of their experiences in the world. Findings from both the literature and empirical data revealed that indeed students struggle with relating what they are taught in the classroom and their everyday life's (see Sections 2.3.1.5 and 4.1.5). Demirci (2012:1486) also supports these findings by defining education as effective social processes in which students earn their standards, beliefs and lifestyles as a society, and also as a process that provides optimum individual development and social adequacy under the influence of selected and restricted environments.

The following section addresses findings pertaining possible solutions identified as important in addressing the identified challenges in the teaching and learning of MG.

5.1.2. Possible solutions identified as important in addressing the identified challenges in the teaching and learning of mathematical geometry

The succeeding are the findings pertaining the proposed solutions with reference to the analyzed data: improvement of visualization skills through indigenous knowledge, student interaction through indigenous artifacts to enforce positive attitude and beliefs in the teaching and learning of MG, lecturer collaboration and indigenous teaching aids as means to eliminate abstract presentation of MG concept, strategy to improve students' understanding of mathematical geometry vocabulary and practical assessments as a strategy to assist students to relate the mathematical geometry taught in the classroom to their everyday lives. Therefore, each solution was explored separately as subsections. In the next section, the study focuses on Improvement of visualization skills through indigenous knowledge as a possible solution.

5.1.2.1 Improvement of visualization skills through indigenous knowledge

The study revealed that the teaching and learning of MG should utilize educational resources such as technology as a means of using resources that will retrieve that interest of students in the classroom, those that incorporate local knowledge because this would assist in eliminating the abstractness of the concept of Geometry. In agreement with the findings, Mamali (2015:19) states that teaching methodology, styles of assessment and lack of background knowledge have a strong influence in the performance of students in Geometry. Spring (2015:5) identified that alternative preparation for MG lessons are more likely to enhance the performance of students in MG. Teaching students using Mathematical software that contains familiar material, such as making use of videos of indigenous artifacts for Geometry lessons and will assist students to recall and understand geometric figures better. Research from both the literature and empirical data (see Sections 2.3.2.1 & 4.2.1) seemed to be in agreement by revealing that even lecturers will be able to prepare lessons in a more interactive way, like using power point presentations that contain those familiar indigenous local materials as a means of using alternative teaching methods, such as Concrete Pictorial Abstract (CPA) method that employs indigenous teaching Aids.

5.1.2.2 Student interaction through indigenous artifacts to enforce positive

Attitude and beliefs in the teaching and learning of MG

The study found that the teaching and learning of MG should make use of peer teaching in a form of tutorial sessions in which students will interact with their peers who had passed that level with good marks previously (see Sections 4.2.2). This will assist in enhancing the students' confidence as group interaction will be encouraged in these sessions. In support of the findings, the use of indigenous artifacts in the classroom can create a relationship between culturally specific activities and classroom activities (Nkopodi & Mosimege, 2009:378). Mamali (2015:23) adds to these findings by stating that factors such as attitudes and beliefs play an important role in Geometry achievement. The findings indicate that building a classroom where interaction is prominent will help lecturers develop classrooms that comprehend effective learning. This is also supported by Katherine (2012:234) when stating that classroom interaction helps lecturers in enhancing effective teaching and learning processes. This is to confirm that interaction through indigenous artifacts is a significant positive attitude and beliefs in the teaching and learning.

5.1.2.3 Lecturer collaboration and indigenous Teaching Aids as a means to eliminate abstract presentation of MG concept.

The study established that in the teaching and learning of MG, lecturers should make use of different teaching resources, such as indigenous teaching aids, as they have the benefit of enabling a link between what is taught in the classroom and the environment at large. These will enable students and lecturers to interact in the classroom using familiar or local resources (see Section 4.2.3).

This finding supports the thought that the teaching and learning of MG has to be contextualized inside social practices (Moloi, 2013:126). Besides, Baturo, Cooper and Norton (2004:88) see contextualization of MG as a generally modern procedure pointed at bringing relevancy for Mathematics education for indigenous knowledge systems. On a very basic level, it includes joining angles of indigenous culture and indigenous into academic approaches to Mathematics education and in turn, ingrains a strong sense of pride within the students' indigenous personality and culture. The classroom interaction can be made possible through the utility of tangible indigenous artifacts in a form of practical assessment made possible by the lecturers (team teaching) in charge.

What was learned from this PAT is that students really enjoyed working cooperatively on this practical assessment (see Sections 3.3.2.5 and 3.3.2.6). Students also highlighted that they were able to involve their parents in responding to the assessment instructions. They further alluded to the fact that the assessment assisted them to smoothly recall this geometric reasoning when determining angles in the formal tasks. This PAT was an example of how indigenous artifacts can be integrated in the mathematical geometry concept (see Figure 3.3.2.5.1). Nonetheless, through these assessments, students got a sense of how the concepts of Mathematics have a connection with their everyday lives and assisted lecturers to entice the students in the Mathematics classroom. Students were able to relate to their cultural background and know their history better.

This task allowed students to actively participate with each other jointly to respond to the pertinent aspects thereof. It was clear from the observation of the student presentation that the students enjoyed doing this task. This ultimately can lead to the enjoyment of Mathematics itself, minimizing the anxiety and negative attitude and beliefs towards this concept and encouraging more students to take Mathematics as a subject. It was found that this pilot can serve as an example question paper of the kind of PAT Assessment (Appendix I [1]) that can be integrated in the teaching and learning of Mathematics to a further extend, it can be used as one of the formal or common tasks that can be used at the college (NQF) level 4.

5.1.2.4 A strategy to improve students' understanding of MG vocabulary

The study revealed that lecturers should speak in a language that accommodates all students by using materials such as indigenous Key Vocabulary List at the beginning of each lesson, so as to reach students' deeper understanding of MG by relating what is taught in the classroom to the students' everyday lives. Language of learning and teaching in classroom (Lolt) is English and it is important that lecturers start by understanding the language in which students are most familiar with at the beginning of each lesson. In other words, lecturers should initially understand prior knowledge of the students, that is, what the students know about the concept before teaching it using the language of teaching and learning (Lolt) (see Section 4.2.4). By so doing, this will assist students to understand each specific concept in depth and the problem of students omitting geometric reasons when determining Geometric angles can be eliminated. In agreement with these findings, Qhosola (2016:54) posits that the teaching of MG involves knowing rationales for procedures, meanings of the vocabulary and explanations of concepts terminologies, not only to confirm the answers, but to show what the procedures mean and why they should make sense to students. Therefore, this plays a vital role in simplifying the MG taught to students in a better and understandable manner.

5.1.2.5 Practical Assessments as a strategy to enable students to relate the MG taught in the classroom to their everyday lives (environment)

The study revealed that for students to identify the concepts done in class in their real-life situations, lecturers should use their different teaching methods, such as practical visible examples and tangible cultural activities, such as bead work, that enable students to understand the concept thoroughly. In support of the findings, Thompson (2008:112) suggests that lecturers should capitalize on the background of students for performance to be enhanced. Students meet Mathematical concepts every day and operate in rich Mathematical contexts, even before they set their eyes on a Mathematics worksheet. Sharma (2011:4) also confirms the findings by stating that student engagement in practical assessments will enable them to be active constructors of their own knowledge, rather than receive preformed information transmitted by the lecturers, based on what the curriculum emphasizes, classroom interactions, and classroom dynamics must be maximized in many ways (see Section 4.2.5).

The succeeding section addresses findings relating to factors that were identified as conditions conducive and essential for the teaching and learning of mathematical geometry.

5.1.3 Some of the enabling factors that were identified as conditions conducive and essential for the teaching and learning of mathematical geometry

This section outlines the findings with regard to factors that this study is dependent on for the successful implementation of the above proposed solutions. These factors, according to the analysis will ensure uninterrupted and smooth implementation of the solutions. The said factors are Proper Academic settings, Availability of resources to properly plan the activities, Consistent usage of Lolt in the teaching and learning of MG, which lead to long-term retention and improved application of MG, Involvement of parents in the teaching and learning of mathematical geometry and Motivation of lecturers and students. The following subsection states the findings pertaining the creation of proper academic setting as a conducive condition for the successful implementation of the proposed approach.

5.1.3.1 Proper Academic settings

The study found that preparation from both sides, the lecturer and the students, is an important aspect in as far as lesson delivery is concerned. That is, this is found out as conducive condition that will ensure smooth implementation of the solutions provided (see Section 4.3.1). Lecturers should plan and prepare lessons thoroughly, so that students can also do their part and be able to participate in class. In support of the findings is Mukeredzi (2013:92), when pointing out that learning by doing presents occasions for engagement in professional development practices, relating to practical knowledge on preparation and organization of the teaching/learning process, such as: teaching strategies, student motivation, and classroom and group organization and monitoring, as well as time management. Classroom practice provides a space for the learning process to unfold (Gorski, 2009:317). Proper academic setting in the classroom links what the lecturer knows and how their knowing is expressed in the lesson as a means of imparting knowledge to students (Connelly, Clandinin & Fang He, 1997:672). The integration of content and the pedagogical process is a theoretical prescription for success of each MG lesson. It is important that lecturers not only focus on lesson planning, but rather do preparations on joint processes of lesson dissemination and students' participation (Nagda, Gurin & Lopez, 2003:168). This said, it is clear that lesson planning and preparation give rise to proper academic settings that will leave room for active teaching and learning in a MG lesson. The next section focuses on the finding concerning the availability of resources to complement properly planned classroom activities.

