Exploring Learning Styles, Instructional Preferences, and Mathematics Achievement among Secondary School Students in Delta North Senatorial District, Nigeria

By

Patrick Nwasiwemua Ojeme

215000108

A thesis submitted in complete fulfilment of the academic requirement for the degree of DOCTOR OF PHILOSOPHY

in

Educational Psychology in the School of Education

Faculty of Humanities

University of KwaZulu-Natal

Supervisor: Professor S. Bansilal

August 2024

DECLARATION

I **Patrick Nwasiwemua Ojeme** declare that

(i) The research reported in this dissertation/thesis, except where otherwise indicated, is my original research.

(ii) This dissertation/thesis has not been submitted for any degree or examination at any other university.

(iii) This dissertation/thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

(iv)This dissertation/thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers.

Where other written sources have been quoted, then:

a) their words have been re-written but the general information attributed to them has been

referenced;

b) where their exact words have been used, their writing has been placed inside quotation marks, and referenced.

(v) Where I have reproduced a publication of which I am author, I have indicated in detail which part of the publication was actually written by myself alone and have fully referenced such publications.

(vi) This dissertation/thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the dissertation/thesis and in the References sections.

Student Name: **Patrick Nwasiwemua Ojeme**

Date: 21 July 2023

Name of Supervisor: **Professor Sarah Bansilal**

DECLARATION BY SUPERVISOR

As the candidate's supervisor, I agree to the submission of this thesis entitled:

Exploring Learning Styles, Instructional Preferences, and Mathematics Achievement among Secondary School Students in Delta North Senatorial District, Nigeria

[redacted]

Signature: -------------------------------------

Professor Sarah Bansilal

21 July 2023

Date

CONTENTS

List of Tables

List of Figures

ABSTRACT

Countries across the world have embarked on curriculum revision in efforts to try and improve the teaching and learning of mathematics. There has been much interest in Africa, particularly in how mathematics could be made more accessible and understandable to learners, so that the countries could benefit from a more highly skilled workforce. One aspect that has received interest is that of learning styles and whether learners who express preferences for certain learning styles perform better than some others who have different learning style preferences. In this study, I set out to investigate the relationship between learning style preferences and the mathematics achievement of senior high school graduates in Nigeria. Furthermore, the study looks at the extent to which gender and age are related to learning styles and mathematics achievement. In trying to get a more in-depth picture. I further looked at students' and teachers' views of the relationship between learning style preferences and mathematics achievement as well as instructional styles and achievement.

The study used a mixed-methods sequential explanatory design approach, where the quantitative data was obtained first, and then the qualitative data. The participants in the study were 171 graduating senior secondary school learners and three mathematics teachers from Delta State in Nigeria, from three schools. The learners completed Kolb's learning style inventory as well as a mathematics achievement test comprising both multiple-choice and open-ended items. Sixteen of the learner participants were selected for interviews, by trying to get a distribution across the different learning styles, genders, and levels of achievement. The study complied with all the ethical protocols of the University of KwaZulu-Natal, and I was granted ethical clearance to conduct the research.

The interviews were semi-structured and probed their learners about their preferred learning styles in learning mathematics as well as the teacher's instructional styles that they preferred and how these influenced their achievement in mathematics. Similarly, the teachers were probed about the differences in learning styles that they may have noticed and achieved, as well as the instructional styles they preferred and why they did so.

The quantitative data generated from the learning styles inventory as well as the mathematics achievement was transcribed into Excel. The inventory was analyzed as directed by the Kolb's learning style studies. This allowed me to characterize each student in terms of four learning styles- Accommodators; Divergers; Assimilators and Convergers. The achievement test was marked by an expert in mathematics. The qualitative data generated by the teacher and learner participants was transcribed and then coded using inductive techniques. The emerged codes were then refined and summarized in terms of the focus of the last two research questions.

The quantitative results showed that the dominant learning style preference according to the learning style inventory was the Diverger learning style which was endorsed by over 80% of the participants. The results provided no significant association regarding the relationship between learning style preferences and mathematics achievement of graduating senior secondary school learners, and neither gender nor age were significantly associated with mathematics achievement.

The qualitative analysis identified many themes related to learning styles. The participants identified that asking questions enhanced learning; sharing ideas and collaboration was an essential part of learning; and listening and reflecting contributed to effective learning practices. In terms of instructional styles, the participants identified teacher questioning practices ad active listening as important strategies.

The study has implications for learning and teaching mathematics in that teachers need to know more about learners' preferences for learning, and what they perceive as effective teaching strategies. It is important for teachers to extend their repertoire of teaching strategies so as to meet their learners' learning needs.

CHAPTER ONE: INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION AND BACKGROUND

Globally, mathematics knowledge and skills have been identified as being required for active citizenship, achieving personal fulfillment, integrating into society, and finding work in a knowledge society (Lee, 2017). Issues related to mathematics education, learning, and student achievement have become a prominent topic in the last decades in view of the worldwide importance of the usage of mathematics in science, technology and everyday life (Bansilal; 2015; Skott, 2019), In the Western world, starting at least in the 19th century, the debate on mathematics education and academic achievement of learners has been huge and has involved some of the most important mathematicians (Bussotti, & Bussotti, 2017). Such a discussion has focused on the impact of different variables, including age, gender, socioeconomic status, and type of schooling, on the teaching and learning of mathematics beginning from basic education, until mathematics education at the university level (Bussotti, & Bussotti, 2017).

In the United States of America, the National Commission on Mathematics and Science Learning and Teaching in the 21st Century (National Academies of Sciences, 2020), also known as the Glenn Commission, took a year to study why the mathematics achievement of learners tended to decline (Patterson, Perry, Decker, Eckert, Klaus, Wendling, & Papanastasiou, 2003). The panel found that the learning and teaching of mathematics in the United States of America needed crucial consideration (Stylianides & Stylianides, 2022). The authors further stated that by focusing on the inherent delight and curiosity behind learners' learning style preferences and mathematical reasoning, the learning and teaching of mathematics would ultimately become joyous in the classroom thereby helping teachers understand the different learning style preferences exhibited by individual learners (Stylianides & Stylianides, 2022).

In all European countries for instance, the mathematics curriculum has been revised with the inclusion of the learning outcomes approach due to the rapid change particularly in terms of science and technology (Blum, Artigue, Mariotti, Sträßer & Den, 2017). The majority of European nations place a strong emphasis on building pupils' mathematical literacy during mathematics instruction at the compulsory level. (Blum et. al., 2017). In relation to the aforementioned reform in Europe, a new scientific knowledge was created as a result of new viewpoints that shifted the focus of thought from concerns about mathematical content and how it should be organized in a curriculum to concerns about how mathematics should be learned and taught as it is rapidly developed through active international interaction (Blum et al., 2017). However, despite the effort and active role played by several European countries, associations and research groups in enhancing mathematical and mathematics education through coordinating nationwide teacher conferences, participating in national programs and reforms, the public image of mathematics and mathematics achievement of learners seems to be on a negative trend, with the number of university mathematics graduates decreasing dramatically and many mathematics departments having major difficulties in attracting learners, for example in Spain, Denmark and Russia (Dreyfus, Artigue, Potari, Prediger, & Ruthven, 2018).

African countries have also embarked on wide scale curriculum revision so that their learners can be better prepared for the 21st century demands, particularly in the learning and teaching of mathematics. In South Africa for instance, there has been a significant reform in mathematics curriculum such that the mathematics education community has grown significantly (Jojo, 2019). Additionally, mathematics and mathematics literacy curriculum were introduced for grades 10-12 to ensure that all South Africans are mathematically literate and numerate (Jojo, 2019). Jojo (2019) also echoes that in the post-apartheid era in South Africa, a redress was etched to ensure that all secondary school learners would have been exposed to some form of mathematics skills and competencies based on their learning style preferences.

In Nigeria, the development of the industrial and technology sectors is receiving more attention. The result is, the National Policy of Education in Nigeria (FRN, 2008), emphasizes the requirement for fundamental mathematics skills and their use in science and technology for deliberate and meaningful development. In other words, a core subject in secondary school is mathematics. In order to prepare learners for problem-solving issues outside of the classroom, the policy also emphasizes the importance of problem-solving in the learning and teaching of mathematics in the classroom. One subject that cuts across all the sciences is mathematics.

Today, mathematical methods pervade literally every field of human endeavor and play a fundamental role in the economic development of a country. According (Ugwu, 2013), mathematics is the foundation of science and technology, the center of all sciences, the way into science, and the secret of science. Here, it is argued that without efficient mathematics instruction and learning, very little development is possible because few people will be able to properly apply science and technology and understand it (Bansilal, 2015). Clearly, it is worthwhile to say here that we need strong achievement in mathematics at all levels of education if we are to advance scientifically and technologically. Sadly, learners' academic achievement in mathematics at the conclusion of secondary school has not improved in the last ten years (Bot, 2018) and quite a number of explanations have been offered to explain why Nigerian secondary school graduates perform poorly in mathematics.

The amount of work assigned, learners' task orientation and skill acquisition, learners' personality and self-concept, and have all been linked to learners' lack of interest in mathematics (Otoo, Iddrisu, Kessie, & Larbi, 2018), feeling of inadequacy (Usman & Musa, 2015), motivation and self-confidence (Sarwar, Hussain & Shah, 2017), anxiety (Zakaria, Zain, Ahmad, & Erlina, 2012). The shortage of qualified mathematics teachers (Oloyede, Adebowale, & Ojo, 2012) , inadequate classroom setup, technology, and instructional materials (Olufunminiyi, 2015), the use of traditional chalk and talk methods (Pellegrino, 2012), as well as teacher qualifications (Bansilal, Lephoto, North, & Zewotir, 2022) are also teacher factors which contribute to poor mathematics outcomes. Dikmen and Akmençe (2018) stated that children are more likely to set objectives for an activity they are interested in and put in the time and effort to achieve those goals. Additionally, student traits including cognitive preferences, and personality as well as learning style preferences play an important role in learning. Other research findings have shown that individual student's characteristics variables such as learning style preferences, age and gender are important factors influencing academic achievements (Chianson et al., 2015). Educational psychologists and mathematics educators have persevered in their search for factors (personal and environmental) that could help learners' mathematical cognition and affective results for academic gains. Learning style preferences appear to be drawing more attention from academics in this field of academic achievement than other personal and psychological factors (Kempen & Kruger, 2019).

As discussed in the paragraph above, mathematics achievement is influenced by many factors, including that of motivation and interest, which can affect both the student and the teacher. When learners show disinterest in a subject, it affects how they respond or pay attention to explanations and participation from the teacher during mathematics classes in the classroom. Additionally, the teacher is impacted when a large number of learners think they won't pass. This is due to the fact that, in addition to this negative reaction from the learners, they are already dealing with a number of other issues (such as low income, low standing in society, a high teacher-to-student ratio, instructional techniques, and so forth) (Ng'eno & Chesimet, 2016). One regrettable result of this is that learners' negative attitudes regarding the topic could be handed down from one generation to the next, creating a vicious cycle of despair. What could be done then to stop such a cycle of despair? Numerous researchers and educators in mathematics have asked this question (Idogho, 2018). One important consideration is the teachers' style of teaching or instructional practices and whether they accommodate learners' diverse learning style preferences (Bansilal, Webb, & James, 2015). This issue of understanding learners' learning style preferences is regarded as a crucial component of learning successfully. Educational psychologists actually hold the view that teachers whose instructional styles take learning style preferences into account are able to help learners learn more effectively (Alade & Ogbo, 2014). They think it's doubtful that learners will learn in school effectively without learning style preferences. The question in terms of mathematics education would then be: Can age, gender, and preferred learning styles of learners be considered during mathematical sessions in the classroom? Furthermore, how could it be accomplished? Therefore, it is important to consider how age, gender, and preferred learning styles affect mathematics learning. The issues of learning style preferences, age and gender n education and its effects on academic achievement are seen as a crucial component of successful learning of mathematics (Bethel-Eke & Eremie, 2017).

Consequently, learning style theories presents an approach to assisting teachers in recognizing the incredibly various requirements that learners bring to the classroom (McLeod, 2017). In addition, these theories provide a framework that enables teachers to knowledgably develop a variety of instructional practices to benefit all learners and enhance their achievement, particularly in mathematics (Vizeshfar & Torabizadeh, 2018)

There is a substantial theoretical base within the notions of learning styles, which advocates for student-centred approaches to teaching. This strategy is founded on the idea that knowledge cannot be imparted to learners in its entirety, but rather by encouraging them to autonomously discover or create new knowledge using their prior knowledge (Clements, Battista & Michael, 1990). This perspective indicates a movement from the traditional method, which views learning as a process of passive knowledge from an authority person, to a student-centred approach, which views learning as an active process in which learners go through a process of transformation (Bansilal, Mkhwanazi & Brijlall, 2014). The focus of the traditional approach is on the breadth and type of knowledge acquired, whereas the focus of the student-centred approach is on the characteristics of the learners' preferred learning styles (Adnan, Abdullah, Ahmad, Puteh, Zawawi, & Maat, 2013). Consequently, the association between preferred learning styles, age, gender, and academic accomplishment requires more study particularly in mathematics (Adnan et al., 2013). Undoubtedly, there is still much discussion on learning style preferences and how they relate to mathematics learning (Odebiyi, 2015). Previous studies have mostly concentrated on identifying people's preferences for and patterns of learning styles (Ibe, 2015). Additionally, the bulk of studies on learning styles included areas like biology, chemistry, and English language (Mahyuddin, Elias, Daud, & Shabani, 2011); consequently, the potential impact of learning style preferences on the mathematical achievement of graduating senior secondary school learners needs further investigation.

1.2 RATIONALE FOR THE STUDY

In the course of my job as a school counselor in Nigeria, I have met a diverse student population whose mathematics proficiency at the secondary school level was relatively poor. I have also observed that despite graduating senior secondary school learners' anticipated career aspirations (medicine, law, accounting, mass communication, philosophy, educational psychology, etc.), a credit pass in mathematics is one of the requirements the West African Examination Council (WAEC) and National Examination Council (NECO) demand from graduating senior secondary school learners before proceeding to tertiary institutions of learning particularly in universities in Nigeria.

In my discussions with some science educators in a seminar on the fall in secondary school learners' mathematics proficiency, I discovered that in our march towards scientific and technological advancement in Nigeria, we need higher achievement in mathematics at all levels of schooling. Okigbo and Okeke (2011) assert that the subject of mathematics plays a crucial role in the study and application of science and technology in much-needed technological and national development which is very important to the developing nations of the world and Nigeria in particular. Hobbs and Davis (2013) stated that without mathematics, knowledge of science stays rudimentary.

In my engagement with learners preparing for the WAEC Certificate Examination on 'developing effective study habit and time management skills training', many learners mentioned that when the teachers used the traditional teacher-centered methods of instruction they found it hard to remain engaged with mathematics. It appears that instructional practices used by teachers in teaching mathematics play a role in motivating learners and maintaining their attention. What I found was also in line with the studies of Wilson (2011) and Ngozi, (2015) in the field of teacher education, which showed that an understanding of the way learners learn improves the selection of instructional practices best suited to student learning. According to Passarelli and Kolb (2012), mathematics achievement of learners may be improved by matching instructional practices to their preferred learning styles.

The research I reviewed was in line with that which suggested a relationship between learning style preferences and mathematics achievement (Adnan et al., 2013). I found that the majority of articles on learning style preferences focused on the relationship between learning styles and learners' ability in subjects other than mathematics (Tan & Laswad, 2011; Jahanbakhsh, 2012; Obiefuna, & Oruwari, 2015; Fatokun, & Adeniji, 2015; Ibe, 2015). Furthermore, most studies used quantitative data analysis methods only, and in this study, I used a mixed methods approach. Firstly, I use statistical data analysis techniques to investigate the association between learners' preferred learning styles and mathematics achievement while also looking at whether age and gender have any bearing on learning style preferences and mathematics achievement. Secondly, I use qualitative data analysis techniques to explore learners' and teachers' perceptions emphasizing the importance of both teachers' instructional practices and learners' learning style preferences in the study of mathematics.

1.3 PURPOSE OF THE STUDY

The purpose of the study is to explore the student learning style preferences and the instructional practices used by mathematics teachers, and to look for associations between various variables such as learning style preference, gender, age as well as school, and that of mathematics achievement of graduating senior secondary school learners in a district in Nigeria. Furthermore I also want to identify the opinions of learners and teachers about the role of the teacher's instructional styles in mathematic achievement.

1.4 THE PROBLEM STATEMENT

The main issue with this study's findings is how age, gender, and preferred learning styles affect Nigerian learners who are graduating from senior secondary school in mathematics (see Section 1.1). This study was primarily motivated by the steady reduction in mathematical proficiency of Nigerian senior secondary school graduates as measured by the West African Senior Secondary School Certificate Examination (WASSSCE) and the National Examination Council (NECO). Therefore, I made the decision to examine more closely the way in which kids prefer to learn mathematics in order to gain more knowledge about ASSSCE and NECO.

It's critical that educators employ effective instructional practices to enhance learners' achievement in mathematics (Umugiraneza et al., 2018; Zakaria et al., 2016). In relation to the above recommendation, the Federal Government of Nigeria through the National Population Council in 2008, emphasized that all elementary and secondary school learners, irrespective of their career objectives should gain admission to higher education institutions in Nigeria. Sa'ad et al. (2014) also stated that the secondary school mathematics curriculum in Nigeria has the following objectives as identified by the Comparative Education and Adaptation Centre (CESAC) in 1982;

- To develop computational skills and foster the desire and ability to be accurate in a degree relevant to the problem at hand.
- To develop precise, logical and abstract thinking.
- To develop the ability to recognize problems and to solve them with related mathematics knowledge.
- To provide necessary mathematical background for further education.
- To stimulate and encourage creativity, originality and curiosity in the student.