5.1.3.2 Availability of resources to properly plan the classroom activities

The study found that adequate and availability of resources to enable lecturers plan their activities well using indigenous teaching aids and tangible resources are conducive conditions. These will enable students to be able to see what the lecturers are talking about and that assessments used when assessing understanding, it is important that the questions in the assessments are similar to those examples done in class. In agreement with the findings is Moloi (2014:112) when arguing that a collective voice of the community can help create a sustainable condition to problems revealed. This voice can be in-terms of the wealth of social indigenous knowledge that rural school community members possess. According to Qhosola (2016:55), content without transformative pedagogy may be rhetorical, intellectualizing, and divorced from reality, while an active and engaging pedagogy without a critical knowledge base may result in temporary feel good emotions. Thus, Lecturers' lesson preparations should be based on different approaches of learning, considers students' perception of the situation within teaching and learning of MG and allow students to develop their own understanding through their existing situation outside the classroom. The subsequent section discusses the findings with regard to the Consistent usage of Lolt in the teaching and learning of MG, which leads to long-term retention and improved application of MG as a conducive condition for the proposed approach.

5.1.3.3 Consistent usage of indigenous language in the teaching and learning of MG leads to long-term retention and improved application of MG

The study found that the use of indigenous language as a language of teaching and learning is important. It is therefore crucial that lecturers maintain a balance between the use of English and students' home language in multilingual Mathematics classrooms, as code-switching in a multicultural classroom is encouraged (see Section 4.3.3). The findings reveal that consistent usage of indigenous language in the classroom will enable students to understand what is taught in the classroom, as they will be familiar with the language of teaching and learning. This will in turn assist students to understand set instructions and maneuver mathematical geometry applications easier. In agreement with the findings, Barwell (2009:32), states that the teaching of MG in multilingual classrooms is complex since it requires lecturers to bring together students with educational needs, who, when taken exclusively, would call for different interventions. Chitera (2009:1) adds that teaching and learning of MG should be done in a language students are familiar with at all times. Not only this, but parental involvement in the teaching and learning of MG was also found to be another conducive condition as discussed in the subsequent subsection.

5.1.3.4 Parental Involvement in the teaching and learning of MG

The study found that as part of the planning process, lecturers and parents need to work together in preparing students and determine how they wish to engage as peers in the content of MG (see Section 4.3.4). This is considered as a conducive condition to the smooth implementation of the solutions. In support of the findings, involving all the stakeholders in ensuring that students acquire knowledge in a way meaningful to their lives takes priority (Ahmed, 1993:3; Boyce, 2004:571; Higgs & Smith, 2008:66). Llamas and Tuazon (2016:59) agree with this statement by stating that parents become comfortable when the education system requires their involvement in educational activities and that students become more focused in their work (Kwatubana & Makhalemele, 2015:315). The findings further reveal that, a strong collaboration of parents with school authorities can lead to increased improvement in both physical and academic performance of the school (Ntekane, 2018:02). Park and Holloway (2013:105) further indicated that the parents' involvement in the students schooling has long been believed to promote a range of positive outcomes, including academic achievement, engagement in school work, and lower dropout rates. To add to this, was importance of lecturers and students' motivation as a condition that can be in sustenance of the proposed approach as discussed in the next subsection.

5.1.3.5 Motivation of lecturers and students

The study found that availability of teaching resources or materials that can appeal to tactile, auditory and visual students can serve as motivation to both lecturers and students. Moreover, the acknowledgement of students' efforts in a form of praise can encourage students to try harder to uplift their performance in MG (see Section 4.3.5). Therefore, this is the condition that could enhance the productive teaching and learning of GM. Sun, Jiang, Chu and Qian (2014:1690) indicate that with the grateful emotions, individuals with high gratitude tend to experience more optimism, vitality, religiousness, and spirituality, which may result in high levels of school well-being. Mosikidi (2012:18) indicates that motivation stimulates people to act in a goal-directed way. Lunenburg and Ornstein (2012: 80) refer to motivation as an internal condition or state that activates human beings to behave in a particular manner. Berg and Theron (2001:166) also indicate that purposeful and organized behaviour in human beings results from motivation. These findings indicate that motivation is a very important tool in as far as the development of both the lecturers and students is concerned.

The following section addressed findings concerning threats that could impede the successful implementation of the strategy that were considered important.

5.1.4 Some of the threats that could impede the successful implementation of the strategy that were considered important

This section presents findings with regards to barriers that still exist in the form of threats for the successful implementation of the strategy. Threats, such as; Poor management of the learning space, lecturer resistance to technology in the classroom, students inconsistently focusing on the set objectives, lack of parental involvement in the teaching and learning of MG and demotivated lecturers and students threaten the enhancement of the teaching and learning of MG. These threats are discussed as subsections and to initiate this discussion, poor management of the learning space is discussed as a possible threat that could impede the successful implementation of the approach in this study.

5.1.4.1 Poor management of the learning space

The empirical data of this study revealed that the incorporation of indigenous teaching aids in the teaching and learning of MG can lead to poor management of the learning space, as students might tend to get carried away with the teaching aids and end up not sticking to the set time (see Section 4.4.1). Time management is very important, classroom interactions might exceed the students' excitements and consequently, the classroom lacks proper elements on facilitation and management. This will eventually threaten the successful implementation of the strategy. It was reiterated by Nketekete (2004:9-10); Sithole (2010:58); Sithole and Lumadi (2012:77), that time can threaten the implementation of the strategy as interactive lessons can be too long for lecturers and students. If lecturers want to balance theory and practical assessments, the time allocated per week is not enough to cover the content (Nketekete, 2004:9-10; Sithole, 2010:58; Sithole & Lumadi, 2012:77).This can be overcome by lecturers informing students of the set objective of each lesson at the beginning of each lesson so that students can know the parts they should pay focus on, to avoid being carried away by excitement.

5.1.4.2 Lecturer Resistance to Technology in the Classroom

Findings from the literature review and empirical data of the study found that not all lecturers are technologically inclined and they are not even willing to be equipped with such skill (see Sections 2.3.4 & 4.4.2). Resistance is indeed a threat as lecturers become dependent on the textbook as the only source of information. This threat can be overcome by exposing lecturers to various trainings that will allow them to be competent in as far as the usage of technological teaching resources is concerned. In support of the findings, Johnson, Jacovina, Russell and Soto (2016:12) state that adopting a new educational technology can be a time-consuming process, hence lecturers should have access to extended support from trained professionals. With additional technology support, lecturers can worry less about technological barriers and instead focus on teaching their students. This will afford lecturers the opportunity of employing different teaching and learning approaches in the classroom (Lucas, 2001:162; McPhail, 2001:488). Empirical data suggests that lecturers should be given technological support that incorporates IK with the goal to eliminate abstract presentation of concepts and adds on the students' perception and disbelief around MG.

5.1.4.3 Students inconsistently focusing on the set objectives

The empirical data of this study found that students' inconsistent focus on the learning objectives is a threat. That is, students do not participate in the teaching and learning of MG. Ultimately, this limits class interaction and also causes students to miss out on the benefits of student-centered undertakings, which include being and this automatically threats the successful implementation of the strategy (see Section 4.4.3). This threat can be overcome by lecturers preparing and planning lessons that incorporate indigenous knowledge artifacts that will stir their curiosity and prompt them to interact with one another.   Effective lecturers must not only be domain experts, but also understand how to flexibly use the availability of different pedagogies when teaching MG (Mahlomaholo & Francis, 2011:295; Mahlomaholo, 2010:11).

5.1.4.4 Lack of parental involvement in the teaching and learning of mathematical geometry

Findings from the literature review and empirical data (see Sections 2.3.4 & 4.4.4) revealed that lack of parental support at home, gives rise to students not practicing Mathematics when at home. This threat can be prevented if the College can create ties to collaborate with parents and include them as stakeholders in the learning process of their children. According to Ntekane (2018:4), parental involvement in learning acts as a gel that helps to make learning for students pleasant and encourages them to work even more as they pursue to make those closest to them proud.

5.1.4.5 Demotivated lecturers and student lecturers for the teaching and learning of mathematical geometry

The study found that there is lack of motivation on the lecturers and the students' side, in as far as the teaching and learning of MG in the classroom is concerned (see Sections 2.3.4 & 4.4.5). Lecturers' lack of motivation comes as a result of lack of researches and students' lack of motion comes as a result of monotonous lessons that are only textbook oriented. It was found that students tend to find the routine lesson boring and tend to be passive in the learning process. Empirical data suggests that this threat can be prevented by lecturers who make use of variety of teaching resources, that entice maximum student participation and incorporate local indigenous knowledge, that makes sense to indigenous students located in the rural areas. In support of the findings, Johnson, Jacovina, Russell and Soto (2016:18) stated that, majority of the current lecturers grew up without access to technologies like the personal computer and the internet, as opposed to students today who are raised in an environment saturated by computer technology. These "digital students" can intimidate their lecturers, especially lecturers with little technological experience. The findings concur with Hughes (2005) and Rakes and Casey (2002) when stating that, if lecturers feel they do not have the necessary competencies when using technology, they may feel less in control of the class and consequently, be unlikely to explore new possibilities that utilize technology when preparing and planning MG lessons. This could indeed threaten the implementation of the proposed approach.

The following section addressed findings pertaining the identified indicators of success of the implementation of the strategy.