Moreover, the Nigerian government established the National Mathematics Center (NMC) and has been funding it as one of its parastatals. The Mathematics Association of Nigeria (MAN) has also undertaken several initiatives to enhance learners' academic success in mathematics by fostering efficient mathematics learning and teaching research. Zakaria et al. (2014) maintain that mathematics achievement of learners can be improved through the provision of proper staffing, teaching and learning materials, curriculum, motivation and attitudes. Karue & Amukowa (2013) also assert that the provision of instructional materials, libraries, laboratory and other physical facilities, and reducing the learners and teachers' ratio to a manageable size are some ways of improving the mathematics achievement of senior secondary school learners in Nigeria.

However, despite all the above-mentioned significant attention devoted to mathematics education in Nigeria, there is still an observable decline in the mathematics achievement of learners in public examinations with a particular reference to WASSSCE and NECO. According to Zakaria et al. (2014), the poor academic achievement of learners in mathematics is a major factor responsible for the decline in science and technology courses at the university level, despite the emphasis by the Federal Government of Nigeria (FGN) on a 60:40 radio in favor of science when it comes to higher education admissions. Supporting the above claims, Sofowora and Adekomi (2012), Ojimba (2012), and Zakaria et al.(2014) summarized the scenario affirming that without mathematics, there is no science, without science, there is no modern technology, and without modern technology, there is no modern society.

The question then arose as to the effect or relationship between learning style preferences, age, gender, and mathematics achievement of graduating senior secondary school learners in Delta North Senatorial District of the Delta State in Nigeria given the situation of mathematics academic achievement of learners.

The issues related to learners' academic progress in mathematics in Nigeria have been the subject of numerous research studies, but none of them, as was previously said, used a sequential explanatory mixed methods research design. Furthermore, even though there has been research on learners' preferred learning styles in Nigeria, none of them have used Kolb's learning style inventory to determine learners' preferred learning styles for mathematics among seniors in senior secondary schools. Therefore, the purpose of this study was to determine the degree to which learning style preferences are predictive of mathematics academic achievement for graduating senior secondary school learners in Delta North Senatorial District in Delta State, Nigeria. It also aimed to determine how learners' learning styles and teachers' instructional styles were perceived by the participants.

1.5 RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

Based on the research problem stated above, this study has the following objectives with respect to the participating learners and teachers from the Delta North Senatorial Districts of Delta State in Nigeria.

- To explore the learning style preferences of the participant learners.
- To determine the relationship between preferred learning style dimensions and the mathematics achievement of the participant learners.
- To explore the possible association between the participant learners’ mathematics achievement and their gender and age.

- To explore learners' and teachers' perceptions of effective learning practices
- To explore effective instructional practices as seen by learners and instructors.

The corresponding research questions of the study presented below are based on the participants, who were senior secondary school learners in Nigeria's Delta State, Delta North Senatorial District.

- What are the learning style preferences of the participants?
- What is the relationship between the preferred learning style dimensions and the mathematics achievement of the participant learners?
- To what extent is there an association between the participant learners' mathematics achievement and their gender and age?
- What are learners' and teachers' perceptions of effective learning practices?
- What are learners' and teachers' perceptions of effective instructional practices?

To guarantee precise and consistent comprehension regarding the current investigation, the following section gives operational definitions of pertinent words.

1.6 SIGNIFICANCE OF THE STUDY

The fact that this study addresses the crucial topic of students' learning style preferences and instructional strategies and how they affect students' learning achievement particularly in mathematics makes it a significant study. It is also significant because it provides teachers with crucial knowledge regarding the relationship between learning style preferences, instructional strategies on students' mathematics achievement, enabling teachers to take the study findings into account when planning their lessons. The study also addresses key issues of learning style preferences and instructional practices and how they affect students' achievement in mathematics. It is significant in addition because it gives teachers meaningful information about how learning style preferences, and instructional strategies affects students' achievement in mathematics. The mixed method design is also a contribution because it can give researchers and educators alike useful information on quantitative data by using qualitative data to support or extend the quantitative findings. The study helps teachers better grasp the varied learning style preferences that both they and their learner's favor.

1.7 THE DIVISION OF CHAPTERS

Each of the following seven chapters makes up this thesis:

The nine chapters of this thesis are as follows:

- Chapter 1 serves as an introduction and gives background data on the study's topic. Along with a brief explanation of the study's justification and definitions of its major terms, the research objectives, problem statement and research questions are offered.
- Chapter Two reviews past and current literatures related to the debates, contentions and argument in the discourse of learning styles preferences, relationship between learning style preferences and academic achievement of learners, relationship between learning style preferences and mathematics achievement as influenced by gender, age, and school they attend and instructional practices used by teachers in teaching mathematics in the classroom.
- Chapter Three explores theories of social constructivism, views of social constructivist learning theories in teaching and learning context, and application of social constructivist theories in secondary school mathematics instruction and learning.
- The research strategy and the research procedures employed are explained in Chapter four. The procedures and methods that were employed to gather and analyze the data are described and discussed. There are explanations for why these research techniques were chosen as the primary means of gathering data.
- The quantitative results of the empirical research are given in Chapter five.
- In Chapter Six, the findings of qualitative research on learners' and teachers' perceptions of instructional preferences for learning styles practices and mathematics achievement are presented.
- Chapter seven deals with the answers to research questions, discussion, limitation, implications for further studies and conclusions.

In the next chapter, past and current literatures relating to the field of learning style preferences and instructional practices will be presented.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter focuses on reviewing past and current literatures related to learners' learning styles, achievement and teachers' instructional styles. The review is organized around the following themes, namely: improving teaching and learning mathematics; teaching and learning strategies; different characterizations of learning style; teachers' knowledge of learning style preferences; research on learning style preferences and academic achievement of learners: factors of age and gender and mathematics achievement as well as the link between learning style preferences, gender and mathematics achievement.

2.2 TEACHING AND LEARNING IN MATHEMATICS

Learning is a cognitive activity conducted by learners with the guidance of teachers (Tuminaro & Redish, 2007). The value of learning is to make the experiences of learners change sustainably, helping them develop their inherent nature to adapt and integrate with the community, nation and humanity. Learning is the student's own action, done by learners and no one can replace them. However, learning can be enhanced under certain conditions and limited when the teaching and learning environment does not include suitable and well-planned activities that can enable learners to build up on their previous learning.

The goal of building equitable classrooms and schools is particularly important today, as schools are introducing new curriculum frameworks, standards, curriculum, and assessments that require more ambitious and complex pedagogy (Cohan & Lotan, 2014). This important aspect of the research is of enormous practical value, and offers theoretical insights and well-documented empirical evidence on issues relating to the learning and teaching of mathematics. Research shows that teachers generally perceive as desirable such practices as learners' involvement in setting goals, learners' interaction in small groups, and learners' involvement in ongoing classroom dialogue (Cohan & Lotan, 2014). Umugiraneza et al. (2017), on the other hand, claimed that teaching styles and assessment practices are key factors that contributes to the improvement of learners' academic achievement both in mathematics. The authors further argued that teaching practices which are in general based totally on "teacher talk" do not involve a whole lot of questioning, discussions, or students' improvement of understanding. To accomplish the above goal, Umugiraneza et a. (2017) proposed that student-centered instructions remain an effective pedagogical practice that supports and enhances learners learning in both mathematics reasoning and problem-solving skills. It is important that teachers provide opportunities for learners to demonstrate what they have learned, since the recognition of their intellectual growth and contributions to the learning and teaching of mathematics in the classrooms can enhance their achievement in mathematics.

Thomas Good and Alyson Lavigne, in their book titled “Looking in the classroom” (Good & Lavigne, 2017), noted that teaching has more influence on student learning than any other variable that can be used to improve student potential and achievement. Good and Lavigne argued that teachers have a greater impact on learners than others because teaching is demanding and requires many skills, much knowledge, and ability to reflect and improve instruction. Indeed, Farrell (2017), has noted that teachers can gain a lot of insight related to their practice as a result of engaging in reflective practice in both teaching and learning in mathematics. Such an approach requires teachers or mathematics teachers to have a range of skills, as well as a sound knowledge of mathematics content when teaching senior secondary school learners (Umugiraneza et al., 2017).

The argument is made that teachers or mathematics teachers at the senior secondary school level need more opportunities to increase their content knowledge in mathematics before they can successfully incorporate student-centered instructional practices in the classroom (Bansilal, 2013). Umugiraneza et al; (2017) call for more research about student-centered instructional practices which includes; teachers’ questioning and explanation, cooperative learning, and problem-based instructional practices in teaching and learning of mathematics. They further argue that incorporating a variety of instructional practices in the teaching and learning of mathematics can accommodate a range of learners’ learning style preferences and this can also contribute to learners’ achievement in mathematics. Given this orientation, Bansilal (2012) asserts that teachers or mathematics teachers must build up mathematical knowledge by observing and reflecting on the teaching and learning in their classrooms particularly at the senior secondary school level. Sofroniou & Poutos (2016) comment that student-centered instructional practices permit learners to develop a range of critical thinking, analytical and communication skills; effective team work, appreciation and respect for others view, techniques and problem-solving methods which promotes active learning and enhance learners’ achievement in mathematics.

The number of research studies carried out over recent years has increased noticeably in the field of mathematics particularly at the secondary school level (Johnson & Johnson, 2014). Sofroniou et al. (2016) agree that substantial research within the mathematics education sector indicates that employing student-centred instructional practices for various activities and exercises does leads to constructive and beneficial achievement for learners.

Similarly, Kolb's (2005) model offers a model that relies to great extent on social constructivism in learning and teaching of mathematics. In order to be able to enhance student's achievement in mathematics, it is necessary for teachers or mathematics teachers to know and understand how learners learn and model the use of instructional practices to elicit talk about thinking (Naidoo, 2011). Naidoo remarks that learners need to verbalize their thinking processes so that gaps or inaccuracies in their thinking process could be rectified through mathematics classroom discussions. Therefore, instructional practices used by teachers during learning and teaching have the potential to influence learners' achievement in mathematics (Delisile, 2016; Firmender, et al., 2014). Some include engaging learners in appropriate tasks to expand mathematical concepts and enhance mathematics achievement through the use of classroom discussions in relation to prior knowledge (Kolb, 2005; Mkhabela, 2016). From the above it can be understood that effective learning and teaching are characterized by appropriate instructional practices that teachers use in their classrooms (Mkhabela, 2016). There are variety of such instructional practices, however the present study will only discuss teacher – centred practices, learner-centred practices, collaborative learning practices, experiential learning practices, reflective practices in learning, questioning strtageies and the use of manipulatives.

2.3 TEACHING AND LEARNING STRATEGIES

Teaching styles and assessment practices are key factors that contributes to the improvement of learners' academic achievement in mathematics (Serbessa, 2006; Umugiraneza et al., 2017). By incorporating a variety of instructional practices in teaching and learning of mathematics, teachers can accommodate a range of learners' learning style preferences while contributing to learners' achievement in mathematics (Umugiraneza et al., 2017). In order to create an optimal teaching and learning environment, teachers are encouraged to use a variety of teaching approaches and teaching styles (Vaughn & Baker, 2001). These authors also point out that the use of "variety of teaching methods and styles ultimately may encourage adaptability and lifelong learning in the teaching–learning process" (Vaughn & Baker, 2001, p. 610). In teaching mathematics, teachers should let learners work independently, they should act as facilitators. One author however enunciates that inappropriate methods of teaching may lead to poor performance of learners in mathematics (Tachie & Chireshe, 2013). This means that students' success depends on the approach used in the classroom.

Effective learning strategies requires teachers to apply novel approaches such as active learning methods based on investigation, discovery, cooperative learning, learners centred and simulations approaches, rather than concentrating on traditional approaches where teachers just engage with chalk and talk (Serbessa, 2006).

In the subsection that follow I discuss different approaches to teaching mathematics, the advantages and disadvantages, as well as the beliefs that mathematics teachers should demonstrate when teaching mathematics.

first describe a well-known approach, which has received much criticism, referred to as teacher-centred approaches. In contrast to teacher-centred teaching, Slavich & Zimbardo (2012) have proposed the term transformational teaching which is based on a belief that teachers can help learners improve their understanding of the content while at the same time helping learners embrace meaningful change in terms of their attitudes, beliefs and skills related to their learning. The discussion on teacher-centred approaches is followed by the discussion of four principles outlined by Slavich and Zimabardo as being aligned to transformational teaching which are student-centred learning, collaborative learning, experiential learning and problem-based learning. I discuss additional issues of teachers' perceptions of learner- centred practices, reflective practice which forms an important part of the practice of teachers whose goal is to help learners understand their work as well as questioning and the use of manipulatives in the classroom

2.3.1 Teacher-centred approaches

Teacher-centered teaching is an approach where the teacher is the person who directs the learning and decides on what is done and how it is accomplished in the classroom. The types of activities usually used in teacher-centered teaching is that of lecturers, repetition and lots of practice of basic skills (Stephan, 2020; Cohan & Lotan, 2014). This approach is also known as the traditional approach (Cohan & Lotan, 2014). According to Nyaumwe *et al*. (2004, p. 33), traditional approaches which involve "teacher-centred instructional methods that do not make learners develop conceptual understanding of mathematics", have been criticised because they do not encourage problem-solving skills in learners. Studies agree that instructional practices which involves much teacher talk is not the most efficient way of facilitating content knowledge with learners, because it limits their active involvement in the learning process (Garrett, 2008).

Although teachers generally perceive practices such as learners' involvement in setting goals, learners' interaction in small groups, and learners' involvement in ongoing classroom dialogue (Cohan & Lotan, 2014), in reality it seems that teachers often resort to teacher- centred teaching (Umugiraneza et al; 2017). Teaching practices which are in general based totally on "teacher talk" do not involve a whole lot of questioning, discussions or student's improvement of understanding (Umugiraneza et al; 2017). A further concern about the use of traditional methods in teaching mathematics is that they do not involve much questioning, discussion or individual development of understanding which are the methods to explore the students' thinking.

Teaching practices which are in general based totally on "teacher talk" do not involve a whole lot of questioning, discussions or student's improvement of understanding (Umugiraneza et al; 2017). Instructional practices which involves much teacher talk is not the most efficient way of facilitating content knowledge with learners, because it limits their active involvement in the learning process (Garrett, 2008). According to Nyaumwe et al. (2004, p. 33), traditional approaches which involve "teacher-centered instructional methods that do not make learners develop conceptual understanding of mathematics", have been criticised because they do not encourage problem-solving skills in learners. A further concern about the use of traditional methods in teaching mathematics is that they do not involve much questioning, discussion or individual development of understanding.

2.3.2 Learner-centred practices.

In contrast to TCA, Learner-centered teaching is a teaching approach in mathematics which seeks to have learners take responsibility for problem solving and inquiry. The role taken by the teacher is that of a facilitator who poses problems and guides learners as they work on the solutions to problems with other peers (Stephan, 2020). In such a tradition, learners are placed at the centre of problem solving while teachers take a less dominant role.This kind of learning is based on the assumption that teachers should design activities and lessons based on learners' needs, abilities interests and learning styles (Slavich & Zimbardo, 2012). Learner-centered instructional practices involve pedagogical practices that support and enhance learners learning both in mathematics reasoning and problem-solving skills. This approach gives learners voice and allows them to work independently. This enables them to discover new ideas, share them, support each other, and come up with new understandings. Learner-centered instructional practices involve pedagogical practices that support and enhance learners learning both in mathematics reasoning and problem-solving skills.

Basically, learner-centered pedagogy is the theory and practice in education based on a constructivist notion of learning, which promotes the inclusion of learners' prior ideas in teaching and learning (Vavrus et al; 2011). This means that learners bring a wealth of experiences into the classroom. According to the constructivist perspective, learners actively construct their own understanding by making an interpretation of the current knowledge (Vygotsky, 1978. Hence, by interacting with one another, learners share their experiences to reach conceptual understanding. They relate the unknown knowledge to their experiences. During their interaction the teacher guides them by way of facilitation.

While learner-centered approaches are advocated by most education policies in Sub-Saharan Africa and other developing countries (Ndlovu, 2019), many practicing teachers may not understand its underlying philosophy (Vavrus et al., 2011). Black (2007) similarly argues that learner-centred pedagogy is not yet understood by classroom teachers. A study with mathematics teachers in South Africa found that teachers relied mostly on teacher-led explanations such as lectures, illustrations and explanations in their classrooms (Umugiraneza et al., 2017). In Malawi, Mtika & Gates (2010) found that trainee or qualified teachers in Malawi were unable to appropriate learner-centred education. They also point out that trainee or qualified teachers' efforts to implement learner-centred practices were resisted or completely 'washed away' by the school system or national curricular orientation. South Africa was no exception as it took an initiative and positive policy position in order to reform its curriculum in the post-apartheid education system. In South Africa, the educational department launched an education policy based on Outcomes-Based Education (OBE) system of education in 1997. One of the reasons why OBE did not work in South Africa was that most teachers misunderstood their role as facilitators and thought it meant that they did not have to do detailed planning for their lessons (Jansen, 1999). One of the roles of the teacher in OBE was to facilitate the learning process which is role of the teacher in learner-centred practices. Many teachers also misconstrued the meaning of a facilitator in a classroom discourse with the purpose of mediating learning. It was clear that teachers needed intensive training and support in order to transform their practices to embrace learner- centred instruction, something that did not happen. (Ferguson, 2010).