5.1.5 **Findings pertaining the identified indicators of success of the implementation of the strategy**

This section outlines findings pertaining the envisaged success that the strategy will lead to if appropriately implemented. The successful implementation of the proposed solutions will lead to so many successes, such as; Increment in student enrollment in Mathematics, Student academic performance and Certification Rate at exit level NQF level 4, and improved teaching skills and Mathematical Proficiency.

5.1.5.1 Increment in Student enrollment in Mathematics

Findings from empirical data of the study reveal that the ability of students to bear positive attitude and belief will indicate that the study was a success, as this will contribute to the students' increased level of interest in the MG (see Section 4.5.1). This increase in the students' interest in MG will be measured by more students' enrollments in Mathematics as opposed to Mathematical Literacy at the beginning of the year. In agreement with the findings, Kosko (2012) states that student enrollment in classes is initiated by frequent

Mathematics discussions amongst students as evidence that students have interest to be exposed to Mathematics contexts continuously. Supporting the afore stated is, Mullis, Martin, Foy and Arora (2012) by emphasizing that even though sound knowledge of Mathematics is generally regarded as a prerequisite for effective Mathematics teaching. There is scant evidence linking lecturers' preparation to Mathematics discussions as having significant and positive impact on Mathematics achievement. Described in another way by Kosko and Miyazaki (2012), they state that a student enrolled in a class with daily Mathematics discussions will have larger gains in Mathematics achievement than a similar student enrolled in a class with little or no discussions and interest in Mathematics.

5.1.5.2 Student academic performance and Certification Rate at exit level NQF level 4

Findings from empirical data revealed that a strong collaboration of parents with College authorities will lead to an improvement in the students' academic performances (see Section 4.5.3). The student performance will increase and it will be visible in the increase in the students' pass rate. In support of the findings, Ntekane (20187:02) states that students whose parents are involved, are active and prepared to learn. They learn to be punctual and diligent as the parents would be persistently enquiring around their progress and they would not need to disappoint them. Taking responsibility becomes a portion of the nature of such students to plan ahead and be able to do their work according to their schedule, which is the quality of being organized (Sapungan & Sapungan, 2014:45).

These benefits serve as indicator that if the strategy is successfully implemented, it will lead to students' performances. Consequently, an increase in the students' performance bear a positive contribution towards the certification rate at NQF level 4. The findings revealed that most visible indicator will be lecturers preparing lessons that are interactive and those that make use of indigenous teaching aids, affording students the opportunity to link the Mathematics they learn in the classroom to their everyday environment.

5.1.5.3 Improved teaching skills and Mathematical Proficiency

Findings from empirical data revealed that lecturers will make use of Conceptual and pictorial teaching methods that display indigenous teaching aids (4.5.4). This indicator will be visible as soon as students reflect on the interacting ability through practical tangible activities in the classroom, giving students the independent opportunities of creating lifelong learning links between the MG they learn in the classroom and their local environment. Students will be actively involved in the teaching and learning process as they will be enthusiastic and participating with confidence with their peers. Research has indicated that students tend to succeed to a greater degree when both student learning styles and the learning environment provided by lecturers are consistent (Singh, Stuart, Yager, Yutakom, Robert & Ali, 2012:198). As lecturers become more proficient in the technical skills required for the teaching and learning of MG, their needs may shift to administrative and peer support to help develop and apply new uses for the teaching resources in the classrooms (Johnson, Jacovina, Russell & Soto, 2016:18).These mentioned elements are discovered to be indicators that will be the evidence that the IK approach is indeed effective in the enhancement of the teaching and learning of Mathematical Geometry at NQF level 4, as a concept of Mathematics.

The following section addresses the conclusion of the study.

5.2 CONCLUSION OF THE STUDY

Working with subject experts, lecturers and students in collaboration to put the proposed approach into practice has professionally elevated me as an individual and us as a research team. This journey has eye-opened us on things we previously turned a blind eye on, such as the rich indigenous knowledge that is present in the local communities and not being put to good use. This outcome came as a consequence of a subsection in the PAT assessment that requested students to go and do research in the communities by involving their parents. This gesture made students realize that Mathematical Geometry is not confined to the westerns. Through this task, it became evident that elders in the communities do know and understand Mathematical Geometry and that they have had the opportunity to make use of it in their vicinity without referring to it as MG. Students came to realize that even though their elders did not get the opportunity to be academically learned, they are culturally learned and the very same aspects they learn at school are present in their respective cultures, referred to in different terminologies.

Not only this, but through working on this study, when students were embarking on this Practical Assessment Task (PAT), they came to realize that Mathematics is quite an interesting subject and that they do Mathematics on almost every activity they embark on, be it for an example, when playing and walking past infrastructure.

Furthermore, Part of the Assessment was that students had to do a 5 minutes' presentation based on what they have researched. It was visible that not only did this PAT assists students to understand this MG better, but it also assisted them to learn more about their culture and their indigenous background knowledge, and this included the lecturer as well. Group interaction was one of the crucial elements emphasized at various levels of contact because of its collaborative qualities.

Nonetheless, with all these said, it is distinct that this approach managed to arouse students' interest in MG, closed the gap that seemed to be prevailing, of students being unable to relate the MG taught in the classroom to their everyday lives and also, emphasized the difference IK can bring in the teaching and learning of MG and Mathematics in general.

This conclusion was reached subsequently after the study had identified the challenges experienced in the teaching and learning of mathematical geometry at NQF level 4 at the TVET College. Through adoption of Critical Emancipatory Research (CER) coupled with the principles of Participatory Action Research (PAR) as guiding tools to investigate the challenges, solutions, conditions, threats and indicators of success to gather data through FGD. The generated data was analyzed using thematic analysis. The findings pertaining the challenges revealed that Visualization skills and inadequate Resources, Attitude and belief, Abstract presentation of concepts, omitting reasons when determining angle in the theorems and students being unable to relate the Mathematical Geometry taught in the Classroom to their environment are the main challenges experienced in the teaching and learning of MG. Based on these challenges identified, the study concluded that, improvement of visualization skills through indigenous knowledge, student interaction to enforce positive attitude and beliefs in the teaching and learning of MG, lecturer collaboration and indigenous teaching aids as means to eliminate abstract presentation of MG concept, strategy to improve students' understanding of mathematical geometry, vocabulary and practical assessments as a strategy to assist students to relate the mathematical geometry taught in the classroom to their everyday lives are possible solutions to the identified challenges. It was also concluded that conducive conditions that the study is dependent on, for the successful implementation of the above proposed solutions were Proper Academic settings, Availability of resources to properly plan the activities, Consistent usage of indigenous language in the teaching and learning of MG, which leads to long-term retention and improved application of MG, Involvement of parents in the teaching and learning of mathematical geometry and Motivation of lecturers and students. From the analysis of the findings, the study concludes that the successful implementation of the proposed solutions will lead to Increment in student enrollment in Mathematics, students' academic performance and the Certification Rate at exit level NQF level 4, and improved teaching skills and Mathematical Proficiency. However, analysis demonstrated significantly that there are barriers that still exist in the form of threats that could hinder a successful implementation of the strategy, threats such as, poor management of the learning space, lecturer resistance to technology in the classroom, students inconsistently focusing on the set objectives, lack of parental involvement in the teaching and learning of MG and demotivated lecturers and students threaten the enhancement of the teaching and learning of MG. From this conclusion, it is evident that there is a need for indigenization of mathematical geometry to attain the aims and objectives of teaching and learning in TVET College.

With all this said, the next section stipulates the recommendations made by this study.

5.3 RECOMMENDATIONS OF THE STUDY

The overall findings of this study revealed that there is indeed a dire need for South Africa to indigenize the curriculum, taking from the analysis of the Research Team's utterances and the feedback from the PAT. The Co-researchers felt that the current Westernized and Eurocentric curriculum does not make sense to indigenous students located in the rural areas of South Africa. Therefore, the study recommends as follows:

1. The study recommends that the Department of Higher Education and Training consider creating curriculum materials that guide lecturers through this process of indigenizing the curriculum. Additionally, that the DHET revise the Mathematics subject and Assessment guidelines document in order to address the scarcity of ideas of indigenizing the curriculum present in the documents.

2. The study recommends that the Department of Higher Education and Training, through the TVET Colleges should ensure that Mathematics lecturers undergo professional development workshops that will develop lecturers to work as a team, share ideas with their colleagues in order to share knowledge.

3. The study recommends that the College, through the office of Academic Affairs and curriculum support should have advanced measures in place that allow the coordination of Mathematics curriculum, and availability of instructional materials, such as;

    - Advance ICT software that will assist Mathematics lecturers in creating academic setting that will encourage students to be enthusiastic in their learning process. Technology allows dynamical approaches to the major concepts in geometry when compared to the traditional paper and pencil practices. Digital technology makes it simple to link multiple representations and modelling of the various geometric shapes and or figures easily. It was deduced from the co-researchers that ICT will assist students to visualize abstract problems and make them more accessible.

    - Availability of Practical assessment that will foster students' interaction through hands on activities. Hands-on activities will provide students with the opportunity to practically build and take apart, create and make drawings, and observe geometric shapes in the world around them.

4. The study further recommends that through the office of Academic Affairs and curriculum support at the College, Mathematics lecturers need to have Mathematics Quarterly programs in place (Rallies) in a form of team teaching, whereby lecturers and students from different campuses of the TVET College will gather in one place and all Mathematics lecturers will meet and work as a team to treat challenging concepts in Mathematics with the students, share knowledge and ideas with their colleagues on how to simplify these challenging concepts, with a common aim of enhancing students' performance in Mathematics.

5. Finally, the study recommends that students' cooperation in peer teaching should be encouraged. Findings indicate that students understand more when they work in groups. Group work therefore improves their performance. Working within groups will help students to develop efficient team skills and improve their communication abilities needed in cooperative learning settings. It also gives students an opportunity to develop their personal, social and psychological skills. This will evoke student ability to take responsibility, encourages creativity, deepens friendships, and builds community among students. The co-researchers emphasized that students complement one another. So, they should have proper platforms to share insights, propose new approaches and challenge assumptions. They could learn new perspectives and insights, techniques and values from interacting with one another.

The following section focuses on the limitations of the study.

5.4 LIMITATIONS OF THE STUDY

Due to the methodology utilized in this study, the research was classified to four Campuses of the TVET College. If more Colleges had been involved in the research, different findings might have emerged in the same Province, whereas this study was only conducted at the TVET College in one of the Districts located in a rural area in the Free State Province. The findings therefore, are limited to rural area perceptions. Possibly, different findings would have been made at provincial level if the study was extended to other Colleges of the Free State province. The results of the study could therefore be generalized only to TVET colleges that share the same rural characteristics with the selected college.

The next section addresses the recommendations for further studies.

5.5. RECOMMENDATIONS FOR FURTHER STUDIES

This study was aimed at enhancing the teaching and learning of mathematical geometry concerned with the performance of students at NQF level 4 in mathematical geometry. In precise, the students' attitude and beliefs, inadequate resources and others which often lead to lecturers using abstract presentation of concepts, contribute to the drop in the certification rate at the college. In the Free State province, there are other Colleges and institutions of education, such TVET Colleges, Secondary schools, as well as primary schools. Hence, this study could also be simulated in these other educational institutions for comparative purposes. Moreover, since the study focused only on Mathematical Geometry, it does not necessarily state that other concepts in Mathematics do not experience challenges. If fact, not only Mathematics, but in other learning areas offered at the College. This is to say, the study could also be replicated to test and provide solutions on tackling challenges in other Mathematics concepts at any educational level, institutions or different learning area.

With all being said, the next section addresses the concluding remarks of this study.

5.6 CONCLUDING REMARKS

This chapter has presented the findings of the study according to the objectives of the study as mentioned in chapter one. It provided the recommendations made in the light of the findings of the study. The limitations of the study also received attention. Contrasting viewpoints encourage more active class participation, the use of indigenous knowledge as teaching resources and Peer teaching amongst students. Team teaching is particularly effective in reducing teaching burdens and boosts morale, sharing in decision-making enhances self-confidence in both the lecturers and students. The performance of students who are studying Geometry can be improved if lecturers teach in an effective way. However, it is not only effective teaching that determines the performance of students in Geometry at NQF level 4. Major findings of this study indicate that there are main factors contributing to the poor performance of students in geometry at the TVET College, such as; Visualization and inadequate resources, attitude and beliefs, Abstract presentation of MG, students being unable to understand the Lolt, specifically in MG and consequently end up omitting geometric reasoning when determining angles. Moreover, students being unable to relate the MG they learn in the classroom and their local environment. With reference to these challenges, the co-researchers stated that the College should come up with packages and reward the hardworking students to motivate them. The potential benefits for the co-researchers will be a pedagogical shift of moving from abstract methods of teaching and learning towards the authentic utilizing of the indigenous knowledge learning approach that will be informed by having emancipated learner-centered Mathematics classrooms. This will allow students to respect cultural heritage and encourage them to know that all people are capable of doing mathematical geometry in their own unique perspectives.

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ETHICSAPPROVAL

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GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

03-Jul-2019

Dear Miss Madimabe, Makhosi MP

Application Approved

Research Project Title:
Enhancing teaching and learning of Mathematical Geometry at Technical and Vocational Education and Training (TVET) colleges using the Indigenous Knowledge approach.

Ethical Clearance number:
UFS-HSD2019/0040/0207

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Prof Derek Litthauer
Chairperson: General/Human Research Ethics Committee

Digitally signed by Derek Litthauer
Date: 2019.07.03
12:36:16 +02'00'

Appendix A : Co-researcher Encoding

Objective 1:Challenges	Co-researcher ID	Responses
Visualisation,	HOD 1	Lecturers do not have enough resources to teach MG in the classroom. MG is a practical topic hence lecturers and student have to always engage in visual and tactical style of teaching and learning when dealing with this concept. Students of the 21 century love technology therefore, lecturers should make use of such in the classroom can prompt the deeper interest of the students and to increase the students level of curiosity as this why student tend not to visualize the geometric figures dealt with in this concept. You can't prove a tangent chord theorem without relating to the drawing
	HOD 2	Since the concept of geometry deals with shapes, it is heavily based on visualization. Student are often unable to comprehend the purpose of geometry, as a result of being unable to visualize as lecturers tend not to bring teaching aids that allows student to see the various shapes as the lecturer tend to verbally present the shape to the students and due to the students inability to create pictures in their minds they tend to experience difficulties in geometry .

	HOD 3 (Mokoena MJ)	Most of the lecturers see geometry as an abstract concept and they have no enthusiastic when coming to dissemination of this concept in class and this tend to demotivate students towards the concept in general and this leads to student not even attempting to visualize the mathematical shapes used in this topic
	FORMER TEACHER (Tshabalala ME)	Students tend to identify geometric shapes based on their appearance not on their properties. MG should be learnt and taught practically where each student should be able to measure angle, draw sketches whilst the terminology used in this concept should be explain to student in simple English , remember , language also play a vital part in making students get a clear visual picture of what is taught .
	MATHS Senior LECTURER	Visualisation is very important . To see a picture or a video can help students understand MG better but it is important to do investigations practicals this can assist students to be authentict as they will be doing the investigations themselves and experiment these Geometrical Figures. The main problem is that our students are not used to doing research in a form of assessment. As the dominant method of assessment in

		education system centres around teach to assess (Formal Test and Examinations).
	MATHS LECTURER 1	Due to student level of confidence in this concept , they tend to have anxiety when learning mathematical geometry which is informed by their lack of understanding of the concept from lower grades and generally cannot uterlise their visualization skills accordingly.
	MATHS LECTURER 2 (Mofokeng K)	Most students lack this skill of visualization, hence it is the lecturer's responsibility to prepare lesson is such a way that this skill is triggerd. The contributing factors are : ✓ Lack of resources and or materials (teaching Aids) to demonstrate to students when teaching this concept. ✓ Lack of lesson preparation and planning.
	MATHS LECTURER 3 (Mokoena TR)	What I have realised is that when students visualise objects or when they see objects, they can only identify shapes but the problem is that they do not know the properties. This means that students are not being taught from the lower grades. They do identify shapes but they do not do that with accuracy. For examples they can identify a square but they do not know the properties of a square and once you rotate a square it becomes a problem because learners tell you it's no longer a square

		but a diamond or a rhombus. The students are very ignorant because mathematics is our daily activities. Everything that we come across is Maths, so I do not know why it becomes difficult when we get to class.
	MATHS SPECIALIST 1	Visualisation is a broad structure. I do believe that since I have taught Mathematics for the past ten years, What is killing Mathematics irrespective of the spectrum of Geometry is the language because whatever you say to a child must produce a picture. Even if you can bring resources to teach a child, but whatever you say when teaching a child will not enhance the resources you have in front of the child. I do believe that the language has a serious impact on the visualisation. This also occurs with visualisating, the section of rotation of geometric figures,before a student can understand how rotation works he or she have to have the image in mind before understanding how to rotate a diagram. It is true that resources bring an idea to a students understanding but we also need to locate the language which we use in the classroom.
	MATHS SPECIALIST 2	Pictures are very important in imprinting knowledge in one's mind. So if sudents do not visualize these geometric figures, then it becomes a huge problem. Sometimes students are unable to comprehend the

		copables of Geometry. Inability to identify various orientations of Geometric figures affect their performance in a sense that they cannot interpret questions on their own.
	STUDENT TUTOR	Lack of pre-knowledge. Student lack of foundation knowledge, as in the lower grades MG is taught towards the end of the year as a result limited time is allocated to it.
	STUDENT 1	Students learn better if they see pictures or diagrams. Lack of resources or various types of teaching aids is one of the factors that contributes to the challenge of visualization as lecturer are only dependent on the figure provided in the textbook .
	STUDENT 2	Student should given the opportunity to learn one aspect , figure or diagram at a time. The linkage of a figure or diagram to its properties should be done stage by stage so that students visalisation skills can be gradually enhanced.
Attitude,	HOD 1	Students seem to be disliking MG because lecturers themselves are not using the appropriate teaching methods to teach this concept. I have this believe that, students look up to their lecturers and the show of