Chisholm & Leyendecker (2008) note that learner-centred education is one of the most pervasive ideas; yet it is so hard for them to take root in the classroom. Learner-centred discourse is much harder to achieve in practice than it is to appear in policy. A learner-centered teaching approach is one that reflects support of learners in developing mathematical reasoning, while encouraging them to perceive the teacher as someone who is there to help them make sense of mathematics while creating contexts which help them develop meaning in mathematics (Brodie & Strader, 2006; Yashau et al., 2005). Such an approach requires teachers to have a variety of skills and sound knowledge of mathematics content. Umugiraneza et al; (2017) calls for more research about how learner-centred instructional practices such as questioning, cooperative learning, and problem-based learning could be promoted in the teaching of mathematics.

2.3.3. Teachers' conceptions of learner -centred practices

Brodie et al., (2006) have argued that teachers take up the ideas of learner-centered practices in different ways. In particular, Brodie et al; found that a majority of teachers take up the outward strategies or forms of facilitating learner-centered teaching without attending to the substance of their learner-centered practices. Achieving the underlying substance of learner-centered teaching would require teachers to employ strategies like group work, ask probing questions, offer meaningful tasks and encourage engagement with learners' ideas. However, Brodie et al. (2002) found that the majority of teachers took up the outward forms of learner-centered teaching such as arranging learners in groups, but neglecting the other more substantial criteria for authentic learner-centred practices. This was further mentioned by Shulman (1987) and Ball et al. (2008) that teachers have to know the students they teach.

In order to facilitate learner-centeredness, it is the learner's participation in the learning opportunities that is the central focus, hence the planning and implementation of the lesson must be done with the learners' needs in mind. The teacher must know what the learners know already and activities must be designed with this knowledge in mind. Learners must be given opportunities to ask questions and the teacher must be able to adjust the direction of the lesson, if necessary, to ensure that learning was taking place.

Teachers may be aware of the need to engage learners meaningfully during learner-centred teaching, but they may not be able to translate that into practice. Also, teachers may be aware that during learner-centred teaching, learners should actively participate but teachers do not enforce that. They have difficulty in making meaningful interventions when learners are working on activities; for example, in instances where teachers could not engage with learners' ideas and try to use these ideas to improve the learning. It is also challenging for teachers to ensure that learners' experience the substantive aims of learner-centred teaching thus there is active participation in their learning activities.

In other words, during learner-centred teaching, the task of the teacher is to help learners' access and process knowledge by guiding them (Di-Napoli, 2004). The learners interact with one another striving to acquire knowledge. Harden et al. (2000) point out that when the teacher guides learners, s/he helps and keeps them focused on the intended learning outcome as he/she is a competent Mathematics education practitioner. As a facilitator of learners' learning, the teacher listens to learners' conversations carefully, observes and asks them probing questions to get clarifications and details of their thinking as they engage in some task situation (Harden et al., 2000; Webb, 2009). Webb (2009) emphasizes that teachers need to listen to the learners so that they can make a hypothesis about their difficulties before deciding on the questions to ask or when giving suggestions. This in itself requires the teacher's professional capacity to facilitate learner-centred teaching. It is worth pointing out that when the teacher facilitates the learning process during learner-centred teaching, he or she is in fact helping learners construct new knowledge (Bansilal, 2010).

2.3.4 Collaborative learning practices

Learning through collaboration is a central tenet of the constructivist model of learning (Vygotsky, 1978; Piaget, 2013). According to Zhou et al., (2019) on the report from the committee on Science, Technology, Engineering, and Mathematics (STEM), it is said that group work in learning and teaching of mathematics plays an essential role in learners' question acquisition and in critizing constructively (Li & Schoenfeld, 2019), thus enhancing learners achievement in mathematics.

From a review by Alegre et al. (2019) concerning studies exploring collaborative learning and learners' achievement in mathematics, the authors revealed that group work is most useful when learners are taught how to work in groups, to present, provide and accept assistance. Alegre et al. (2019) observed that cooperative learning improves achievement of learners and the authors also suggests that instructional practices used by teachers provides opportunities for learning that are difficult to establish in the classroom settings. The authors also interestingly reveal that collaborative learning approaches are useful to enable learners to take part in discussion, reflection, feedback and to combine learning, clarify understanding and explore ideas and concepts. For example, during learner-centered teaching, teachers may be aware of the need to involve learners in group work, but they do not put that knowledge into practice, claim Esmonde et al. (2009). Teachers may also be aware that learners should actively participate during learner-centered teaching, but they do not enforce that (Ndlovu, 2019). The author also emphasises that when learners are engaged in group discussion or are presenting their findings to the class as a whole, they find it difficult to intervene meaningfully. This is especially true when teachers are unable to engage with learners' ideas and use them to enhance learning (Ndlovu, 2019). The challenging component for teachers according to the above author is ensuring that the primary substantive goals of learner-centered teaching are upheld, such as that learners actively participate in group work activities.

In looking at the uses and benefits of group discussions in learning and teaching of mathematics, several studies have also been conducted in order to explore how effective, competitive, individualistic, and cooperative group learning practices are in encouraging productivity and achievement of learners (Johnson & Johnson, 2014; Sofroniouon & Poutos, 2016). Both cooperative and collaborative learning approaches depend heavily on group work, which has generated a lot of studies (Sofroniouon et al., 2016; Johnson & Johnson, 2014). Additionally, research shows that group work pedagogy fosters learners' interpersonal interactions and academic achievement more than competitive or individualistic learning methods (Sofroniouon et al., 2016).

According to research, group projects are now strongly supported in all educational institutions at all levels as a result of collaborative learning (Sofroniouon et al., 2016) and preparing learners for a world where they will be working cooperatively to solve problems, communicate and listen (Remillard, 2015). McDonough (2004) emphasize that mathematics teachers might not be able to provide direction and assistance to every pair or group in the classroom, especially with a large number of learners, presents a significant challenge for them as they use group work as a strategy to facilitate learner-centered teaching. Additionally, even though the teacher has instructed the learners to work in small groups, the teacher may begin instructing the class as a whole during group work (Ndlovu, 2019). This frequently occurs as he/she reverts to their teacher-centered teaching-driven belief system. According to research (Brodie et al., 2009; Chisholm & Leyendecker, 2008; Jansen, 1999; Mtika & Gates, 2010), despite countries' advocacy for the deployment of learner-centred teaching, classroom teachers ultimately choose to use the traditional teacher-centered teaching methodologies. This occurs in part because teachers must employ group collaboration as a technique to improve learner-centred teaching (Ndlovu, 2019).

Brodie et al. (2002) have claimed that educators adopt learner-centered methods in a variety of ways. Brodie et al. found, in particular, that the majority of teachers adopt the visible tactics or forms of supporting learner-centred teaching without paying attention to the actual content of their learner-centred practices. The fundamental principles of learner-centered teaching must be implemented by teachers, who must also use techniques like group work, probing questions, meaningful assignments, and encouraging interaction with learners' ideas (Ndlovu, 2019). Yet, Brodie et al. (2002) discovered that most teachers adopted the visible manifestations of learner-centered teaching, such as grouping learners, while ignoring the other, more important requirements for genuine learner-centred practices. The main goal of learner-centeredness is to maximize student engagement in learning opportunities; as a result, class design and execution must be done with the learners' needs in mind (Ndlovu, 2019). The activities must be planned with this information in mind, and the teacher must be aware of what the learners already know (Ndlovu, 2019). To ensure that learning is occurring, learners needed to have the chance to ask questions, and the instructor needed to be flexible enough to change the course of the class as needed.

Collaborative and cooperative learning through group discussions can address these issues and improve learners' progress and achievement in mathematics because learning mathematics is frequently perceived as a lonely, individualistic, or competitive activity, leading to mathematical anxiety or avoidance among learners (D'Souza & Wood, 2016). All learners learn concepts and problem-solving techniques, build their self-confidence, and get over their fear of making mistakes through group work interaction (Piaget, 2013; Sofroniouon et al., 2016).

Since learning mathematics can often be viewed as lonely, individualistic or competitive matter, with learners developing mathematical anxiety or avoidance, collaborative and cooperative learning through group discussions can address these problems (D'Souza & Wood, 2016). Group cooperation can help to overcome these challenges and help learners cope with difficult tasks that are too difficult for individual work (Sofroniouon et al. 2016). Zakaria, et al. (2010) observed that the use of group work did generate more interest in mathematics and made it more enjoyable for both learners and teachers prompting greater achievement of learners in mathematics.

However, group work can occasionally be ineffective, primarily as a result of a lack of knowledge on the part of the teacher of the critical factors that affect its achievement (Sofroniouon et al., 2016). Less capable group members, for example, may occasionally let others complete and conclude group exercises (Sofroniouon et al. 2016), whereas more capable student members may exert less effort to avoid performing all the task (Sofroniouon et al., 2016). Furthermore, skilled members may learn a great deal more by thoroughly describing the information being taught to less capable learners who have understanding in class because the amount of time spent explaining topics can be positively connected with the length of time studying (Sofroniouon et al., 2016).

In order to create an optimal teaching and learning environment, teachers are encouraged to use a variety of teaching approaches and teaching styles (Vaughn & Baker, 2001). These authors also point out that the use of "variety of teaching methods and styles ultimately may encourage adaptability and lifelong learning in the teaching–learning process" (Vaughn & Baker, 2001, p. 610). The use of a variety of teaching and assessment methods can stimulate learners' achievement (Clarke, 2005). Often, inappropriate methods of teaching may lead to poor performance of learners in mathematics. According to Nyaumwe *et al*. (2004), traditional approaches do not help learners develop conceptual understanding of mathematics and have been criticised since they do not encourage problem-solving skills in learners. A further concern about the use of traditional methods in teaching mathematics is that they do not involve much questioning, discussion or individual development of understanding.

2.3.5 Experiential Learning practices

One of the traditions associated with learner-centered teaching is that of promoting experiential learning which assumes that people learn best through experience or hands on (Stephan, 2020; Kolb, 2015). With experiential learning, the emphasis is on the direct sense experience and the action in the context as the source of the learning (Kolb, 2015). Cox (2013) asserts that Kolb's model of experiential learning focuses on both the environmental aspects of learning such as auditory, visual, kinaesthetic and tactile as well as the perception and processing of information. A teacher who uses an experiential learning approach will promote learning by enabling learners to engage in activities based on experiencing, interacting or manipulating with forms of the content and to then allow them to reflect on their personal experiences (Slavich & Zimbardo, 2012). Some of these activities could be undertaken within a classroom, but the emphasis is on those which occur outside the classroom, where concepts are naturally integrated into their lives.

Ferguson (2010) encourages mathematics teachers to use "inquiry-based mathematics instruction" where learners are given the opportunity to identify and tackle complex tasks and can also involve the application of mathematics in real-life settings (Ferguson, 2010; Slavich

& Zimbardo, 2012). Inquiry-based instruction fits in well with the student-centered paradigm where learners are invited to work in ways that mimic the work of mathematicians and scientists. It also involves phenomena, asking questions, interpreting and evaluating their solutions, as well as communicating their findings (Dorier & Maass, 2014). The connection of mathematics to real-world contexts gives teachers the opportunity to make mathematics seem more accessible and enjoyable to learners. Another teaching approach that contributes to effective learning is the integration of games and simulations in the teaching process (Slavich & Zimbardo, 2012; Moore, 2012). The use of games and simulations in the mathematics classroom, enhances mathematical thinking and contributes to knowledge building (Nisbet & Williams, 2009). Ke & Grabowski (2007, p. 256) also found that "playing games plays important roles in a child's psychological, social, and intellectual development".

2.3.6 Reflective Practices in Learning and Teaching of Mathematics

Central to student-centred traditions especially those of experiential learning, is the notion of reflective practice. A crucial element of improving one's practices is engagement in reflections about what happened and what could be possible (Bansilal & Rosenberg, 2011). For teachers who are interested in improving their practice, research suggests that they should be committed to continuously engaging in reflections about what happened and what is possible (Bansilal & Rosenberg, 2011). Bansilal and Rosenberg (2011) argue that reflection has been a guiding principle in the conceptualization of instructional practices within mathematics classrooms. Their contention is that teachers' reflections provide insights into instructional practices needed in the learning and teaching of mathematics (Bansilal & Rosenberg, 2011).

Reflection could mean the ability of mathematics teachers to look at what they engage in, the classroom, for instance, thinking about why they engage in such practices, and thinking about the impact of such practices on mathematics competence and mathematics academic achievement (Akinyode & Khan, 2016; Agoro, 2013; Bature et al., 2015; Bature & Atweh, 2020). Agoro (2013) asserts that reflective instruction is important specifically in teaching graduating senior secondary school learners in a developing country like Nigeria, where textbooks are not available and the available ones are beyond the reach of many teachers, with little or no access to professional benefits and adequate instructional materials (Agoro, 2013). Thus, reflective instructional practice can contribute to a transformation tool in enhancing mathematics competencies and mathematics academic achievement (Agoro, 2013; Bansilal & Rosenberg, 2011).

Reflective instructional practice might occur at all stages in learning and teaching in mathematics how the lesson is introduced in the classroom (including materials to use), how it is delivered and assessed (Akinyode & Khan, 2016). In their study about 'investigating teachers' formulations of learning objectives and introductory approaches in teaching mathematics and statistics', Umugiraneza et al. (2008) state that the way the lesson is introduced in the classroom, can affect students' learning and achievement. Saylor and Johnson (2014) also found that teachers could shape their instructional practices through reflective observations and interactions with the learners on mathematics concepts during lessons in the class.

Saylor and Johnson, (2014), researching the role of reflection in mathematics and science teachers' training and development, provided holistic evidence of the role of reflection in teaching and learning of mathematics. The authors argue that the use of reflective practices by senior secondary school mathematics teachers provides insight for improving instructional practices and student learning style preferences through thoughtful and reflective instructions for possible achievement of learners in mathematics.

Passarelli and Kolb (2012) revealed that learning occurs through reflective connected experiences in which knowledge or mathematics knowledge is constructed based on teacher effectiveness, as well as effective practices and learning experiences in the classroom. The authors further stated that reflection involves the integrated functioning of both the teachers and learners in experiencing, thinking and acting during lessons in the classroom. Adamu (2015) asserts that mathematics instructional practices should include specific modes of instruction, for instance, reflective practice, active engagement and social interaction in the teaching and learning of mathematics at senior secondary school levels. From the literature it is also very clear that consistent reflection will not only positively impact learners' achievement in mathematics but will also bring to light issues that need attention and provide opportunities for both learners and teachers to reflect on their basic ideas in mathematics activities and interact with each other in finding solutions to mathematics problems (Bansilal, 2015; Agoro, 2013).

2.3.7 Using questioning in the classroom

To increase learners' achievement, the teacher must improve his or her questioning techniques. Marzan et al. (2001) claim that a teacher's reflective classroom practices are greater than those without questioning. As the teacher asks learners some questions, their mathematical reflective thinking and participation are stimulated hence enabling learning (Ndlovu, 2019). Classroom teachers can employ four basic forms of questioning, according to Badham (1994), to encourage reflective and effective learning. Starter inquiries are the initial type of questioning that Badham identified. These inquiries essentially guide learners' thinking toward the new information and ask for a variety of responses from learners in order to spark a reflective discussion (Badham, 1994). For example, if the topic for the day is "Addition of fractions with different denominators", one of the questions that the teacher may ask learners would be: Give me an example of a pair of some fractions which have different denominators. This question would give learners a place to start while considering the new information they are going to learn (Ndlovu, 2019). It is expected that learners will be able to name these fractions in order to answer this question. Starter questions are 'pivotal' questions that require learners to reflect and direct their attention to the new issue (Ndlovu, 2019).

Questions that encourage mathematical thought are the second type of questioning that Badham identified. These types of questions, in accordance with Badham (1994), assist learners in connecting prior knowledge and reflective experiences with new knowledge. An example of a reflective follow-up question would be to ask as to how a pair of fractions with distinct denominators may be represented as fractions with the same denominator (Ndlovu, 2019). In essence, the teacher asks learners this kind of question to ascertain what they already know and to assist them in reflecting and connecting that knowledge (Ausubel et al. 1978). At this point in the classroom, the teacher is expected to take some time to ensure that the learners' past understanding is reflected.

Assessing questions make up the third type of question. Essentially, these are follow-up questions, probing questions, or leading questions where the teacher feels that the learners' responses are insufficient or improper (Ndlovu, 2019). When learners are working on a task or encountering a problem, a teacher will pose such questions. Assessing questions include: How did you...? Why do you suppose...? Why not? What about...? These kinds of questions enable the teacher to elicit clarification and elaboration from learners, as well as to assess their level of understanding and promote critical thinking (Badham, 1994). Such inquiries entail cognitive information manipulation in support of a hypothesis or a problem-solving strategy (Ndlovu, 2019).

Final reflective questions make up the last group of questions. Such questions, in accordance with Badham (1994), enable learners to share and compare their solutions, as well as the steps they took to get those solutions. Wait time is crucial in all the categories of inquiry to encourage learners' thought after the teacher pauses with a question (Shahrill, 2013). In other words, the instructor needs to give learners ample time to wait before asking them to react to a question. This would encourage learners to participate actively and provide reflective comments (Ndlovu, 2019). From the above discussion, it can be concluded that reflective practice should apply to all parts of teaching practice.

2.3.8 Using manipulatives

Manipulatives refer to the use of concrete objects such as Dienes blocks, geoboards, paper folding, rubber bands, and Cuisenaire rods that can be used in the teaching and learning of Mathematics (Clements & McMillen, 1996). Clements and McMillen mention that though learners who use manipulatives in their Mathematics class usually do better than those who do not use them, this is only true for certain topics. Some classroom teachers use manipulatives when mediating mathematical concepts, in the belief that the use of manipulatives would help learners cope with the abstractness of mathematical concepts (Tall, 2008). It is well known that manipulatives, when used effectively can help learners bridge the divide between the concrete and the abstract nature of concepts. For example, when working with properties of figures, it helps learners to work with activities which involve folding, measuring, and matching activities. As learners "see' these properties, it may be easier to understand the abstract formulations of the properties.

2.4 DEFINITIONS AND EXPLORATION OF LEARNING STYLES PREFERENCES

Learning style has been defined as the ability of learners to perceive and process information in learning situations (Vaishnav, 2013). For Vaishnav (2013), learners or secondary school learners learn mathematics in different ways. While some learners learn by reflecting and acting and reasoning logically, others prefer to learn intuitively which connects with their learning style preferences (Vaishnav, 2013). This is like the definition of learning style given by McLeod (2017), who asserts that learning style is the characteristic ways of perceiving and processing information.

Educational psychologists and theorists have had a long tradition of research into learning styles (Cassidy, 2004). The learning styles encompass feeling, thinking, doing, and watching to varying degrees depending on student maturity (Kolb & Kolb, 2005).

Understanding how learners learn mathematics, whether they have specific learning style preferences, and whether these are linked to achievement can help us better understand how teachers should teach to assist learners to improve their learning of mathematics (Akinyode & Khan, 2016; Kolb & Kolb, 2017).

In this current study, learning style preferences are the ways in which school learners prefer to learn mathematics. In other words, a learning style refers to the learning preference of a student.

There are various definitions for learning style preferences. Ishak and Awang (2017) described learning style preference as a method in which learners or graduating senior secondary school learners absorb and retain new information or skills, regardless of how it is described, though the process is different for each student. Prior research has suggested that learning style preference is a balanced measurement of a student resulting in how the student reacts to the environment as well as his/her view of learning process (Banaga, & Fabella, 2018).

Passarelli and Kolb (2012) underline the importance of comprehending how learners learn, and knowing more about their learning styles can help improve the selection of instructional practices used by teachers to help orientate learners according to their preferred styles. These authors define learning style preference as the combination of cognitive, affective, social, and physiological behaviours that serve as relatively stable indicators of how senior secondary school learners perceive, interact with, and respond to the mathematics learning environment (McLeod, 2017; Vaishnav, 2013; Sengodan & Iksan, 2012).

According to Kolb and Kolb (2018), different persons or secondary school learners have a natural preference for a distinct type of learning when it comes to mathematics. Akinyode and Khan (2016)'s study of learners' preferred learning styles using the Kolb Learning Style Inventory (KLSI), each student processes information in a unique way. Sengodan and Iksan (2012) highlighted a few variables that can affect learners' preferences for learning styles, including instructional methods, gender, the social environment, educational experiences, or the student's fundamental cognitive structure.

Different learners have different learning styles, according to other studies. For instance, Yamazakiet al. (2018) discovered that while some secondary school learners may benefit from group talks, others may benefit more by listening intently and focusing. Others might choose to consider it first, take notes in class, and work on the task by themselves (Akinyode & Khan, 2016).

Gogus and Ertek (2016), in their study on learning and personal attributes of learners in predicting and classifying learning style preferences, revealed that learners and their learners' perceptions and habits influence their learning style preferences. This is because making learners aware of their learning style preferences and how to accommodate this in the learning environment, specifically in the mathematics classroom context, results in significant benefits to learning achievement (Gogus & Ertek, 2016). How learners construct knowledge, their learning style characteristics and preferences can aid teaching practices as well (Kolb & Kolb, 2017).

This research builds on existing knowledge in the field of experiential learning using Kolb's learning style model to classify graduating senior secondary school learners into different learning style preferences in mathematics as it offers an overview of learning style preferences regarding instructional practices and learning achievement in mathematics (Akinyode & Khan, 2016; Kablan & Kaya, 2013).

In his experiential learning theory, Kolb (1984) defined learners' learning style as a collection of multiple modes that determine how a student perceives, processes and understands information. As shown previously, Akinyode and Khan (2016) reported that learners possess different types of knowledge and process information differently to complete their learning cycle. Research also indicates that learning style is the ability of learners to perceive and process information in mathematics learning and teaching in the classroom context (Vaishnav, 2013).

A deeper understanding of Kolb's learning style preferences is presented by Cox (2013) who asserts that while some learning style categories focus only on the environmental aspects of learning (auditory, visual, kinesthetic, and tactile), Kolb's learning style model includes perception and processing. This argument suggests that in Kolb's learning style model, learners perceive and process information in a continuum of interactions within four learning modes: concrete-experience (CE-feeling), abstract-conceptualization (AC-thinking), reflective observation (RO-watching) and active experimentation (AE-doing) (Cox, 2013; Kolb & Kolb, 2017).

As previously mentioned, Andreou et al. (2014) proposed that learning styles can be categorized using combinations of the modes as Diverging for Watching and Feeling, Assimilating for Watching and Thinking, Converging for Thinking and Doing, and Accommodating for Doing and Feeling. The argument made here is that a student's preferred learning method can have a significant impact on their academic success (Akinyode & Khan, 2016)

Pang and Platt, (2018) reported that learning style is a propensity to a particular way of learning. They argue that cognizance of learning style is important for educators, specifically mathematics educators, because learners learn in different ways. Pang and Platt, (2018) further explain, for instance, that some learners may learn better with a concrete, experiential type of educational experience (effective listening in mathematics class) while others prefer reflective types of learning opportunities, such as discussions.

In this study, learning style preferences are the ways in which learners prefer to learn mathematics in the classroom. The four learning style preferences identified in this study are: diverger, assimilator, converger, and accommodator.

From the foregoing, it is evident from the various studies reviewed that variations exist in the definition of learning style preferences. What is demonstrated here is that the act of learning between learners, specifically graduating senior secondary school learners, can never occur in the same way amongst any two learners. Besides, research indicates that educators or secondary school mathematics teachers should be prepared to incorporate instructional practices aimed at encouraging learners' learning style preferences for better academic achievement in mathematics (Kablan & Kaya, 2013). To this end, the current study is intended to investigate the influence of learning style preferences and instructional practices on the mathematics achievement of graduating senior secondary school learners.

2.5 DEVELOPMENTS IN THE FIELD OF LEARNING STYLES

Although there is considerable interest in the subject of learning styles among educators and parents alike, there is also a notable lack of unity within the field (Yamazaki et al., 2018). Wilson (2012) reported that between 1902 and 2002, learning styles theory expanded significantly, with no fewer than 71 different models published during this 100-year period. For Wilson (2012), many of these models share some characteristics and have a unique perspective, focusing distinctively on student preferences, abilities, and even preferences based on ability.

The literature on the development of learning styles attempted to classify the development of learning style models because each student has a natural preference for the way in which he/she prefers to receive, process and interpret formation particularly in the classroom

(Yamazaki et al., 2018; Wilson, 2012; McLeod, 2017; 2013). Yamazaki et al; (2018) tried to examine multiple learning style models as presented with various definitions of learning style including Kolb's learning style inventory which this study applied through experiential learning theory (ELT) (Passarelli & Kolb, 2012).

Taking the above view as a basic idea leads to the implication that secondary school educators and mathematics educators should not assume that:

- All secondary school learners, especially graduating senior secondary school learners, learn the same way; and
- Mathematics educators' own instructional practices or preferences for teaching are broad enough to accommodate the learning style preferences of most or all learners in the class.

Passarelli and Kolb (2012) echo that learners learn in different ways; in other words, mathematics educators in secondary school education would have a responsibility to expand their repertoire of teaching practices to embrace the learning style preferences of learners at the senior secondary schools. It is important to note that teachers' understanding of learners' learning style preferences could enhance effectiveness in learning and teaching of mathematics and achievement in mathematics at senior secondary school level (Wilson, 2012). Passarelli and Kolb (2012) explain that teachers' understanding of the way learners learn by the teachers can influence the selection of instructional practices to be oriented according to the preferred learning style of both boys and girls in the classroom context. Passarelli and Kolb (2012) argue that in fact mismatches can occur between a student's learning style preference and a teacher's instructional practices which could bring about a negative attitude of learners towards both the subject matter and the teacher. This, according to Kablan and Kaya (2013), could lead to poor achievement in mathematics.

The development of the field of learning styles arises from various theoretical foundations and definitions and, therefore, presents some challenges to understanding and implementation (Wilson, 2012). However, in order to understand fully the relationships between the diverse models of learning styles, it is important to recognize first the theoretical foundations underlying them (Passarelli & Kolb, 2012; Wilson, 2012). Vizeshfa and Torabizadeh (2018) reported that both Experiential Learning Theory (ELT) and the Approaches to Learning Model (ALM) are two important theoretical foundations underlying learning style models.

Although the various theories present differing views on how the learning style preferences should be defined and categorized, they do agree that all learners have their own preferred learning style (Wilson, 2012). Prior research has suggested that despite opposing opinions, a common concept is that learners or secondary school learners differ in the way they learn, particularly in mathematics (Vizeshfar et al., 2018).

In a study on the effect of teaching based on dominant learning style preferences, Vizeshfar et al. (2018) reported that the idea of preferred learning style of learners has greatly influenced education despite criticism that this has received from various researchers. Research also indicates that proponents of learning style theories recommend that teachers or mathematics teachers assess their learners' learning style preferences and adapt classroom instructional practices to best fit each student's preferred learning style (Kolb & Kolb, 2017). The central issue most researchers attempted to address is that although there is sufficient evidence that learners' express preferences for how they prefer to learn, including mathematics (Pritchard & Alan, 2014), few studies have found any validity in using learning styles in education (Wilson, 2012).

In view of the inclusion of learning style preferences and instructional practices, learning style models have numerous proponents, each with a unique element based on the same basic concept that learners have preferences for the ways in which they engage in learning in the mathematics classroom (Wilson, 2012).

Given the above orientation, the next section focusses on the review of various learning style models which includes Dunn and Dunn, Fleming Learning Style Model, Honey and Mumford, Felder and Silverman, as well as Kolb's Learning Style Inventory (LSI) for a better understanding of the development in the field of learning style theories.

2.6 DIFFERENT CHARACTERIZATIONS OF LEARNING STYLES

Over the years, several theories and types of learning style models have been developed. Some of these models are based on learners' internal cognitive processes and the development of new concepts in learning through new experiences (Kolb & Kolb, 2017). Several learning styles models have emerged. For instance, the Dunn and Dunn (1993) learning style model anticipates an observable impression in student learning and behaviours when a match has been achieved between instructional practices and learning style in mathematics (Dunn et al., 1995).

Dunn et al. (1995), in their practical approach to learning style models, defined a learning style as a biologically and developmentally imposed set of characteristics that make the same instructional practices wonderful for some and terrible for others. The authors identified several learning style elements: (1) time, (2) schedule, (3) amount of sound, (4) type of sound, (5) type of work group, (6) amount of pressure, (7) type of pressure, (8) motivation, (9) place, (10) physical environment, (11) conditions, (12) type of VARK. The acronym VARK stands for Visual (V), Aural (A), Read/Write (R), and Kinesthetic (K). Fleming (1995) in his VARK model defines a learning style as "an individual's characteristics and preferred ways of gathering, organizing, and thinking about information."

Honey and Mumford's learning styles (1986) was based upon the work of Kolb and his experiential learning theory. In their study on suitable instructional practices and media for student learning style preferences, Honey and Mumford (1986) identified four distinct learning style preferences: "activist," "theorist", "reflector" and "pragmatist". According to their theory, different learners naturally prefer different styles of learning, depending upon the situation and their learning experiences. For Honey and Mumford (1986), learners must be able to identify their natural learning style preference, understand it and find ways to learn that complement their preferred learning style.

An additional review of learning style literature includes the Felder–Silverman Learning/Teaching Style Model. Felder and Silverman (1998) define learning styles as the characteristic strengths and preferences in the ways learners take in and process information. The model also presents different dimensions that are indicative of learning preferences. For Felder and Silverman (1998), learners' learning style preferences are categorized into active and reflective, sensing and intuitive, visual and verbal, and sequential and global.

In this study, the learning styles model that is used is that of Kolb's learning styles inventory (KLSI) (Kolb & Kolb, 2005). The model consists of four main learning style preferences and is outlined in much more detail in Chapter 3. Briefly Kolb's early model (Kolb, 1984) describes four different phases that a student goes through in the individual learning, based on how they grasp experience and how the experience is transformed. Kolb's' concept of learning style describes the person's individual differences in learning according to the extent to which they prefer the different phases of the learning cycle. The learners who prefer the four different learning styles are called divergers (prefer learning through concrete experience and using reflective observations); assimilators (favour abstract conceptualization and reflective observations); convergers (learn through abstract conceptualizations and active experimentation), and accommodators (prefer concrete experiences and active experimentation when learning).

The above explanations of various learning style models are predispositions and are not to be accepted as completely being so (Wilson, 2011). The studies identified learning style preferences and instructional practices as a tool that can be used in mathematical classrooms to enhance learners' competences and achievement in mathematics at senior secondary school level. With the above information, linking instructional practices associated with Kolb's learning style preferences on mathematics achievement of learners is central to this current study.

Table 2.1 presents a brief summary of some learning style models adopted by various authors.

Table 2.1: Differences and similarities of learning styles.

Model	Definition of learning style	Number of Dimensions	Instrument	Content	Instrument Mechanism
Dun & Dun	"The way in which individuals begin to concentrate on, process, internalize, and retain new and difficult information" (9)	5	Productivity Environmental Preference Survey (PEPS)	Text only	Likert-type scale
VARK	"An individual's characteristics and preferred ways of gathering, organizing, and thinking about information" (9)	2	VARK questionnaire	Text only	Select one or more answer from the four alternatives
Honey & Mumford	"The way in which learners naturally approaches learning process that makes	4	Honey & Mumford questionnaire	Text only	Likert-type scale

	it more effective and enjoyable” (10)				
Felder–Silverman	“The characteristic strengths and preferences in the ways individuals take in and process information” (10)	5	Index of Learning Style (ISL)	Text only	Select only one answer from two alternatives
Kolb	“Generalized differences in learning orientation based on the degree to which learners emphasize the four modes of the learning process” (11)	4	Learning style inventory	Text only	Rank-order set of item

2.7 TEACHERS’ KNOWLEDGE OF LEARNING STYLE PREFERENCES

The field of learning style preferences as discussed in the previous definitions of learning styles has implications for both teachers and learners and may be capable of influencing a variety of perceptions and learning abilities. While many claim this influence is positive, bringing about increased understanding and improved achievement (Akinyode et al. 2016; Kablan et al., 2013; Passarelli & Kolb, 2012; Bethel-Eke et al. 2017; Kolb et al., 2017), some researchers argue that there is a need for further and more focused scientific study in the field of learning style (Wilson, 2011; Manolis et al. 2013; Rohrer & Pashler, 2012).

Learning style preference is one of the most common and important parameters that could be used when designing learning environments, to consider the individual differences among learners (Alzain et al., 2018; Wilson, 2011). In her research on the teacher’s use of circular reasoning in mathematics, Bansilal (2012) reported that both schools and education management teams should prioritize the creation of supportive environments within which mathematics teachers can adopt effective instructional practices with consideration of learners’ learning style preferences. Kazu (2009) also found that schools or educational systems should help in raising learners who are able to look at the world from different perspectives; thus, learners' learning style preferences should be taken into consideration in achieving the above objectives (Bansilal, 2012). These authors identified that the issues of learning style preferences and instructional practices as effective tools in secondary school are areas requiring attention. Kazu (2009) argued that learners' learning style preferences should be determined beforehand by considering differences such as personality, perception, ability and intelligence. Bansilal et al., (2015) assert that teachers need support and direction on which instructional practice they can use to teach learners with different learning style preferences in the class. Awang, et al., (2017) clearly stated that instructional practices are an important factor that should be considered in teaching learners with various learning style preferences.

However, some questions remain about the most effective ways to enhance learners' academic achievement from the current field of learning styles. Findings of some studies showed largely that learners' learning style preferences cannot be a sole basis for designing instruction but are important building blocks in the design of effective learning in mathematics (Wilson, 2012; Romanelli et al. 2009; Rohrer & Pashler, 2012).

Several schools of thought, including education professionals, have demonstrated an increasing interest in learning styles and related assessment instruments, instructional models and pedagogical techniques (Bansilal, 2012; Wilson, 2012; Passarelli et al. 2012). Prior research has also suggested that teachers who have a greater understanding of learning styles can increase their effectiveness in both instruction, assessment and achievement (Wilson, 2011; Kablan & Kaya, 2013). Evans and Kozhevnikova (2011) highlighted how learning is affected by learners' and teachers' beliefs and conceptions of learning and teaching. In so doing, they argued for the need to consider more integrated learning style dimensions that have the potential to capture major individual differences in the way learners go about learning, specifically in mathematics. In their work, Evans and Kozhevnikova (2011) assert that teachers must be prepared to handle the complexity of learning style preferences by acknowledging the multi-faceted nature of learners' learning style preferences and the teaching requirements needed to encourage student-centred learning. Accordingly, for Akinyode and Khan (2016), knowledge of learners' preferred learning styles is important for educators, specifically for teachers, in considering and developing instructional practices that influence a student's commitment collaboration during mathematics learning.