		enthusiastic in the lecturer when teaching, has a very big contribution to making the student fall in love with the content at hand.
	HOD 2 (Motloung MA)	In my classroom I have observed that students usually develop attitude after few attempts of trying to solve maybe a theorem and seem to keep getting an incorrect answer. Attitude differ from student to student. Some students have ignorance.
	FORMER TEACHER	Most of the students show negative attitude and lack of interest towards MG as compared to other mathematical concepts. Student find MG as a demanding concept that recquires visualization and analytical skills which to them it is a challenge all together.
	MATHS LECTURER 1	Students lack confidence in MG and this in turn make them to suffer from anxiety, this makes them not to focus in class and ultimately miss out on the knowledge taught per lesson. This as a result of anxiety student end up having attitude towards MG.
	MATHS LECTURER 2	Most of the students seem to have negative attitude towards MG, as they have this believe that MG is difficult and this consequently make students to be somehow comfortable with their underperformance.
	STUDENT 1	Students attitude when coming to mathematics as subject is very different as compared to other learning areas, reason being MG need

		time for practice, re-doing what was done in class alone in your own spare time and this is what tend to bore most student hence many opt to go do mathematical literacy instead.
	STUDENT 2	The problem arises from lower grades which creates a blockage in our level of understanding. When lecturers also come to class with only textbooks,, we tend to get used to the same teaching method again and again we end up losing enthusiasm in the classroom altogether.
Abstract presentation of concepts,	HOD 1	It has come to my attention that lecturers do not do MG practical rather they focus on the audiological part of it, which reduces the concentration span of students to other topics.
	HOD 2	Sometimes presentations of concepts such as MG is a challenging issue on its own. Our textbooks nowadays have few examples that one can refer to when preparing for a MG lesson.
	HOD 3	Resources are the best when you have to bring the practicality of what you are teaching, but at the same time you need to mind your language make use of simple english. What is the easiest way of putting things to the students than to put it as it is transcribed in the textbook?

		As it has been said, we have to relate Mathematical Geometry of our daily lives.
	FORMER TEACHER	What is important is that ,a lot of MG taught in the lower grades does not foster students into higher levels of geometric thinking, many MG questions in the text book are merely about calculations and students spent most of their time doing calculation than analyzing and investigating shapes.
	MATHS Senior LECTURER	I back to differ slightly, experience has taught me that, there is one mistake that we make when interpreting the information about earlier grades. My opinion –i s that, why don't lecturers teach what they are supposed to teach? As much as it is known that knowledge builds up from previous grades if a learner understands what you are saying or teaching at that current moment , I see no need to dependant on what the previous lecturer did or did not teach.
	MATHS LECTURER 1	As I have spoken about anxiety, this element is not only experienced on the student side only but also in the lecturers side. Some Lecturers offer mathematics as per job requirement (subject allocation) not because they are passionate about it and this contributes to the lecturer

		not doing thorough research and seeking assistance where he or she is lacking and as a result end up doing abstract presentation of concepts.
	MATHS LECTURER 2	The teaching of Mathematics in general at TVET Colleges is still done in an abstract way of teaching , whereby lecturers fail to conceptualise abstract concepts as lecturers tend not to aim at delivering this concept of MG in a simplified manner.
	MATHS LECTURER 3	The issue of preparation cannot be over emphasized,meaning we as lecturers have to prepare and gather the resources and materials that the students can relate and be able to understand the MG concepts better.
	STUDENT 1	An abstract lesson gives room for passive learning to take place and as a result route learning becomes dominant in the classroom. AS student we are ignorant and if the lesson is not triggering our curiosity and inquisitions we tend to memorize.
Omitting reasons when determining angle in the theorems	HOD 1	Students struggling with recalling the reasons because of language barrier lecturer do not provide student with acceptable reasoning from the exam guidelines at times.
	HOD 2	Student not providing reasons when determining angle is an indication that the student is not yet competent in MG concept. This is due to the

		fact that reasoning skills are not enhanced through-out the lesson, as theorems are answered in routine procedural steps(Well Known Steps) and the reasoning part of the answer is informed by student turning a blind eye on the set mark allocation of a given question.
	HOD 3	On the other hand Language is barrier. One can recall that schools situated in the Rural Areas communities , English is done as a second additional language, so if student do not understand the terms or key vocabulary used in this concepts, they tend to mix things up an provide correct angles with no accompanying mathematical reasoning.
	FORMER TEACHER	Majority of students can determine angles but they find it difficult to give reasons for their answers. This is due to a lot geometric terminology, lack of logic in solving MG questions. This as a consequence of students not being exposed to proper key vocabulary term in lower grades.
	MATHS LECTURER 1	If a lecturer use abstract method of presenting concepts, student tend to use route learning and just memorize the theorems, once the theorem orientation changes, it becomes difficult for the student to can identify some angle as they know them but the theorem changed.
	MATHS LECTURER 2	You see, mark allocation in theorem is dependent on the accompanying reasoning. Students tend to either not answer the

		theorem questions and if some do, they determine the angle but not give correct reasoning.
	STUDENT 1	The background information we have acquired in the previous grades should assist us to blend harmoniously at higher levels, so we as student tend to learn to forget. When we pass a grade , we clear our minds not taking into consideration that education as a whole occurs in stages and it is a chain in continuation.
students being unable to relate the Mathematical Geometry taught in the Classroom to their everyday lives (Environment	HOD 1	Lecturers do not bring shapes and other tactile objects to engage students and relate all exercise to daily life of learners like huts for cone shapes , assisting students them to identify objects at their home that are quads and or triangles etc.
	HOD 2	It is due to the abstractness of MG that student are unable to see the link between the what is taught in the classroom and what they see or do in the real life situation. Students' homes and environment plays an important role in the development of knowledge (Cognitive levels of thinking).
	FORMER TEACHER	As a nation we proclaimed our independence as total liberation from the chains of the colonial power, but yet the liberation of the people's mentality is still a big

		challenge and the curriculum taught in the institutions is still culturally oppressed
	MATHS Senior LECTURER	It is very important for students to identify the concepts done in class in their real life situations so as to use their different method of understanding this concept. Practical visible examples can make students understand this concept better and easier
	MATHS LECTURER 1	Lecturers appear to have more trust in the textbook and has resorted to its utility holistically. Teaching aids have always been the best demonstrator of what the content entails. These aids can assist to close the gap that seem to be existing as far as linking the environment to the classroom content.
	MATHS LECTURER 2	Right! This comes as a result of abstract teaching method, is the lecturers responsibility to broken down the lessons in the simplified manner, no example apart from those given to them in the textbook where made in class, then consequently students eventually will not see the relevancy of what is taught in the classroom to that of their real life experiences.

	STUDENT 1	In concepts such as MG it is quite a challenge to see its applications in real life as the concept is abstract on its own. We tend to relay on what the lecturer disseminates to us.
	STUDENT 2	When teaching MG, Lecturers tend not to use practical examples that are applicable to the our local homes (geographical Area), like the various types of roofing present in their communities to demonstrate the different types on angles, examples that are in the our real life situations.

Objective 2: **Solutions**	Co-researcher ID	Responses
Visualisation,	HOD 1	Since we are in the 21st century , this generation of students, are more interested in technology, Imagine if MG was to be taught using technology,as opposed to the old school way? If technology was to be integrated in the teaching and learning of MG? It would be abstract on its own and consequently this would assist in eliminating the abstractness of the concept Geometry. For example, teach students using software's such as making use of videos for Geometry lessons and learn from those videos. Even us as teachers we could prepare our

		lessons in a more interactive way like using power point presentations. That could increase the interest of learners in attending classes
	HOD 2	Teachers must use different teaching methods. The issue of resources is very crucial when it comes to Mathematics because if the teacher relies on textbooks only that results to a problem. Since there is an issue of load shedding, it suffices for one to resort for a different teaching method in the classroom. For example, a Concrete Pictorial Abstract (CPA) method. From our textbooks, Geometry is abstract, but it is easy for learners' a teacher applies the CPA method. A learner could ask about when he/she can apply the rectangle. It is important to concretely bring something that is three-dimensional in class. The students can be able to relate that real life. Take for instance if they come across a card box, a student will be able to recognise that it is three-dimensional although they have learnt it in a two D because in every question paper it is two D.
	HOD 3	Different teaching methods are very important when teaching MG. The way you are you teaching the student how to remember the what they are being taught, is dependent on how are you teaching them reach the solution. On the issue of technology as well, there is what we call TPACK approach which states that you cannot make use of any type of technology while you do not know the relationship

		between the topic and that form of technology. Most usually say that if we have laptops and projectors you would project that to students. Meanwhile, lecturers needs to be able to choose the right resources for the right topic because it doesn't mean that when you have a technological gadget you have a solution.
	FORMER TEACHER	As it has been said, language is very important, that is why I think when you teach learners you should speak in a language that accommodates all of them. Besides that, before you embark on a new concept, it is vital to check learner's background knowledge through posing questions. In the institutions of Higher Education and Training, we underpin the knowledge, in other words, the student already has an existing knowledge and we build up from that knowledge
	MATHS Senior LECTURER	We have indigenous languages. Firstly, I need to interpret and understand the argument behind language. Inorder for all the stakmeholders involved in the process on teaching and learning to work together in try to find a solution, It starts with the language. Which means we as the nation have agreed that the language of teaching in class is English and if we as teachers and lecturers from grade 4 to grade 12/ college level where to stick to that, we can locate a response to all of these challenges combined. And that boils back to the type of teacher and lecturers standing in front of the learner/and

		student. Going back to the saying, because our forefathers never fought for our language to be intergrated into the a curriculum we are suffering the consequences.
	MATHS LECTURER 1	As it has been said, language is very important, that is why I think when you teach s you should speak in a language that accommodates all of them. Besides that, before you embark on a new concept, it is vital to check learner's background knowledge through posing questions.
	MATHS LECTURER 2	There is a saying that says attitude determines altitude. Therefore, attitude is very important and the teachers should love the subjects that they teach. Because if teachers love their subjects they will go an extra mile and see to it that the learners understand. Remember that these learners come from families whereby they are being told by their parents that they also failed mastering Mathematics and they gave up along the way. Students come with that mentality in the classroom but we as teachers should remove that perception in learners. We should also try to check the concept and relate it to other subjects and real-life situations. In that way, learners will have interest in learning.
	MATHS LECTURER 3	Teaching resources can be in a form of a pamphlet that consist of key vocabulary words that explains the important different terms that are

		included in the reasoning of theorems. Terms like Arc, Diameter, Complimentary, Subtended etc.
	MATHS SPECIALIST 1	A lecturer has to defy the odds and try to reach out to the students. In a classroom of twenty five students, it is not everyone that will pass. And according to the policy of the department 90% of the students may pass and 10% of the students may fail. On average if all the students have passed, it is 30% but our District says 40% because they believe that if you fall at least it will be on acceptable average. Apart from what the policy says when I go to class for the first time at the beginning of the year, before I even start a lesson I see all my learners as achievers and I wish all of the would pass. Because these students will be future leaders, then regardless of whether they were rejected where they come from but we must to make a change in their lives. We need to be prepared psychologically as lecturers and do justice to those students.
	MATHS SPECIALIST 2	The concept of modelling maths meaningful in making connections of students lives to the content being presented. This will clarify the and close the gap of no connection between classroom activities

	MATHS TUTOR	Peer teaching in a form of tutorial sessions in which students will interact with their peer who had passed that level with good marks previously. This will assist in enhancing the students confidence as group interaction will be encouraged in these sessions.
	STUDENT 1	Some teachers know too much and if they know too much, that this is why they tend not to have the patience of assisting students how are struggling in MG. Patience is one aspects that is need to be exercised by both lecturers and students to solve the prevailing challenges.
	STUDENT 2	Team teaching in a form of allies can aslo assist us as students whereby, students from all the different campuses of the same college can be combined during holidays whereby lecturers will share the various sections in this MG and present to the student mass.

	Objective 3: **Conditions**	Objective 4: **Threats**

HOD 1	The use of home languages as resources to support teaching and learning is important. It is important to advise lecturers strive a balance between the use of English, which is the LoLT, and the use of learners' home languages in multilingual mathematics classrooms.	Lack of participation of student in the Lesson as a result of Lolt.
HOD 2	Lecturers need to make use of teaching aids, tangible resources so that they can be able to see what we are talking about.	Unavailability of teaching materials, whereby the lecturer only depend on the prescribed textbook as the only source of information.
HOD 3		No funding available to compensate student tutors. Should students be taken to rallies, financial implications are crucial and needed.
FORMER TEACHER	Lecturers need to make use of teaching aids, tangible resources so that they can be able to see what we are talking about.	Lack of participation in the may limit class interaction and also cause students to miss out on the benefits of student centred

		undertakings, which include being exposed to multiple ways on analyzing, interpreting and solving MG problems.
MATHS Senior LECTURER	Availability of teaching resources or materials those that can appeal to tactile, auditory and visual students	Students not being self-motivated, being unable to have the correct revision method and studying skills those that gives them a drive to practice Mathematics daily.
MATHS LECTURER 1	As part of the planning process, lecturers and parents need to work together in preparing students and determine how they wish to engage as peers in the content of MG.	Lack of computer skills to use technology when enhancing and retrieving students interest. Skills on how to ensemble a data projector
MATHS LECTURER 2	time to evaluate and work with each student	Lack of Professional Qualifications for Lecturers offering mathematics hinders lecturers from preparing lesson that caters for various teaching methods and contructive approaches.
MATHS SPECIALIST 1	Preparation from both side the lecturer and the students is a important aspect in as far as lesson delivery is concern .Lecturers should plan and prepare lesson thouroughly so that	

	students can also do their part and be able participate in class	
MATHS SPECIALIST 2	Integration of ITC in the teaching and learning of MG, such as Geogebra or heymaths to explain more shapes and practicals.	Time- management is very important. Though classroom interactions should be encouraged, lecturers should be time cautious as the periods of all the learning areas at the college are equivalent and the use of teaching aids might need more time to disseminate the content to students whilst facilitating learning.
MATHS TUTOR	Availability of Compulsory tutorial session that marks attendance full time.	Lack of concentration in the MG lesson as a result of being unable to visualize MG shapes and or figures.
STUDENT 1	Assessments used when assessing our understanding it is important that the questions in the assessments are similar to those examples done in class.	Students tend to fear seeking help from fellow students and end up losing on crucial information.
STUDENT 2		Lack of parental Support at home, this in turn gives rise to students not practicing mathematics when at home, due to he fact

		that when we seek assistance at home we tend to get negative responses from our parents.

EVIDENCE OF SUCCESS

	HOD 1	Lecturers do not have enough resources to teach MG in the classroom. MG is a practical topic hence lecturers and student have to always engage in visual and tactical style of teaching and learning when dealing with this concept. Students of the 21 century love technology therefore, lecturers should make use of such in the classroom can prompt the deeper interest of the students and to increase the students level of curiosity as this why student tend not to visualize the geometric figures dealt with in this concept . You can't prove a tangent chord theorem without relating to the drawing
	HOD 2	Since the concept of geometry deals with shapes, it is heavily based on visualization. Student are often unable to comprehend the purpose of geometry, as a result of being unable to visualize as lecturers tend not to bring teaching aids that allows student to see the various shapes as the lecturer tend to verbally present the shape to the students and

		due to the students inability to create pictures in their minds they tend to experience difficulties in geometry .
	HOD 3	Most of the lecturers see geometry as an abstract concept and they have no enthusiastic when coming to dissemination of this concept in class and this tend to demotivate students towards the concept in general and this leads to student not even attempting to visualize the mathematical shapes used in this topic
	FORMER TEACHER	Students tend to identify geometric shapes based on their appearance not on their properties. MG should be learnt and taught practically where each student should be able to measure angle, draw sketches whilst the terminology used in this concept should be explain to student in simple English , remember , language also play a vital part in making students get a clear visual picture of what is taught .
	MATHS Senior LECTURER	Visualisation is very important . To see a picture or a video can help students understand MG better but it is important to do investigations practicals this can assist students to be authentict as they will be doing the investigations themselves and experiment these Geometrical Figures.

		The main problem is that our students are not used to doing research in a form of assessment. As the dominant method of assessment in education system centres around teach to assess (Formal Test and Examinations).
	MATHS LECTURER 1	Due to student level of confidence in this concept , they tend to have anxiety when learning mathematical geometry which is informed by their lack of understanding of the concept from lower grades and generally cannot uterlise their visualization skills accordingly.
	MATHS SPECIALIST 1	✓ Visualisation is a broad structure. I do believe that since I have taught Mathematics for the past ten years, What is killing Mathematics irrespective of the spectrum of Geometry is the language because whatever you say to a child must produce a picture. Even if you can bring resources to teach a child, but whatever you say when teaching a child will not enhance the resources you have in front of the child. I do believe that the language has a serious impact on the visualisation. This also occurs with visualisating, the section of rotation of geometric figures,before a student can understand how rotation works he or she have to have the image in mind before understanding how to rotate a diagram. It is true that resources bring an idea

		to a students understanding but we also need to locate the language which we use in the classroom.
	MATHS SPECIALIST 2	Pictures are very important in imprinting knowledge in one's mind. So if sudents do not visualize these geometric figures, then it becomes a huge problem. Sometimes students are unable to comprehend the copables of Geometry. Inability to identify various orientations of Geometric figures affect their performance in a sense that they cannot interpret questions on their own.
	STUDENT TUTOR	Lack of pre-knowledge. Student lack of foundation knowledge, as in the lower grades MG is taught towards the end of the year as a result limited time is allocated to it.
	STUDENT 2	Student should given the opportunity to learn one aspect , figure or diagram at a time. The linkage of a figure or diagram to its properties should be done stage by stage so that students visalisation skills can be gradually enhanced.

EVIDENCE OF SUCCSESS

Challenge	Co-researcher	Response
	Former Teacher	Students interest in the concept will increase in terms of positive attitude
	Maths Lecturer 1	More enrollment of students in Mathematics will be seen
	Maths Lecturer 2	Students will be able to link the mathematics they learn in the classroom to their everyday environment
	HOD 3	The teaching of mathematics will be done using ITC resources those that display indigenous knowledge images
	HOD 2	Strong collaboration of parents with college authorities can lead to increased improvement in both physical and academic performance of the college

	Student 1	Classroom students' interaction will be actively enthusiast and students will display a increase levels in confidence and participation.
	Maths Specialist 1	Student motivation in terms of performance will increase as this will be visible in the increase in their pass percentages
	Maths Senoir Lecturer	The certification rate at NQF level 4 will increase because most of the student tend to do well in other learning areas and remain with mathematics as this consequently affects the college certification rate.
	HOD 1	Lecturers will prepare lessons which are interactive and those that make use of indigenous teaching Aids
	Maths Tutor	Lecturers will make use of Conceptual and pictorial teaching methods those that display indigenous teaching aids as more means to make students to relate to their learning process

Appendix B

CONSENT TO CO-RESEARCHER IN THIS STUDY

I,________________________________(co-researcher's name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study. I understand that my participation is voluntary and that I am free to withdraw at any time without penalty . I am aware that the findings of this study will be anonymously processed into a research report, journal publications and/or conference proceedings.