Studies agreed that effective teaching requires flexibility, creativity and responsibility in order to provide an instructional environment able to respond to learners' diverse learning style preferences (Tulbure, 2012). But even while many educators, including mathematics teachers, acknowledge the existence of learning style preferences, not all of them are capable of or willing to implement learning style preferences in their daily instructional practices within the classroom thereby probably affecting learners' achievement (Wilson, 2012). Ellington and Benders (2012) explored the importance of learning style preferences in education and how teachers' understanding of learning style preferences in secondary school could improve learners' achievement, The study found that understanding learning style preferences of learners can provide effective instructional practices for teachers or mathematics teachers to use. The authors argue that learners who share a learning style that is in line with the teacher's remember information longer and are more optimistic about learning in mathematics. The above argument suggests that as teachers are expected to understand learners' specific learning style preferences in the mathematics classroom, they will provide effective instructional practices capable of promoting problem-solving skills (Ellington & Benders, 2012). The authors also found that by promoting problem-solving skills in the classroom, teachers are preparing learners for real life situations.

According to Ellington and Benders (2012), learners may not benefit from instructional practices that are incompatible with their learning style preferences. It is, therefore, important to consider that when teachers provide a learning situation that suits the distinct learning style of learners, these learners can achieve greatly and become more comfortable with their own learning style preferences instead of having to adapt themselves to the differing instructional practices of teachers (Bansilal et al. 2017). For proper direction of the process, Ellington and Benders (2012) suggest that teachers' flexibility is important in knowing their learners' learning style preferences through their instructional practices. Prior researchers and learning style experts have long established that learners will learn more and enjoy class experiences and environment when instructional practices are tailored to their learning style preferences (Wilson, 2012; Bethel-Eke et al., 2017; Kolb & Kolb, 2017).

As indicated from various studies above, evidence exists that developing instructional practices and materials for a wide range of learners' learning style preferences should be a priority for all teachers, particularly mathematics teachers (Bansilal et al., 2017; Ellington & Benders, 2012). What is demonstrated here is that integrating different learning styles in the classroom environment can enhance the effectiveness of both teaching and learning in mathematics.

Although there is a broad theoretical foundation for the existence of learning style preferences and instructional practices, the need remains for further research concerning the relationship between learning style preferences and academic achievement of learners in mathematics (Wilson, 2011; 2012; Rohrer & Pashler, 2012). Undeniably, substantial arguments still surround the issues of learning style preferences and its functions in the instructional process (Pashler et al., 2008).

A better understanding of the above situation will involve a brief review of research on the relationship between learning style preferences and academic achievement of learners.

2.8 LEARNING STYLE PREFERENCES AND ACADEMIC ACHIEVEMENT OF LEARNERS

The concept of learning style preferences has undergone extensive analysis in empirical literature to understand the dynamic processes of learning and its relationship with learners' academic achievement in mathematics (Nuzhat et al., 2011). The literature concerning the relationship between learning style preferences and academic achievement contains conflicting results (Wilson, 2011). A large majority of published resources, particularly those aimed at promoting various methods and tools for the link between learning style preferences and academic achievement of learners with a particular reference to mathematics, did not present empirical evidence in support of the effectiveness of learning style preference and learners' academic achievement (Wilson, 2012; Knupsky, 2016; Pashler et al., 2008).

Knupsky (2016), argued that most resources claiming to provide such evidence regarding learning style preferences and academic achievement relied upon less than desirable research designs and did not deserve attention as indicators of the influence of learning style preferences on student achievement in mathematics (Pashler et al; 2008). Wilson (2012) also stated that only changes in instruction would produce higher levels of academic achievement among learners. Some studies pointed out that the interpretations of learning style preference theory involving learners' academic achievement, will not result to improved learning as related to mathematics achievement (Rohrer & Pashler, 2012).

Another study also emphasized that despite the spread of learning style theories and learning style models, the instrument still appears to retain several weaknesses which limits its uses, including low predictive powers with reference to learners' achievement (Manolis, et al. 2013; Pashler et al. 2008).

Ignacio and Reyes (2017) explored the connection of learning style preferences to mathematics achievement goals using Kolb's learning style model. The main objective of the study was to determine if there was a significant difference in each mathematics achievement goal of 187 high school learners selected through cluster sampling technique in Philippines. The findings of the non-experimental quantitative design study showed that there was no significant difference in the mathematics achievement goals based on learners' learning style preferences. Thus, learning style preference was not found to be an initial predictor of mathematics achievement of learners. They further argue that exploratory research in the field of learning style preferences is needed to understand why learners with an approach type of achievement goal hold assimilator learning style preference and why learners with an avoidance type of mathematics achievement goals hold accommodator learning style preferences (Ignacio & Reyes, 2017).

In support of the above findings, Yilmaz and Akkoyunlu (2009) investigated the effects of learning style preferences on achievement of learners in different learning environment using Kolb's learning style inventory to measure learners' learning style preferences and the pre-posttest design to identify learners' achievement scores. Consequently, the findings of the study showed that learning style preferences did not affect the achievement of learners in different learning environments.

Ahmad et al. (2014) examined learning style preferences towards mathematics achievements among higher education learners and found no significant relationship between learning style preferences and learners' mathematics achievements. The authors argue although that the differences of learning style preferences between learners have no impact on academic achievement of learners in mathematics, learning style preferences play a role in learners' classroom achievement.

However, regardless of the controversies regarding the lack of strong empirical evidence for the influence of learning style preferences on learners' achievement with a particular reference to mathematics (Pashler et al., 2008), some prior research studies world over, including Nigeria, have reported that when learning style preferences are taken into account during teaching and learning process as discussed previously, the academic achievement of learners in mathematics is improved (Akinyode & Khan, 2016; Orhun, 2013; Vaishnav, 2013; Mahyuddin et al., 2011; Elci, et al., 2012). Tulbure (2012) on the other hand, made some relevant suggestions for adapting the instructional practices to the four most influential learning style preferences described by Kolb, (2005) by analyzing separately the academic achievement of Assimilators, Divergers, Convergers and Accommodators in order to unravel the underlying differences among the learning style preferences and instructional practices capable of influencing learners' academic achievement.

2.9. FACTORS OF AGE AND GENDER AND MATHS ACHIEVEMENT

The Trends in International Mathematics and Science Studies (TIMSS 2015) study on the highlights of mathematics and science achievement of grade 9 South African learners shows that most countries do not reflect a gender gap (Reddy, Visser, Winnaar, Arends, Juan, Prinsloo, & Isdale, 2016). For the 39 participating countries, there were only six who reported a statistically significant gender gap favouring boys while there were seven countries whose results reflected a statistically significant gender difference favouring girls (Reddy et al. 2016). Else-Quest et al. (2010) in their meta-analysis of the results of the TIMSS and PISA studies across 69 countries, based on learners 14-16 years old found that mean effect sizes in mathematics achievement were very small but national effect sizes showed much more variability. The authors suggested that the variability in the gender differences across the countries may be related to the differences in the status and welfare accorded to women by the different countries. Else-Quest et al. (2010) note that gender differences in achievement and attitudes were associated with gender ratios in school participation figures. Else-Quest et al. (2010) argue that gender differences are associated with the differential cultural and social norms present in opportunity structures for girls and women.

In terms of difference in achievement in mathematics in South Africa, the result has been uneven. Some studies show that the gender gap in mathematics has narrowed and, in some cases, has even been reversed in some settings in South Africa, while others suggest that there is a gender bias with boys doing better than girls. Results from the Southern and Eastern Africa Consortium for Monitoring Educational Quality tests, SACMEQ II and SACMEQ (III) found that girls outperformed boys in mathematics (Saito, 2010). In the TIMSS 2015 results in South Africa, there was a 7-point gender difference favouring boys in the achievement scale, and the difference was not statistically significant (Reddy et al., 2016) However when factors such as age appropriateness, school location and degree of familiarity with the test language were considered, boys achieved significantly higher marks than girls in the TIMSS 2015 results for South Africa (Bansilal & Lephoto, 2022). In the current study, I would like to explore whether there are differences in learning styles according to gender and whether there are differences in achievement according to gender.

There is not much research in the African context, besides in South Africa, about the extent to which age appropriateness is associated with achievement in mathematics. There does not seem to be any research about possible relationships between age and Kolb's learning styles. Hence in this study it was decided to look at the age appropriateness factors in relation to learning styles and to achievement. One factor associated with patterns of low achievement is that of grade repetition which occurs when learners begin a new school year in the same grade as the previous year, instead of being placed in a higher grade. Grade repetition is more common in developing countries than in developed countries and is particularly common in remote rural areas (Brophy, 2006). The low achievement levels of grade repeaters are usually associated with poverty indicators, at both the school and the family levels (Brophy, 2006). In South Africa, the poorer learner is more likely to be over-age since most learners are over-age in the no-fee schools while 64 percent of the learners in fee-paying schools are of the appropriate age (Zuze et al. 2017). Taylor et al. (2010) found gender differences in that most over-age learners in South Africa are male. In this study, I decided to include the age appropriateness as a factor to be considered.

2.10 LINKS BETWEEN LEARNING STYLE PREFERENCES, GENDER AND MATHEMATICS ACHIEVEMENT

Research has also consistently found positive relationships between learning style preferences and gender on the academic achievement of learners (Orhun, 2013; Bhatti & Bart, 2013; Bosman, 2015). Although prior research studies have indicated these significant results, there is a gap in research that investigates the relationship between learning style preferences and gender towards mathematics achievement among graduating senior secondary school learners (Eze, 2015). In respect to the above issue, investigation of gender demographic characteristics is critical in the current study to understand the function of the relationship between learning style preferences of boys and girls towards mathematics, and mathematics achievement among graduating senior secondary school learners in Nigeria.

Some prior studies conducted on this relationship provided mixed findings. For instance, Barkatsas et al. (2009) investigated the relationship between learning style preferences and attitudes of male and female learners towards mathematics in Greece. The findings of the study indicated that boys expressed more positive views towards mathematics and more positive views towards the use of Kolb's learning style inventory in mathematics, compared to girls (Barkatsas et al. 2009).

Bhatti and Bart (2013), investigated the influence of learning style preferences on learners' achievement using Kolb's LSI. The findings of the study indicated that male and female learners had different learning style preferences (Bhatti & Bart, 2013). In this respect, the authors suggest that while female learners tend to prefer to experience new information concretely, male learners preferred to experience new information through abstract conceptualization (Bhatti & Bart, 2013).

Bosman et al. (2018) investigated the relationship between learners' academic achievements in mathematics and English language and their learning style preferences in South Africa. The findings of the study indicated that gender affected learning style in both mathematics and English language achievement of learners (Bosman et al., 2018).

The above findings are consistent with the findings of Middleton et al. (2013) who examined the relationship between learning style preferences and attitudes of male and female learners towards mathematics in a high school in United States of America and reported that gender did influence learning style preferences of learners in mathematics.

In contrast, Obiefuna and Oruwari (2015), conducted a study to assess the effects of learning style preferences and the achievement of senior secondary school learners in Nigeria using Kolb's LSI. The findings of the study indicated that gender variable had no significant impact on learners' learning style preferences and academic achievement of learners in mathematics (Obiefuna & Oruwari, 2015).

The findings of the above study are also consistent with the findings reported by Fatokun and Adeniji (2015) on learners' learning style preferences and memory improvement strategies for effective learning of mathematics and science at tertiary level in Nigeria; The findings of the study indicated that learning style preferences based on gender did not have an influence on learners' achievement in mathematics (Fatokun & Adeniji, 2015).

Adnan et al. (2013) conducted a study about learning style preferences and mathematics achievement among high performance school (HPS) learners in Malaysia. The findings of the study indicated that there was a significant difference between learning style preferences and mathematics achievement based on gender.

Ibe (2015) investigated the effects of learning style preferences on the biology achievement of senior secondary school learners in Nigeria using Kolb's LSI. The findings of the study indicated that the interaction effect of gender with preferred learning styles on the academic achievement of biology learners showed no significant difference in the biology mean scores of the learners with different learning style preferences and their gender (Ibe, 2015). The author argued that the four learning style preferences of Kolb were gender friendly in the sense that they did not favour a particular gender (Ibe, 2015).

Buaraphan (2015) investigated grade 1-12 male and female learners' learning style preferences in Thailand using Kolb's Model. The findings of the study indicated that the female learners, the grade level 1 learners and the learners from large schools had significantly different mean scores in the four learning style preferences (Diverger, Assimilator, Converger and Accommodator) higher than male learners in other grade levels and learners from small-size and medium-size schools respectively (Buaraphan, 2015). The author suggested that learners' learning style preferences is related to their gender.

Kozlova (2018) investigated learning style preferences of male and female learners of English for Specific Purpose (ESP) in Czech Republic using Kolb's LSI. The findings of the study indicated that male and female learners tended to prefer different learning styles (Kozlova, 2018).

Biabani and Izadpanah, (2019) investigated the relationship between Kolb's learning style preferences and learning slang among Iranian EFL learners with a gender-based focus. The study showed a non-significant correlation between gender and learning style preferences, in other words, both male and female participants performed similarly in terms of Kolb's learning style preferences (Kozlova, 2018).

Borun et al. (2010) explored the effects of learning style and gender on preferences for college learners using Kolb's Learning Style Inventory (LSI). The results of the study indicated a statistically significant difference in learning styles based on gender variable (Borun et al., 2010).

Lau and Yuen, (2010) investigated gender in learning style preferences among secondary school learners who studied computer programming in Hong Kong. The findings of the study indicated that female learners had a higher preference for concrete sequential and abstract random learning style compared with males. The findings also indicated that male learners had a higher preference for concrete random learning style than female learners. In other words, both male and female learners had different learning style preferences.

Bhatti and Bart (2013) assert that female learners achieved significantly better in mathematics than their male counterparts, the reason being that some instructional practices used by mathematics teachers during lessons favour Assimilator learning style preference which seemed to be the most preferred learning style by female learners rather than male learners who exhibit dominance on Diverger and Converger learning style preferences (Orhun, 2013; Bosman, 2015; Bhatti & Bart, 2013). Based on the literature, it is also important to note for this research that learning style preferences are influenced by demographic variables such as gender. Thus, the way girls prefer to learn mathematics is very different from boys at secondary school level.

2.11 CONCLUSION

Based on the literature review on the link between learning style preferences and academic achievement of learners in mathematics, there were studies which showed that learning style preferences had an association with achievement but there were studies which also showed that it had no effect. Also, research studies exploring the relationship between learning style preferences and academic achievement of secondary school learners using Kolb's Learning Style Inventory (KLSI) in the context of mathematics in Nigeria is limited (Obiefuna & Oruwari, 2015). In this respect, the current study identified a gap in research on the effect of gender and learning style preferences of graduating senior secondary school learners with particular reference to mathematics education and mathematics achievement of learners in Nigeria. A further gap is that most studies about learning style preferences, do not include any qualitative methods, which is done in this study to provide a more nuanced perspective of teachers and learners' understanding of learning styles. The next chapter focusses on the conceptual and theoretical framework essential to this study.

CHAPTER THREE: THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1 THEORETICAL FRAMEWORK

This chapter focuses on the theoretical and conceptual frameworks for the present study. By drawing on Kolb's (1984) idea of "experiential learning" from both the Learning Style model and social constructivist methods of learning and teaching mathematics at the senior secondary school level, it is possible to comprehend the theoretical framework. Constructivism has a long and distinguished history, although many different perspectives coexist within it (Piaget 1966; Brün, Fisher, Von Foerster, Von Glaserfeld, Goldschmidt, Jones, & Rose, 1984; Vygotsky, 1978), portraying learners as independent constructors of their own knowledge, with varying learning styles, capacity or confidence to rely on their own constructions. However, all views share one central premise: a student is believed to construct, through reflection, a personal understanding of relevant structures of meaning derived from his or her action in the learning and teaching perspective with a particular reference to the learning and teaching of mathematics (Fenwick, 2010).

The Swiss Psychologist Jean Piaget (1966), after observing learners learning through play, described this construction process as oscillating between assimilation and accommodation. He suggested that learning happens when learners interact with activities or task in their classrooms both in mathematics classrooms which to build and refine constructs of knowledge in their heads. Learners sometimes assimilate new knowledge by incorporating them into their personal internal network of knowledge constructs and accommodate it by altering these constructs when confronting new experiences that may contradict their past knowledge. The important issue is that each student is active in the learning process, not passively absorbing whatever happens, and each student may construct very different understandings after interacting with the same learning activity or task in the same learning and teaching environment both in mathematics classrooms (Fenwick, 2010). This notion challenged ideas of knowledge as a body of information created by scientists and experts, existing outside of learners, and "learning" as a processing of ingesting these others' knowledge (Fenwick, 2010).

Vygotsky (1978) emphasized the role of learners' interactions with their social cultural environment in this process of constructing knowledge. He developed a theory of what he called the "zone of proximal development", a time-bounded site of learning activity surrounding a student that can limit or enhance cognitive development. The student learns by engaging fully in this zone, particularly through dialogue. Vygotsky's ideas have been influential in subsequent situative theories of learning. However, Vygotsky, like other constructivists, believed that the outcome and objective of learning was the development of each individual student consciousness, experiencing self-mastery, through a process of reflection (what Vygotsky called "inner speech") as well as interaction with fellow learners in the classroom.