I agree to the recording of the Focus Group Discussion.

I have received a signed copy of the informed consent agreement.

Full Name of Co-researcher:………..

Signature of Co-researcher:________________________________Date: ___________________

Full Name(s) of Researcher(s): MADIMABE MAKHOSI PRINCESS

Signature of Researcher: _____ _____ Date: 27 JULY 2019

Appendix D

Great Place. Great Choice for Lifelong Learning.

Private Bag X870.
Maluti TVET College
Witsieshoek
9870
24 May 2019

Mr Tsotetsi ME
Deputy Principal Academic Affairs
Central Office
Mampoi Road, Phuthaditjhaba
academic.dep@malutitvet.co.za
Tel: 058 713 6100
Fax: 058 713 6975
For attention: Ms Madimabe MP (2005027053)

RE: LETTER OF APPROVAL TO CONDUCT RESEARCH AT MALUTI TVET COLLEGE

It is has being brought to my attention that Madimabe MP will be conducting a research study at Maluti TVET College under the research title: **Enhancing teaching and learning of Mathematical Geometry at Technical and Vocational Education and Training (TVET) colleges using the Indigenous Knowledge approach.** Ms Madimabe has informed my office of the design of the study as well as the targeted population (participants).

This letter is in response to your request for permission to conduct research in the above mentioned College and It is with this communique that On behalf of Maluti TVET College Academic confirm that your request has been **approved**, as the College supports this effort and will provide necessary assistance where needed for the successful implementation of this study.

Sincerely

Mr Tsotetsi ME
Deputy Principal Academic Affairs
Maluti TVET College
Signature :..........................
Date :30/05/2019

higher education & training
REPUBLIC OF SOUTH AFRICA
2019 -05- 30
CENTRAL OFFICE
Private Bag X870, WITSIESHOEK, 9870
Tel: 058 713 6100, Fax: 058 713 6490

MLT-CENT-Letter of approval 2019-05-24 Page 1 of 1 TME/mmp

Appendix G

Focus group Discussion Schedule of meetings

Hours per session		Number of Participants per session	Perseverance of each meeting	Number of meetings	Data Collection Instrument
1ST SESSION 2hrs	2ND SESSION 2hrs	10 co-researcher namely : ✓ 2 HODs', ✓ 2 Maths Lecturers, ✓ 1 Former Teacher , ✓ 1 mathematics specialist, ✓ 1 Senoir lecturer, ✓ 1 mathematics Tutor ✓ 2 mathematics students	Briefing and planning meeting	1.	Focus Group Discussions
3 hrs including a 15 minutes break in between			Phase one: diagnosis meeting	2.	Focus Group Discussions
			Phase two: Action Planning meeting	3.	Focus Group Discussions
			Phase three: Taking Action meeting	4.	Focus Group Discussions
			Phase four: Evaluation	5.	Classroom Presentation
			Phase five: Specifying the learning	6.	Focus Group Discussions

Appendix H

Makhosi Madimabe
School of Education Studies

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INVITATION TO A FOCUS GROUPS DISCUSSION MEETING

Venue: TVET College [redacted]

Date: [redacted]

Time : 09h00-12h00

AGENDA

1. Opening and Welcome
2. Attendence Register
3. Co-Reseachers Introductions
4. Purpose of the Meeting
5. Discussions Commences
6. Overall Review
7. Vote of Thanks
8. Closure

Kind Regards

[redacted]

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

Makhosi Madimabe
School of Education Studies

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Transforming lives.

ATTANDENCE REGISTER

NO	SURNAME & INITIALS	DESIGNATION	EMAIL ADDRESS	CONTACT NUMBERS
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

Appendix I[1] : Practical Assessment Task NQF level 4 Mathematics Question Paper

NATIONAL CERTIFICATE (VOCATIONAL)

MATHEMATICS

NQF LEVEL 4

Practical Assessment Task

ASSESSOR: MADIMABE MP

MODERATOR: TSHABALALA ME

OCTOBER 2019

Marks :50

DURATION: 5 DAYS (2 hrs 30 minutes per day)

INSTRUCTIONS TO CANDIDATE:

- Write clearly and legibly.
- Answer all questions.
- Show all the working that you have used in determining your answer.
- Number the answers correctly according to the numbering system used in the question paper.
- This is a group assessment.

A maximum number of **2 students** allowed in each group.
No late submission: 11 October 2019

Questions

All measurements in cm.

TOOLS NEEDED:

Tools for the project: Scissors, ruler/measuring tape, pair of compasses, string, coloured beads, white cloth, needle, hard paper, A2 chart paper (or box) and glue.

STEP 1: Using the above materials, Construct a beaded diagram theorems on a scale size of 10 cm by 10 cm that represent:

- ✓ Angle at the centre is two times the angle ant the circumference.
- ✓ The sum of opposite angles of a cyclic quadrilateral is equal to 180^0 .
- ✓ Angles subtended by the same arc are egual.
- ✓ Angle subtended by diameter is equal to 90^0

STEP 2: Do a brief research on the historical value of beads in a cultural context of the community which your home is located and determine the role of these theorems your in real life situation and prepare a 5 minutes presentation. (Consult the Life Orientation lecturer and your parents/Guardians at home on this).

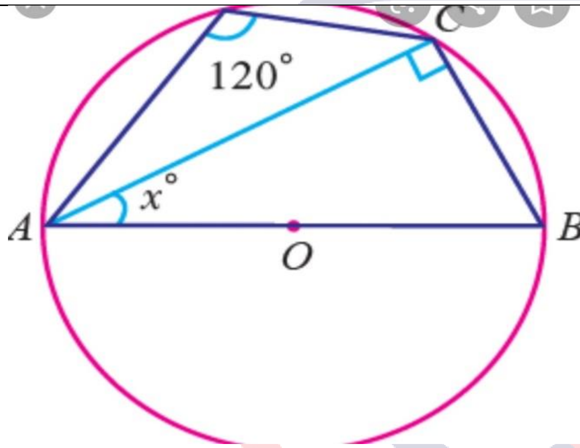
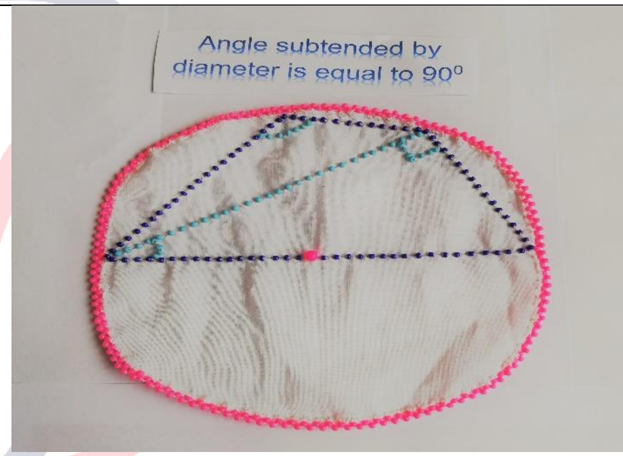
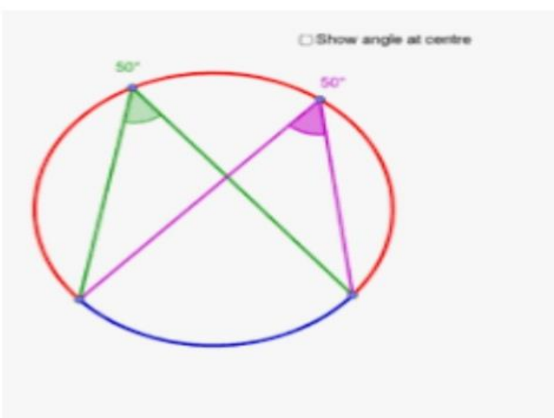
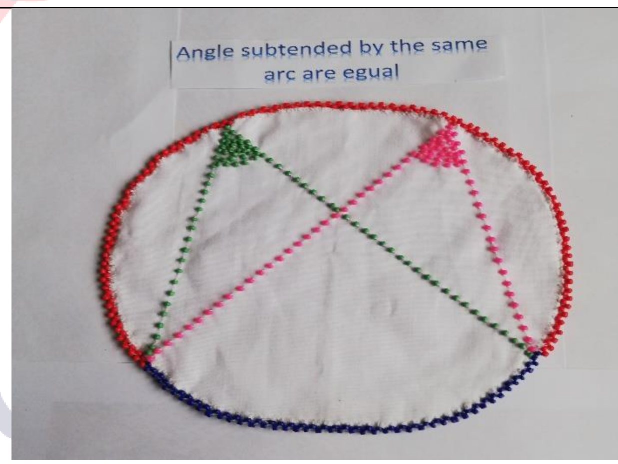
Hand in the following on the 11 October 2019

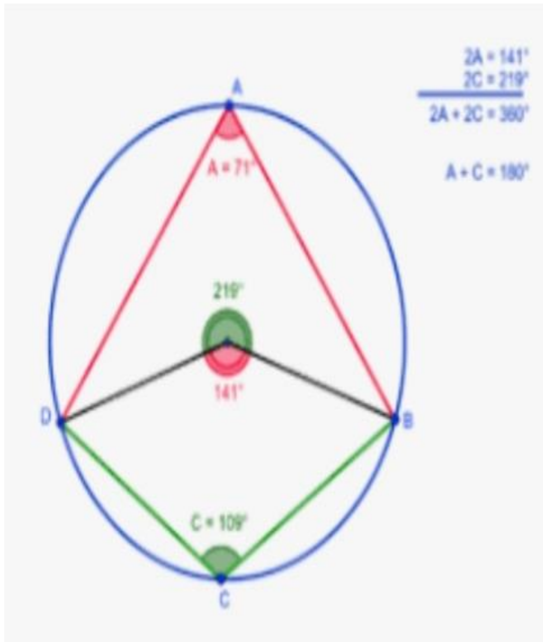
1. Make use of chart presentation.
2. Choose a member in a group to give a presentation.