Brookfield (1995) and Taylor (1994) both have made considerable contributions to constructivist views of learners learning by theorizing how critical reflection interrupts and reconstructs human beliefs. Brookfield (1995) suggested that when we reflect on our experience with sceptical questioning and imaginative speculation, we can refine, deepen, or correct our knowledge constructions (Fenwick, 2010). He describes three stages in the process of reflecting critically: "(1) identifying the assumptions that underlie our thoughts and actions; (2) scrutinizing the accuracy and validity of these in terms of how they connect to, or are discrepant with, our experience of reality; and (3) reconstituting these assumptions to make them more inclusive and integrative" (p. 177).

Greenwood (1993) has been a significant promoter of constructivism to understand learners' learning and reflections, with the well-known constructs of reflection-on-action (reflecting after something happens) and reflection-in-action (reflecting as something happens). Schön was most interested in how reflection, and particularly critical reflection, plays out not only on the content that the teacher wishes the learners to learn (the direct object of learning) but also on the abilities that the learners can develop through learning the content (the indirect object of learning) in their practice. He proposed that learners learn by noticing and framing problems of interest to them in particular ways, then inquiring and experimenting with solutions. When they experience surprise or discomfort in their learning activity, this reflective process begins. Their knowledge is constructed through reflection during and after some experimental action in the classroom. When these learners meet such unique problems or situations containing some element of surprise, they are prompted to reflect-in-action by creating an on-the-spot experimentation, thinking up and testing out and refining and retesting various solutions for the problem. Schön contends that to make it possible for learners to experience variation, certain patterns of variation and invariance must be used, when they examine what they did, how they did it, and what alternatives exist. Garrick (1998) also reminds us that experience is constituted by the particular discourses comprising a situation: this shape the way learners perceive mathematics problems, which they approach and reflect upon differently.

Based on the constructivism theory, Kolb has established a theory "experiential learning theory" is based on the learning style inventory – Diverger (CE-RO), Assimilator (AC-RO), Converger (AE-AC) and Accommodator (AE-CE). Learners' preferences for learning were analyzed to gauge their effectiveness when used in combination with instructional practices. The contribution highlighted in this study is focused on how leaning style preferences and instructional practices may be essential for learners' achievement in mathematics.

3.2 LEARNING THROUGH REFLECTION ON EXPERIENCE:THE CONCEPTUAL FRAME

The most prevalent understanding of experiential learning in the learning and teaching of mathematics is based on reflection. This process involves questioning the assumptions of learners and instructional practices that makes the learning and teaching of mathematics easier (Bansilal & Rosenberg, 2011). Encouraging reflection in the learning and teaching of mathematics helps learners progress in their understanding. In the learning and teaching of mathematics, Attard (2017) stresses that critical reflection is a skill that doesn't come naturally for many learners but is seen as one of the most important elements of the learning process. Theoretical models in this perspective explain ways learners attend to and perceive experience, interpret and categorize it as concepts, then continue adapting or transforming their conceptual structures. Learners are understood to construct their own knowledge, through interaction with other learners and teachers within the mathematics. Critics of this perspective and alternative explanations of experiential learning take exception to the way the "learners" are considered fundamentally separate from their relations with others. They argue that reflective practices in the learning and teaching of mathematics cannot be separated from some sort of event called "experience". Bansilal (2015) on teacher learning through teaching and researching reported that the role of reflection on the teaching and learning of mathematics in the classroom cannot be overemphasized. There is evidence that reflective practices increase knowledge as well as overall learning effectiveness and influence learners' achievement in mathematics (Passarelli & Kolb, 2012). Critical reflection, says Schön, is more than simply reflecting-in or reflecting-on action. When learners engage in critical reflection, they question the way they framed the problem in the first place. Even if no apparent problems exist, the student questions situations, asking why things are the way they are, why events unfold in the way they do. This is critical reflection to problematize what otherwise are taken-for-granted in the classroom. As well, learners reflect critically when they problematize their own actions, asking: Why did I do what I did? What beliefs inform my practice, and how are these beliefs helping or hindering my work? (Fenwick, 2010).

3.3 KOLB'S MODEL OF LEARNING STYLES

Kolb reported that without reflection on experiences, learners can make mistakes in the learning process, thus, affecting their achievement in mathematics (Passarelli & Kolb, 2012). According to earlier research, reflection has an important role in helping learners understand mathematics topics including problem-solving, comprehension, understanding, and answering questions, as well as creating crucial personal and social relationships (Akinyode & Khan, 2016).

Kolb and other theorists maintain that, although all learners are exposed to a multitude of learning experiences, but not everyone learns from these experiences. Experience alone does not teach. Learning happens only when there is reflective thought and internal processing of that experience by the student, in a way that actively makes sense of the experience, links the experience to previous learning, and transforms the student's previous understandings in some way (Fenwick, 2010).

Learning style dimensions proposed by Kolb and Kolb (2011) were intended to provide teachers with instructional practices that may be appropriate to teach learners or graduating senior secondary school learners with various learning style preferences (Passarelli & Kolb, 2012). Kolb's concept was constructed on the premise that is important for educators or mathematics educators to be critically reflective of learners' learning style preferences (Akinyode & Khan, 2016) as well, as to integrate appropriate instructional practices to improve learning in mathematics classroom context (Akinyode & Khan, 2016) Learning style dimensions proposed by (Kolb & Kolb, 2011) were built on the previously established models to give teachers teaching strategies that might be suitable for learners or graduating senior secondary school learners with various learning style preferences (Passarelli & Kolb, 2012). Kolb's concept was constructed on the premise that it is important for educators or mathematics educators to be critically reflective of learners' learning style preferences (Akinyode & Khan, 2016), as well to integrate appropriate instructional practices to improve learning in classroom mathematics (Akinyode & Khan, 2016).

Kolb (1984) explained that learners usually go through the four-stage cycle of learning several times during their individual learning process (concrete experience, reflective observation, abstract conceptualization, and active experimentation). For instance, Concrete Experience in Kolb's Learning Style Inventory (LSI) involves feeling which provides the basis for the learning process, Reflective Observation includes watching, which enables the learners to make sense of the experience and concentrate on comprehending the significance of concepts and ideas through thorough observation (Obiefuna & Oruwari, 2015). As a consequence, Abstract Conceptualization involves learners' ability to think, to assimilate observations and considerations which then leads to a theory (Ng'eno & Chesimet, 2016). For this reason, Active Experimentation on the other hand, involves doing, for instance, learners engages in practical applications of ideas generated and test theories that could lead to experiences (Akinyode & Khan, 2016).

Further understanding of Kolb's four stage learning cycle depends on a clear explanation of the learning cycle as mentioned above (Akinyode & Khan, 2016). As a result Passarelli and Kolb (2012) assert that, Kolb learning cycle characterizes the modes by which learners or senior secondary school learners can learn and understand mathematics concepts. In this respect, it is important to reiterate that Kolb's Learning Style Inventory (LSI) was used in this current study to identify dominant learning style preferences of graduating senior secondary school learners in mathematics in Nigeria.

Within the classroom context, when talking about the learning and teaching of mathematics, social constructivism based on Kolb's experiential learning theory (1985) is applicable. Kolb's theory claims that knowledge construction can result from eliciting learners' experience and encouraging focused reflection, and analysis of it, from using student-centered instructional practices that encourages the learners to reflect on the experiences in order to construct new knowledge in learning and teaching of mathematics. This constructivist view is embedded in the writings of David Boud and associates (Boud, 2010); Kolb (1984); Dorothy (1996) and many others. David Kolb's theory of 1984 attempted to clarify exactly how different people learn by integrating their concrete emotional experiences with reflection. For him, reflection is all about cognitive processes of conceptual analysis and eventual understanding. Kolb believed that experiential learning is a tension- and conflict-filled process that occurs in a cycle. New knowledge and skills are achieved through confrontation among concrete experience, reflective observation, abstract conceptualization, and subsequent active experimentation (Fenwick, 2010).

First, the learners go through some kind of concrete experience. This could be a simulated experience developed especially for a learning situation, such as a case study or role play, or an exercise involving the student in experimenting with the skills to be learned (Fenwick, 2010). Second, the student takes some time for reflective observation. The student asks of the experience: What did I observe? What was I aware of? What does this experience mean to me? How might this experience have been different? Third, the student uses insights gained through the reflective observation to create an abstract conceptualization. This is where the student asks: What principle seems to be operating here? What general 'rule-of-thumb' have I learned here? What new understanding does this experience reveal about my learning style and achievement in mathematics? Finally, the student applies the new learning through active experimentation. The student asks, what will I do next time? How will I adopt this principle for other contexts? The new "principle" is tested out in similar situations, then in different situations, and the learner continues to revise and reshape the learning based on what happens through experimenting with it. The student may not actually test out the new skill but may simply think through its application.

In the KLSI model, the concept of learning style is a description of the learners' individual differences in learning depending on which phases of the learning cycle that the learners prefer in their learning. There are four phases in the Kolb's learning cycle (Paraselli & Kolb, 2012) as illustrated in Figure 3.1 Learners usually go through the four stage cycle of learning several times during their individual learning process (concrete experience, reflective observation, abstract conceptualization, and active experimentation) (Kolb, 1985) Concrete Experience involves feeling which provides the basis for the learning process, Reflective Observation includes watching, which enables the learners begin to make sense of the experience and focus on the understanding of the meaning of ideas and concepts by careful observations. These are described in greater detail below:

- The foundation for the learning process is provided through Concrete Experience (CE). Prior research has suggested that learning or mathematics lessons and activities are learned when through flexibility and open-mindedness (Akinyode & Khan, 2016). Research also shows that at this time, kids engage in personal experiences, emphasizing emotion over thought (Akinyode & Khan, 2016).

- Reflective Observation (RO). In this stage, learners or secondary school learners learn by their experiences and by articulating why and how the concepts occurred (Kolb & Kolb, 2017). Research indicates that learners at this stage try to reflect, observe, and critically examine their experiences of the activities from all perspectives both in mathematics classroom Reflective Observation includes watching, which enables the learners begin to make sense of the experience and focus on the understanding of the meaning of ideas and concepts by careful observations. Learners at this level attempt to reflect, pay attention to, and critically evaluate their experiences of the activities both within and outside of the mathematics classroom. (Akinyode & Khan, 2016).

- Abstract Conceptualization (AC). Abstract Conceptualization involves learners' ability to think, assimilate the observation and reflections into a concept (Akinyode & Khan, 2016). Research indicates that learners tie their observations and reflections from RO to a mathematical notion at this point. In this way, secondary school learners grasp mathematics problems or classroom activities using logic and concepts rather than emotions. (Khalil et al., 2018). Hence abstract conceptualization calls on learners to apply reason and a methodical approach to problem solving (Ng'eno, & Chesimet, 2016).

- Active Experimentation (AE). During this stage, learners engage in practical applications of ideas generated in learning mathematics to make predictions about mathematics concepts (Akinyode & Khan, 2016). There is evidence that learners are also likely to act on those predictions that lead to experiences (Akinyode & Khan, 2016). These arguments imply that the learners may be required to apply or test the conclusions, generalizations, and solutions in new contexts (Akinyode & Khan, 2016).

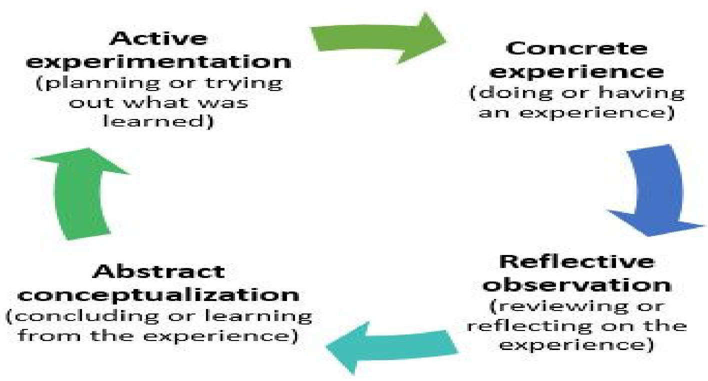


Figure 3.1: Kolb's model of learning. Adapted from Kolb (1985)

The ways in which a person grasps experience can range from concrete experience (CE) to abstract conceptualization (AC). Similarly, the ways in which a person transforms experiences, can range from reflective observation (RO) to active experimentation (AE). In Kolb's Experiential Learning Theory (ELT) the model is these two constructs of grasping experience and transforming experience are used to propose four regions bounded by two main axes which describe different ways in which a person grasps experience and transforms that experience, as depicted below in Figure 3.2. The one axis forms a continuum along the two related modes of dealing with experience where on the one end you have Concrete Experience (CE) and the other Abstract Conceptualization (AC) based on how learners grasp experience. The second axis forms a continuum of the two dialectically related modes of transforming experience where on the one end there is Reflective Observation (RO) and on the other it is Active Experimentation (AE). The four regions bounded by the two intersecting axes describing how learners grasp experience and how they transform experience are aligned to the four main learning styles defined by the model. Hence four learning style preferences emerged which includes diverging (CE-RO), Assimilating (AC-RO), Converging (AE-AC) and Accommodating (AE-CE) as shown in Figure 3.2 (Akinyode & Khan, 2016).

The categorization in accordance with Kolb's Learning Style Inventory (KLSI) is a major aspect of the present study. Given this orientation, the learning style preferences of senior secondary school learners in mathematics are presented below.

- Divergers prefer learning through concrete experiences and reflective observations (Akinyode & Khan, 2016). In this respect, senior secondary school learners who are divergers view mathematics situations or concepts from different perspectives (Akinyode & Khan, 2016). There is also evidence from research studies suggesting that divergers absorb information best through group discussions with a focus on creative ideas in developing mathematical competence in problem solving in the classroom (Kablan & Kaya, 2013). There is also evidence that divergers are motivated to discover the relevance or "why" of a situation and prefers to reason from concrete information (Cox, 2013). The central issue addressed here is that diverger learners appear to have one major trait and that is to explore what a system has to offer and prefers to have information presented in a detailed, systematic and reasoned manner (Cox, 2013).

- Assimilators favors abstract conceptualization and reflective observation (Akinyode & Khan, 2016). Typically, some studies indicate that assimilators prefer abstract tasks like coming up with action issues to answer math problems (Akinyode & Khan, 2016) and are also not interested in the actual application of ideas (Kolb & Kolb, 2017). This argument suggests that, in secondary school mathematics classes, assimilators are likely to consider the teacher and fellow learners as the leader and information giver (Akinyode & Khan, 2016). As a result, they like to listen effectively and watch carefully before engaging in a task

(Kablan, & Kaya, 2013). As a consequence, assimilators are more concerned with abstract concepts and with organizing information (Akinyode & Khan, 2016). There is evidence from research studies that learners or secondary school learners with assimilator learning style preference tend to do very well in mathematics and basic sciences (Ng'eno & Chesimet, 2016). Some studies also categorically stated that learners or senior secondary school learners with assimilator learning style preference are more successful than the rest of the learners in mathematics in terms of academic achievement (Kablan & Kaya, 2013). In one study, (Kablan & Kaya, 2013) argue that learners might need to utilize their abstract conceptualizing skills or assimilating learning style as opposed to their actual experience and talents to be successful in mathematics at senior secondary school level.

- Convergers learn through abstract conceptualization and active experimentation (Kolb & Kolb, 2017). Research indicates that the strength of converger learners lies in practical applications of ideas in the mathematics classroom (Ng'eno & Chesimet, 2016) Researchers also argue that converger learners are good at finding practical ideas and theories leading to solution to problems particularly in mathematics (Kablan, 2016). Consequently, converger learners in senior secondary school mathematics classes, achieve greatly when given opportunities to try out personal effort in solving mathematics problems (Kablan & Kaya, 2013).

- Accommodators are skilled at concrete experience and active experimentation as their dominant learning modes (Kolb & Kolb, 2017). Some studies indicate that, accommodator senior secondary school learners acquire knowledge best through detailed sampling and depend profoundly on experimentation (Akinyode & Khan, 2016). Other studies demonstrated that, learners or secondary school learners with this learning style preference are interested in hands-on experience especially in mathematics activities at senior secondary school level (Buaraphan, 2015). In examining the effectiveness of accommodator learning style preference among senior secondary school learners, Kablan and Kaya (2013) also argue that the learners with such learning style preference are likely to rely on their feelings rather than logical analysis when it comes to problem solving in mathematics. (Akinyode, & Khan, 2016) clearly emphasize that although accommodators enjoy group discussions like diverger learners, they prefer to engage in new and challenging mathematics problems as well as activities using alternative strategies in completing task (Kablan & Kaya, 2013).

Insights drawn from scholarly literature suggest that learning style preferences of learners are noticeable at every level of educational attainment at senior secondary school level

(Akinyode & Khan, 2016). The authors agree that the way in which learners receives and process information affects their academic achievement in mathematics. At this point it is important to note that this study expands on prior research on the association between senior secondary school learners' mathematical achievement and preferred learning styles and instructional strategies.

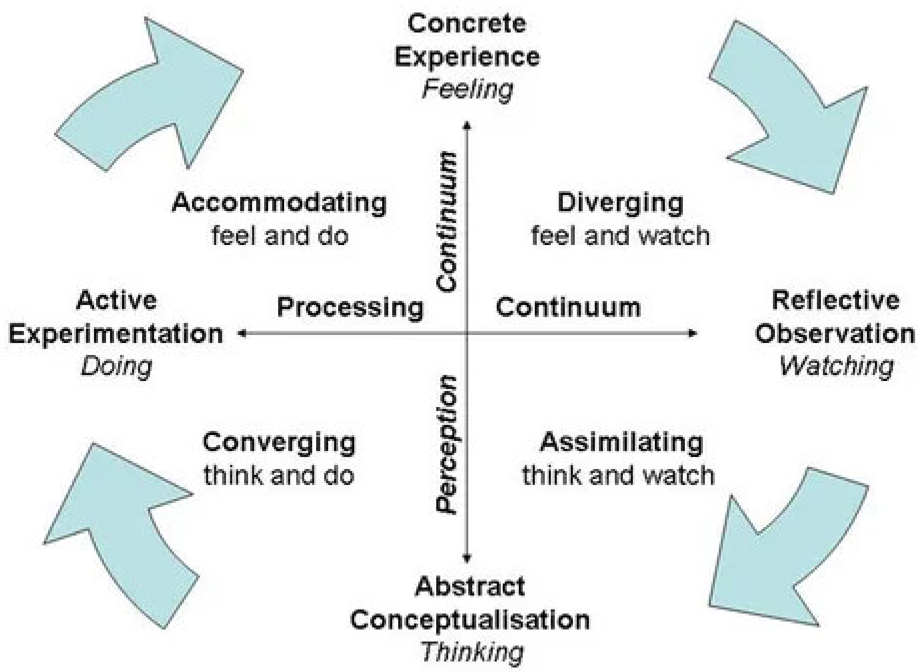


Figure 3.2: Kolb's model of learning style. Adapted from Kolb (1985)

3.3 SUMMARY

Understanding learners' unique learning style preferences can assist educators or mathematics teachers in helping learners and senior secondary learners become lifelong learners, which should be the ultimate purpose of education. Research indicates that teachers, including mathematics teachers, must be encouraged to incorporate the diversity of their learners and develop a classroom environment with a variety of instructional practices that can help impact learners' achievement particularly in mathematics (Kablan, 2016). In this respect, Kolb and Kolb (2017) argue that teachers must utilize best instructional practices that integrate learners' learning style preferences to enhance effectiveness in learning and teaching within the classroom. They proposed that a comprehensive model for secondary school education should include the role of experiential learning. This argument suggests that learners can achieve meaningful learning in mathematics if mathematics teachers are willing to design learning around learners’ interests (learning style preferences, experiential learning, problem-based learning, corporative learning, etc.) and help them to eliminate fear while engaging in difficult tasks in mathematics by monitoring and flexibly guiding them to the right answers (Kolb & Kolb, 2017; Ng’eno & Chesimet, 2016; Passarelli & Kolb, 2012). The implication of this process is that teachers, particularly math teachers, must be educated on learners' preferred learning styles because there is evidence from the literature that effective learning achievement, particularly in mathematics at the senior secondary school level, will result from a deep and personal understanding of learners' preferred learning styles and appropriate instructional practices. The next chapter outlines the research methodology.

CHAPTER FOUR: METHODOLOGY

4.1 INTRODUCTION

In the chapters two and three, the related literature and theories underpinning the study were reviewed. Chapter two detailed the literature relating to relevant issues in the field of learning style preferences and academic achievement. Furthermore, several learning style theories and models were also explained including the diversity in the field of learning style preferences. In chapter three, the framework employed in the study was presented.

This chapter outlines the research methodology, which includes the research questions. It is important to note that the research paradigm is that of interpretivism since the main aim of this study is to understand the subjective world of human experience of the participants (McMillan & Schumacher, 2014). A detailed explanation of how the research questions were investigated in the study with reference to ethical considerations in research is presented. Besides this, a description of different data methods used or applied in data collection, are also outlined. The data analysis procedures applied in this study are also discussed along with the validity and reliability issues of the instruments used for data collection.

4.2 CONTEXT OF THE STUDY

This study was in Nigeria and arose as a result of the concerns with the declining pass rates in mathematics nationally. The National Policy of Education in Nigeria (FRN, 2008) prioritises the application of mathematics to other subjects for development, hence a core subject in secondary school is mathematics. However, a noticeable problem is the low level of the achievement of secondary school learners in both local and standardised examinations, in Mathematics as a subject. Learning style preferences have been seen as the ways in which learners use to perceive and process information within the classroom context and questions have arisen about possible associations between learning style preferences and academic achievement of learners in mathematics. Ignacio and Reyes (2017) used the Kolb's learning type model to examine mathematics achievement goals and reported no connection between learners' aspirations for academic progress in mathematics and preferred learning styles of the learners. However, I believed that it was important to examine the learning style preferences of learners as a result of the consistent decline of learners' mathematics achievement particularly senior secondary school learners. This study sought to look at learning styles in more detail by also considering the interaction of variables of gender, age and school with regards to achievement in mathematics. Furthermore, it also looked at student and teacher perceptions of the links between learning styles and achievement. One of the reasons I decided to work with Kolb's learning style inventory in classifying learners into four different learning style preferences was that learners have different abilities and capabilities in learning, with an emphasis on the consistent decline of mathematics achievement of learners in mathematics in relation to gender issues in learning mathematics (Borun, 2010; Obiefuna & Oruwari, 2015). The participants were boys and girls in the same classrooms who were preparing for the last examination marking the end of secondary school education, and their achievement in mathematics from the examination would determine whether they would proceed to higher institutions of learning, particularly university. For these reasons, I chose the most widely used and reliable learning style inventory to determine the dominant learning style preferences of the learners which included both boys and girls and adapted it to suit the needs of this study.

Another consideration was the beneficiaries of the research results. It was determined that the prime beneficiaries of the research results would be the learners and teachers, particularly those who teach mathematics. I also considered the fact that Kolb's learning style model, derived from experiential learning theory, give learners useful, simple-to-understand information that they may use as a reference while answering questions or completing other tasks.

I also decided to concentrate on mathematics achievement of learners because mathematics is not only a compulsory subject at senior secondary school level in Nigeria but also a criterion for entry into higher institutions of learning regardless of the area of career interest.

The research was conducted with learners across three schools in Delta North Senatorial District of Delta State in Nigeria where mathematics achievement had been steadily declining.

4.3 RESEARCH QUESTIONS

The four main variables identified for this study, were namely:

- four learning style preferences of Diverging, Assimilating, Converging and Accommodating as identified in Kolb's learning style model (see chapter 2);
- gender (male and female).

- age; and
- mathematics achievement of learners.

The following research questions based on the participants who senior secondary school learners in the Delta North Senatorial District of Delta State in Nigeria were, were formulated to guide this study:

- What are the learning style preferences of the participant learners?
- What is the relationship between preferred learning style dimensions and mathematics achievement of the participant learners?
- To what extent is there an association between the participant learners' mathematics achievement and their gender and age?
- What are learners' and teachers' perceptions of effective learning practices?
- What are learners' and teachers' perceptions of effective instructional practices?

Justification

There are several prior research studies including this current one supporting the above hypothesis (see section 2.7). Given this orientation, prior research studies have consistently found no significant association between learners' learning style preferences and mathematics achievement based on gender (Bhatti & Bart, 2013; Madu et al., 2019; Orhun, 2013). In this regard, I thought that it was crucial to ascertain whether there is a statistical relationship between preferred learning styles and gender factors among seniors in senior secondary school. Hence it would be very important for teachers to realise that male and female learners do or do not necessarily have different learning style preferences and then to teach learners mathematics concepts with or without consideration of their gender and preferred learning style. Furthermore, there were no studies which took age appropriateness into account when looking at learning styles and achievement. In light of results from South Africa showing that overaged learners perform significantly lower than those who are the appropriate age for the grade, I thought it prudent to consider this factor of age. Overall, I also wanted to go beyond Kolb's learning styles (Kolb, 2009) and elicit the perceptions of teachers and learners about effective learning practices which may or may not be part of Kolb's characterisation of the four learning styles (Kolb, 2009). It was also important to look at the role of teachers' instructional practices in promoting effective learning.

I ensured that the research was conducted ethically before the hypotheses were statistically tested. This was carried out by applying the principles of ethical research as discussed in the next section.

4.4 SELECTION OF PARTICIPANTS

The criteria applied in selecting the participants for the quantitative phase included:

- learners from nearby schools to the researcher's place of residence (Delta North Senatorial District in Delta State in Nigeria);
- being a graduating senior secondary school male and female student in the three schools conveniently selected for the study;
- availability of the learners in the school for a period of three months (February to April 2018); and
- willingness to participate in the study by signing the consent and parental consent forms and returning them to the researcher.

In the next section the research location, research design and methods used in the research are explained.

4.5 RESEARCH LOCATION

For proximity reasons, this study was restricted to three (3) public secondary schools in Delta North Senatorial District of Delta State in Nigeria. The three (3) public secondary schools (Ogbemudein Secondary School, Owah Model Secondary School and Ime-Obi Secondary School) that were selected and approved for this study are located in both urban and rural areas of Ika-South and Ika North-East in Delta North Senatorial District in Delta State in Nigeria. There are three senatorial districts in Delta State (Delta Central, Delta North and Delta South) and nine local government areas in Delta North Senatorial District (Aniocha North, Aniocha South, Ika North-East, Ika South, Ndokwa East, Ndokwa West, Oshimili North, Oshimili South and Ukwuani) (Omeluzor et al., 2013).

Additionally, there is a total number of one hundred and forty-four (144) public secondary schools in Delta North Senatorial Districts and the majority of the learners and teachers in all the public schools are indigenes of Delta State (Omeluzor et al., 2013). In this respect, it is worth noting that the English language is used as a medium of instruction in all the schools. The researcher is from Ika South Local Government Area where two of the schools are located, thus the convenience-sampling technique (McMillan & Schumacher, 2014) was used in selecting the three public mixed secondary schools (Ime-obi secondary school, Ogbomudein modern secondary school and Owah modern secondary school) for the study. Given this orientation, only graduating senior secondary school learners who were preparing for WASSCE & NECO were used in the research study.

Geographically, Delta State has a total population of 1,293,074 (according to the 2006 population figures) (Omeluzor et al., 2013). For the purpose of clarity, it is important to mention here that Delta State presently covers a landmass of about 18,050 km^2 of which more than 60% is island (Omeluzor et al., 2013). The State is bounded in the North and West by Edo State, the East by Anambra, Imo, and Rivers States, Southeast by Bayelsa State, and on the Southern flank is the Bight of Benin, which covers about 160 kilometres of the State's coastline (Omeluzor et al., 2013). The next section, the population of the schools and participants used in this study are explained in detail.

4.6 SAMPLING

The population of the study was the total number of graduating senior secondary school learners who was preparing for the 2018 West African Senior Secondary School Certificate Examinations (WASSSCE) and National Examination Council (NECO). Sampling is the process of choosing units from an interested community so that the outcomes of the study can be fairly generalised to the group from which the sample was taken (Singh & Masuku, 2013). Sampling is important because it is problematic and frequently impossible to use the entire population during quantitative data collection procedure, hence it is more appropriate to select a sample from the population applying some practical methods for investigating the population (Singh & Masuku, 2013). The sample was composed of 171 graduating senior secondary school learners from Delta State in Nigeria. The sampling technique which was used to select the schools for this study was convenient and purposeful.

Convenience sampling requires researchers to select participants that are available within the units of the population (Leedy & Ormrod, 2013). What is demonstrated here is that participants are selected to take part in a research study because of accessibility and cooperation

(Singh & Masuku, 2013). The quantitative portion of this study included a total of 171 graduating senior secondary learners since they were consistently present in the three public schools, which were easily accessible and conveniently situated near the researcher's home. As a result, the sample used in the quantitative phase was representative, which suggests that the findings from the data collection instruments could be generalised to the school population (Leedy & Ormrod, 2013).

Purposeful or purposive sampling means that the researcher makes specific choices about which people to include in the sample (Palys, 2008; Teddlie & Yu, 2007). The researcher targets a specific group knowing that the group does not represent the population, it simply represents itself. Tongco (2007) articulated that "choosing purposive sampling is fundamental to the quality of the data gathered; thus, reliability and competence of the informant must be ensured" (p. 147). In purposive sampling, the researcher must first think critically about the parameters and then choose the sample accordingly. The qualitative portion of the current research study which consisted of the individual interviews, likewise, used purposeful sampling. According to its name, sampling is carried out with a certain objective in mind (Singh & Masuku, 2013), and individuals or study participants are chosen in this particular sort of sampling for a particular objective (Leedy & Ormrod 2013). When a researcher wishes to focus on a certain segment of the population, they utilise purposeful or purposive sampling (Etikan, Musa & Alkassim, 2016). Due to these factors, 16 learners were chosen via purposive sampling throughout the qualitative portion of the study. The table below provides a summary of the learners that were selected:

Table 4 .1: Student participants who were interviewed.

Student	Gender	Age	School
P1	F	16	S1
P2	F	17	S1
P3	M	17	S3
P4	M	18	S1
P5	F	17	S2

P6	F	16	S2
P7	M	16	S3
P8	F	17	S1
P9	M	16	S3
P10	F	17	S3
P11	M	16	S3
P12	M	18	S2
P13	F	17	S1
P14	M	18	S2
P15	M	18	S1
P16	F	16	S3
TOTAL	F+M	270	S1,S2,S3

There were three mathematics teachers who participated in the interview phase and their details are presented below;

Table 4.2: Teacher participants who were interviewed.

Participants	**Gender**	**Age**	**School**
TA	M	38	S1
TB	F	55	S2
TC	M	57	S3

4.7 RESEARCH DESIGN: SEQUENTIAL EXPLANATORY MIXED METHODS DESIGN

Researchers refer to a research design when they discuss a general strategy for resolving a research challenge. A study design, in accordance with Leedy and Ormrod (2013), is a detailed plan for identifying relevant answers to problems. According to Timans et al. (2019), a research design is a collection of choices about the issue to be examined, the population to study it among, the research methodologies to use and the goal of the study. Therefore, a study design provides the general framework for the processes the researcher will use, the data they will gather, and the data analysis they will perform (Leedy & Ormrod, 2013). In a nutshell, it serves as the study's ‘paradigm’ (Tashakkori & Creswell, 2007).

A researcher considers the sort of study that will be conducted and the type of study that will best address the articulated questions when deciding which research design to adopt (Leedy & Ormrod, 2013). Therefore, the emphasis must be placed on both the study topic and problem, and the type of answers desired (Leedy & Ormrod, 2013). For the aforementioned objective, attention is constantly placed on the logic of the study and the type of evidence needed to properly address the research topic (McMillan & Schumacher, 2014; Timans et al., 2019).

This study's unique research methodology was a sequential explanatory mixed techniques approach. The purpose of this sequential explanatory QUAN-QUAL mixed method design was to explore from the learners’ perspectives how they engaged in learning mathematics and the effect of their learning style preferences on mathematics achievement using quantitative surveys and qualitative individual interviews amongst the graduating senior secondary school learners. These learners were preparing for the 2018 West African Senior Secondary School Examinations (WASSSC) and National Examination Council (NECO) examinations leading to the completion of secondary school education in Delta State in Nigeria. The qualitative phase was exploratory whereas the quantitative phase was descriptive. These types of research designs were used for the following reasons:

- In order to ascertain how the learners are participating in learning mathematics, descriptive research designs can aid by offering responses to factual inquiries (Lin & Tai, 2015). Because of this, descriptive research frequently uses statistics to describe the kind, shape, and distribution of the measured data (Hauserman et al., 2013; Woodwell, 2013). The research strategy in this case was defined as descriptive since descriptive statistics (such as average scores and correlation) were used to determine the primary learning style preferences of the learners and their various genders.
- Exploratory study was also employed because this design had not been used previously in the public secondary schools in the Delta North Senatorial District of Delta State in

Nigeria to examine the association between preferred learning styles and academic achievement of learners in mathematics.

The sequential explanatory mixed methods research design was also deemed most suitable for the following reasons:

- A mixed methods research design, which employs a combination of quantitative and qualitative research methodologies, is optimal for understanding the study problem since it allows for the collection of a variety of data types (Creswell, 2011; Woodwell, 2013).
- The triangulation process leads to the notion that the data received will be more reliable (Woodwell, 2013). As part of a mixed methods study design, triangulation is the attempt to compare data that was gathered using two or more data gathering methods (Creswell, 2011; Strydom, 2013). Triangulation will demonstrate to the researchers that they can be confident that their conclusions are accurate when several study methodologies yield data that is essentially the same (Creswell, 2011; Strydom, 2013). A questionnaire for collecting quantitative data and individual interviews for gathering qualitative data were used to achieve the triangulation of approaches in this study.
- The sequential explanatory mixed methods design was suitable for this study because it enabled the researcher to gather qualitative data following a quantitative phase to explain or further the quantitative findings (Creswell, 2011; McMillan & Schumacher, 2014; Timans et al., 2019). Consequently, it better explained the existence of relationships and the extent to which learning styles and gender influenced mathematics achievement of graduating senior secondary school learners in Delta North Senatorial District of Delta State in Nigeria.

The mixed methods sequential explanatory design consists of two distinct phases: quantitative followed by qualitative (Creswell, 2011).

The reason for using this approach is that the quantitative data and their subsequent analysis provided a general understanding of the research problem (Creswell, 2011). In this context, it is worthwhile to consider that this mixed methods design included straightforwardness and provided opportunities for the exploration of the quantitative results in more detail (Timans et al., 2019; Creswell, 2011). Although this design was considered useful for the study based on the unexpected results from the quantitative data, it required lengthy time and resources to collect and analyse both types of data (Timans et al. 2019; Creswell, 2011).