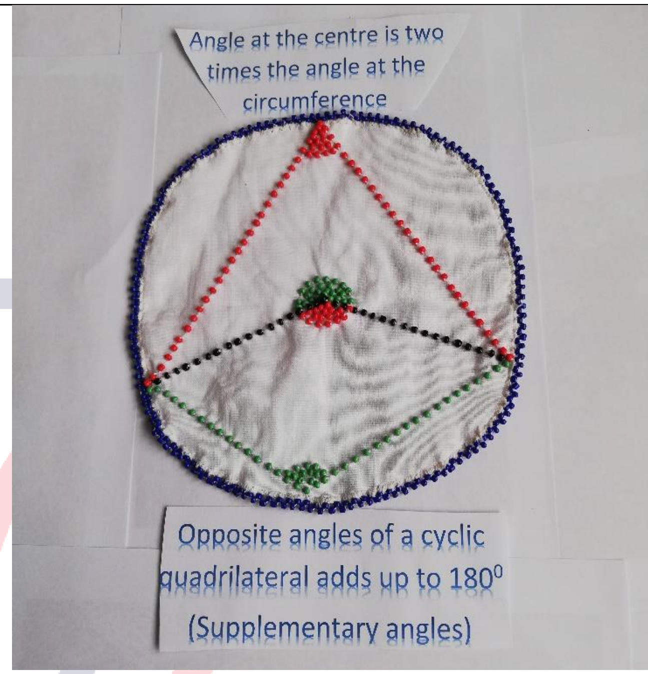
Mark allocation according to RUBRIC **TOTAL 50**

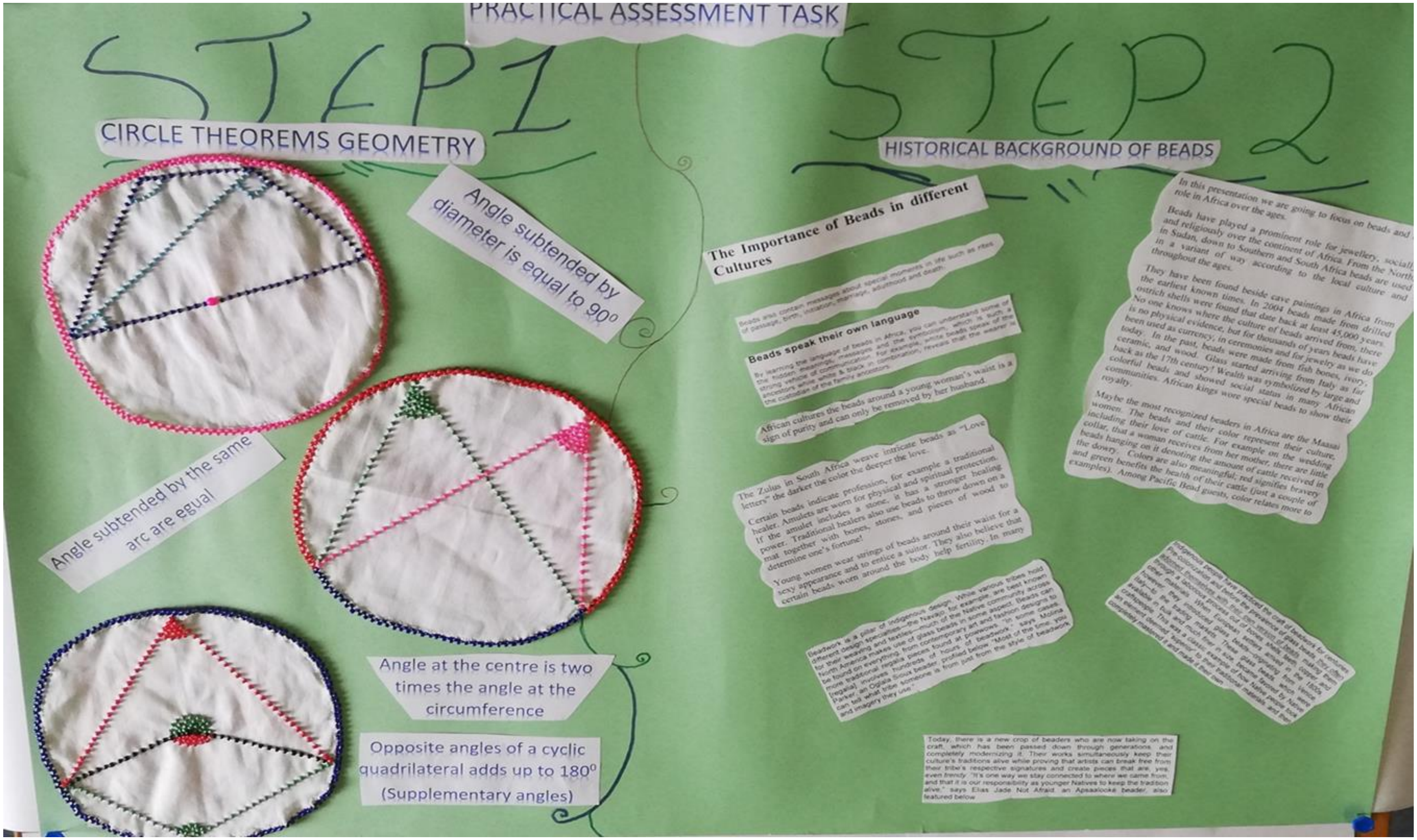
Appendix I[2] : Rubric (Marking Tool)

	SUBJECT: MATHEMATICS			LEVEL : 4		
		Criteria				Marks
	Assessment Objectives	2	3	4	5	50
Step 2	**Reseach/ Collection of data**	No reseach done at all	Reseach too little. Not sufficient to put up a believable project.	Just enough reseach to put up an undrstandable project. Lack of refrencing and diversified resourcing	More than enough reseach. Shows use of more that one resource with evidence of refrences.	
	5 minutes presentaion	Student lacks creative way of talking and doesn't show confidence in own work.	The presentation is not properly prepared. Lack of coordination	Good presentation, with little evidence of research.	Excellent presentation Creativity present.	
	Group Participation	Rest of group no knowledge and participation	Limited supportive knowledge and participation of group.	Supportive knowledge and participation of group.	Good participation and insight of whole group.	
Theorem Presentatio	**Colour Variation of Beads**	Lack of color coordination in the beads in the theorems	Some minimal colour coordination of Beads in the theorems.	Colour coordination is good but with some elememts missing in some theorems	Excellent colour coordination of beads in the theorems.	
	Bead work presentation of Theorems	Beads are poorly arrange	Beads are all over the place. Lines coodination in the theorem not clear.	Good try with the use of beads variations, but with some elements missing (e.g. labels)	Neat, correct scaling, use of colour and accurate.	
	Line accuracy Theorems presented	No records kept as evidence of own work.	Records don't correspond to the project/assignment	circumferences , chords, diameters are differentiated. Show knowledge of the work, but not clear to the reader	circumferences , chords, diameters are differentiated. Show know ledge of the w ork, clear, correspond to the	
knowledge of theorems variety	**Understanding instructions by the group**	Group does not follow instructions. Work all over the place	Very little referal of instructions and easily fall behind with the work	Instructions followed, But not all of them	All instructions followed hence excellent organisation of work	
	Geometric Reasoning	little evidence of improvement in students geometric reasoning on theorems	students geometric reasoning on theorems has improved	students geometric reasoning on theorems is good	excellence in students geometric reasoning on theorems	
	Group Participation	Lack of coordination within the group	Some minimal coordination by the group.	Group coordination is good but with some elememts missing	Excellent group coordination.	
	Overall Neatness	Not neat	Neat	Neat and clean	Very neat	
	Lecturer's comment					
Total						

Appendix I[3] : Practical Assessment Evidence	
Circle Theorem Geometry	Indigenized Circle Theorem Geometry
	
	


2A = 141°
2C = 219°
2A + 2C = 360°
A + C = 180°
A
A = 71°
219°
141°
D
B
C = 109°
C


Angle at the centre is two times the angle at the circumference
Opposite angles of a cyclic quadrilateral adds up to 180⁰
(Supplementary angles)


PRACTICAL ASSESSMENT TASK
STEP 1
STEP 2
CIRCLE THEOREMS GEOMETRY
Angle subtended by diameter is equal to 90°
Angle subtended by the same arc are egual
Angle at the centre is two times the angle at the circumference
Opposite angles of a cyclic quadrilateral adds up to 180°
(Supplementary angles)
HISTORICAL BACKGROUND OF BEADS
The Importance of Beads in different Cultures
Beads speak their own language