The researcher conducted this research study to understand learning style preferences required to enhance the mathematics academic achievement of graduating senior secondary school learners in Nigeria. In this respect, the purpose of this sequential explanatory mixed methods study was to identify the influence of learning style preferences on mathematics achievement of graduating senior secondary school learners by obtaining quantitative results from a survey of 171 learners and then a follow-up individual interview with 16 purposefully selected learners to explore those results in greater depth through a qualitative interview analysis (Timans et al., 2019).

In the first quantitative phase of the study, the quantitative research questions focused on selected learning style preferences (diverging, assimilating, converging and accommodating) which served as predictors to mathematics achievement of graduating senior secondary school boys and girls in Nigeria. In addition, the sequential approach started with the learning style inventory (a quantitative research method) where evidence concerning learners' learning style, demographic detail (gender) and their mathematics achievement was obtained. During the analysis of the above data, some vital opinions were selected and explored further in a small setting through the use of individual interviews. Consequently, the quantitative phase was followed by the individual interviews (a qualitative research method). There were some basic reasons why the individual interviews became very necessary, for instance:

- to gather data that was challenging during the quantitative phase of the study, particularly information about how learners learned mathematics in the classroom; and
- to further analyse the quantitative phase's findings.

4.8 INTEGRATION

According to earlier research studies, the steps or phases in the research process where the blending or integration of the quantitative and qualitative methodologies develops is called integration (Creswell, 2011; McMillan & Schumacher, 2014; Onwuegbuzie & Combs, 2011; Teddlie & Tashakkori, 2009). Since the results of the data analysis in the first phase of the study inform or direct the data collection in the second phase, the quantitative and qualitative phases are integrated in the intermediate stage of mixed methods sequential designs (Creswell, 2011; Onwuegbuzie & Combs, 2011). This orientation allows researchers to normally connect the two phases while choosing the participants for the qualitative follow-up analysis based on the quantitative findings from the first phase (Creswell, 2011).

In the sequential explanatory study, I connected the quantitative and qualitative phases during the intermediate stage of the research process while selecting the participants for the qualitative direct interview from those participants who participated in the survey in the first qualitative phase based on their mathematics achievement scores, preferred learning style and gender status. The utilisation of both qualitative and quantitative data gathering techniques, such as a questionnaire and individual interviews, allowed this study to be considered as a mixed methods research.

During the discussions of the overall study's findings, I combined the findings from the quantitative and qualitative stages. As mentioned earlier, I asked both quantitative and qualitative research questions to better understand graduating senior secondary school learners' preferred learning styles in learning mathematics. As a result, I merged the findings from both study phases in the discussion part to fully address the questions and create a detailed and significant background for the research problem. Accordingly, I interpreted the results that helped answer the study's major quantitative research question: What is the relationship between learning style preferences and mathematics achievement of graduating senior secondary school boys and girls? The interview data that was used to address the primary research question in the study's qualitative phase was then covered: How did the learners' and teachers' perceptions of learning style preferences and instructional practices contribute to learners' achievement in mathematics? This procedure allowed the second qualitative phase's findings to further clarify and provide an explanation for the statistical findings from the first quantitative phase (Creswell, 2011).

I proceeded thereafter to discuss in detail the findings of the results by grouping the findings to the corresponding quantitative and qualitative research sub-questions related to each of the explored learning style factors affecting graduating senior secondary school learners' mathematics achievement. I engaged in the discussion by citing relevant and related literature, reflecting both quantitative and qualitative published research studies on the topic. Therefore, combining the quantitative and qualitative findings helped explain the results of the statistical tests, which emphasised the expanding purpose for a mixed methods sequential explanatory design (Creswell, 2011; McMillan & Schumacher, 2014; Onwuegbuzie & Combs, 2011; Teddlie & Tashakkori, 2009).

4.9 DATA COLLECTION METHODS

As previously mentioned, the modified Kolb's Learning Style Inventory (KLSI), the Mathematics Achievement Test (MAT) (for the quantitative phase), and individual interviews (for the qualitative phase) were the three main methods for gathering data in this study. The three main methods of data collection are now explored. For each data collection technique, information is given about the individual participants and how they were selected, as well as the design and administration of the particular data collection.

4.9.1 Quantitative Phase 1: Description of Kolb's Learning Style Inventory (KLSI)

Before discussing the learning style instrument used to classify participants into four different learning style preferences (diverging, assimilating, converging and accommodating), it is very important to consider here that the goal of the quantitative phase of this study was to identify the preferred learning styles and the potential influences on the mathematics achievement of graduating senior secondary school boys and girls in Nigeria. Kolb's LSI is based on experiential learning theory (Kolb, 1984: Kolb & Kolb, 2017; Passarelli & Kolb, 2012). It is a short survey questionnaire consisting of 12 items. Participants were required to use the numbers from 1 to 4 to rank four sentence endings corresponding to the four learning modes for Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE) (Akinyode & Khan, 2016; Kablan & Kaya, 2013; Kolb, 1984; Kolb & Kolb, 2017; 2014; Passarelli & Kolb, 2012). Then, based on the preference for each of the aforementioned modes (determined by the total score for each of the four modes over the 12 items), four distinct learning styles (i.e. diverging, assimilating, converging and accommodating) were identified (Akinyode & Khan, 2016; Kablan & Kaya, 2013; Kolb, 1984; Kolb & Kolb, 2017; 2014; Obiefuna & Oruwari, 2015; Orhun, 2013; Passarelli & Kolb, 2012).

Furthermore, I modified the original LSI, which assisted participants in identifying which phases of the learning cycle they enjoyed and disliked, to gain a greater grasp of the questionnaire's items and prevent any participant misconceptions. In essence, the Kolb LSI aids learners in creating workable plans for finishing the entire cycle in order to improve their overall learning style preferences (Akinyode & Khan, 2016).

Table 4.3 below, indicates the descriptions for each of the learning modes as listed in the KLSI version 3.2 workbook (Kolb & Kolb, 2013).

Table 4.3: KSLI description of modes of learning (Kolb & Kolb, 2013)

LEARNING MODE	DESCRIPTION	CHARACTERISED BY
Concrete Experience	Learning by experiencing	Learning from unique experiences, connecting with others, and exhibiting sensitivity to others' sentiments
Reflective Observation	Learning by reflecting	observing intently before passing judgment, considering problems from different angles, and seeking the purpose of anything
Abstract Conceptualization	Learning by thinking	methodically evaluating concepts, making methodical plans, and acting based on knowledge of a situation
Active Experimentation	Learning by doing	Ability to complete tasks, take risks, and exert influence on others and events

The Kolb's Learning Style Inventory (KLSI) had two primary sections and was utilized in this research investigation. The first portion (which included four items) asked for the learners' demographic data, including:

- age;
- gender;
- type of school; and
- class

4.9.1.1 Pilot study (KLSI)

The Kolb's Learning Style Inventory (KLSI) was pre-tested in a pilot study. A pilot study asks if something can be done and allows for consideration in proceeding with the instrument for the research study (Leon, Davis, & Kraemer, 2011). Leon et al., asserted that the pilot study is important for the following reasons:

- to improve the quality and efficiency of the main study;
- to increase the researcher's experience with the study methods;
- to test for validity, which refers to the degree to which the instrument measures what it is intended to measure (Schulze & Bosman, 2018); and
- to test for the instrument's length, layout, language, potential ambiguity, and clarity of the instructions (Babbie, 2010; Schulze & Bosman, 2018).

In the pilot study that was conducted in this research, the researcher, through the assistance of an experienced mathematics teacher who was teaching the graduating senior secondary school learners, administered the KLSI to 15 learners in a secondary school that was not part of the study setting to check how well it worked. The learners were conveniently selected from the class in which the mathematics teacher was teaching. The learners were told that it was a pilot test of the inventory that was going be used for a research study, and that all responses were to remain unidentified or anonymous. In this respect, the main aim of the pilot study, was as follows:

- to examine the effectiveness of the inventory's items with regard to the appropriateness of the language and their clarity; and
- to calculate the time needed to complete the inventory.

The following amendments were made after receiving responses from the learners:

- Question 1: the term "when I learn" was restated to "when I am learning mathematics" for clearer understanding of the question to the learners.
- Some learners found the first sentence unit in question 1 difficult to understand "I like to come to an understanding of my feelings" and this was changed to "I like to consider my attitude towards mathematics." The word "feelings' was completely replaced with "attitude" throughout the items of the inventory.
- Question 5: the first sentence unit needed some clarification and was changed to "I'm always ready to learn new things with my classmates".

- Since all learners were able to complete the pilot within 20 minutes, the time limit for the main test was set to 20 minutes.

4.9.1.2 Test-retest reliability

There have been many test-retest reliability studies of the randomized format KLSI that have been published. For instance, Veres, Sims and Locklear, (1991) administered the LSI three times at eight-week intervals to initial (N = 711) and replication (N =1042) groups of learners and found test-retest correlations well above .9 in all cases. Kappa coefficients indicated that very few learners changed their learning style type from the administration of the tests. However, Ruble and Stout (1991) administered the LSI twice to 253 learners and found test-retest reliabilities that averaged .54 for the four LSI scales. A Kappa coefficient of .36 indicated that 47% of learners changed their learning style classification on re-test. In these studies, test-retest correlation coefficients ranged from moderate to excellent.

4.9.1.3 Internal validity evidence

Over 17 published studies have been identified that used factor analysis to study the internal structure of the LSI. Most of these studies which focused on LSI 2, studied different kinds of samples and used a number of different factor extraction and rotation methods and criteria for the interpretation of results. Seven of these studies supported the predicted internal structure of the LSI (Brew, 1996; Cornwell & Manfredo, 1994; Katz & Heimann, 1991; Marshall & Merritt, 1985), four studies found mixed support (Loo, 1999; Willcoxson & Prosser, 1996), and six studies found no support (Cornwell & Manfredo, 1994; Geiger et al. 1992; Metallidou & Platsidou; 2008; Newstead 1992; Ruble & Stout, 1991; Jong et al., 2006).

4. 9.1.4 The administration of KLSI

The KLSI was administered to 171 graduating senior secondary school learners who submitted consent and assent forms across the three schools selected for the study. The KLSI was administered and completed during free times with the assistance of mathematics teachers in the three schools who actually suggested that free times in the classes be used for the purpose. The participants were assured of confidentiality of their responses. The instructions on the first page of the instrument were clear enough for learners to understand. The researcher also informed the participants that they were free to ask questions if they were not sure of any item in the inventory. The KLSI took the learners 15 to 20 minutes to complete.

The participants completed the instrument and handed it to their mathematics teachers across the three schools to check if they had fully responded to all the items in the inventory, and these were then handed over to the researcher by the mathematics teachers.

4.9.2 Quantitative Phase 2: Mathematics Achievement Test (MAT)

A Mathematics Achievement Test (MAT) was developed by the researcher, three senior secondary school mathematics teachers in Nigeria and the supervisor, who is a professor in mathematics education, for reflective assessment of the level of achievement of mathematical concepts of the learners using the four learning style preferences discussed above. The test items covered the main topics of mathematics taught up to the third term of the school year from the mathematics syllabus and scheme of work for graduating senior secondary school learners in Nigeria. The level of achievement of a student was taken to be the student's total test score. MAT was trial tested on 15 graduating senior secondary school boys and girls collected twice with an interval of one week in one school in Delta North senatorial districts in Delta State in Nigeria. Spearman's Rank correlation test statistic was used to determine the reliability coefficient as ordinal data was considered (Mukaka, 2012).

4.9.2.1 Administration of Mathematics Achievement Test (MAT)

After grouping the learners or participants into their respective preferred learning styles (Divergers, Assimilators, Convergers and Accommodators) as categorised with KLSI in the three schools, the MAT was administered to all the participants who took part in the first phase of the data collection process of this study (KLSI). The MAT questions consisted of 20 multiple choice questions and 4 theory questions for the learners to answer within two hours and 30 minutes. The first section (consisting of four items) requested the learners' verbal as well as non-verbal and spoken and heard (Cohen et al. 2011). There are several types of interviews ranging from highly structured to unstructured. Highly structured interviews are those in which specific predetermined questions are asked in a particular sequence. An unstructured interview is where a researcher has a topic to explore, but the questions and the order of the questions are not pre-determined, but flow as the interview proceeds (Merriam, 2002).

My study used semi-structured interviews, which consisted of more or less structured questions, and neither the exact wording nor the order was predetermined. The main purpose for choosing semi-structured interviews was to allow for flexibility during the interview process, especially when participants were detailing important information regarding their learning style preferences in the classroom. In the qualitative phase of the study, the semi-structured interview was used as a tool for data collection. Some of the questions for the semi-structured interview were predetermined, as they were based on face-to-face interviews and formed the guide for the interviews. Thus, the semi-structured interviews were guided by a list of questions or issues that were needed for exploration, and neither the exact wording nor the order of the question was predetermined. The main purpose of the interview was twofold: firstly, to probe the learners in order to get a deeper understanding of how they engaged in learning mathematics and secondly, its influence on their mathematics achievement. Depending on the responses of the respondents, sometimes the questions did not take the same form from inception but were adapted with the main aim of obtaining reliable data for this study. Cohen et al. (2000) maintain that the semi-structured interview is well suited for a sequential explanatory mixed methods research design as it enables respondents to express their opinion about the phenomenon. It also allows flexibility of sequence of discussions, and it enables participants to raise and pursue issues that might not have been included in the quantitative phase. A digital wave recorder was used to record the semi-structured interviews.

Comprehensive audio recording can overcome the partialness of the interviewer's view of a single event and can overcome the tendency towards only recording the frequently occurring events thereby having a capacity for completeness of analysis and comprehensiveness of material (Cohen et al., 2000). The radio recordings were transcribed verbatim as closely as possible. During the qualitative data analysis phase, I had to listen to the audio recordings together with the reading of transcriptions several times before making sense and bringing meaning to them. One of the advantages of interviews is that it allows for greater depth of understanding and a disadvantage is that the researchers' presence is prone to subjectivity and bias on the part of the interviewer.

4.9.2.2 Semi-structured interviews - learners

An important and significant variable in this exploratory study was the learners, as they were the main component of the learning and teaching context. It is precisely for this reason that my study incorporated learners as the source of data evidence. Semi-structured interviews were conducted with individual interviews with the learners selected from each of the participating schools. The individual interviews were done at a separate venue, away from the classroom and conducted without interference from anyone. These interviews took place outside their classroom instruction time, mainly during their break-time, for which I was grateful. Initially, some general questions were asked in order to get the learners to feel comfortable in my presence, and to elicit accurate and true responses to questions.

As soon as I detected that learners were comfortable and responding, I then asked questions pertinent to my study. On completion of the individual interview, I then gave each student a token of appreciation for his or her time and effort. The learners were interviewed individually, where they were probed about their perceptions about the relationship between learning style preferences in learning mathematics and mathematics achievement. They were also asked questions about their own personal learning preference styles and how it helped them in learning. Furthermore, they were asked about their teachers' instructional practices and whether they thought it helped them in their own learning. The questions in the interview guide comprised of the core question. When the learners responded to the core question, they were asked follow up questions, if necessary to clarify their points or to probe emerging findings more closely. The associated questions related to the central question made it easier for the researcher to focus on the interview content and the verbal prompts (Jamshed, 2014). I also ensured that learners were given time to express themselves, as this added to the depth and richness of data.

4.9.2.3 Interviews with the teachers

Two male and one female mathematics teachers participated in the individual interviews one mathematics teacher from each from the three schools selected for the study. An important and significant variable in this exploratory study was the mathematics teachers. Semi-structured interviews were conducted with the teachers selected from each of the participating schools. The individual interviews were done at a separate venue, away from the classroom and conducted without interference from anyone. These interviews took place outside their classroom instruction time, and mainly during their break-time, for which I was grateful. Initially, some general questions were asked in order to get the teachers to feel comfortable in my presence, and to elicit accurate and true responses to questions. As soon as I detected that mathematics teachers were comfortable and responding, I then asked questions pertinent to my study. On completion of the individual interview, I then gave the teachers ~~a~~ token of appreciation for their time and effort. The teachers were interviewed individually, where they were probed about their perceptions about the relationship between learning style preferences in learning mathematics and mathematics achievement. They were also asked questions about their own personal learning preference styles and how it helped them in the teaching and learning of mathematics.

4.10 DATA ANALYSIS

A mixed methods approach combining quantitative and qualitative analysis was used in this study. Quantitative analysis was used to analyse quantitative data, whereas qualitative analysis was used to analyse qualitative data (e.g., to explore how learners engage in learning mathematics in the class towards their learning style preferences, how their mathematics achievement is influenced by their learning style preferences, recommendations with regards to learning and teaching of mathematics at secondary school level and reasons for the use of learning style preferences in learning mathematics).

4.10.1 Quantitative Analysis

Quantitative analysis was used to analyse the results of the quantitative data generated using KLSI and MAT. According to Boston et al., (2011), quantitative analysis is usually concerned with the objective measurements and statistical, mathematical, or numerical analysis of data collected through questionnaires and surveys. The KLSI questionnaire consisted of 12 items where participants used the numbers from 1 to 4 to rank four sentence endings corresponding to the four learning modes for Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE). The items were developed for learners to assign a:

- 4 to the word which best characterised their learning style;
- 3 to the next best;
- 2 to the next; and
- 1 to the least characteristic word.

Assigning a different number to each of the four words in the 12 items was used because it is a scaling method of the KLSI and easy to understand (Kolb 1984: Kolb & Kolb, 2017). Table 4.1 as seen earlier in this chapter, shows the four learning modes and descriptions as categorised to measure the learning processes of learners that characterises their best learning style preferences (Kolb, 1984; Kolb & Kolb, 2017; Passarelli & Kolb, 2012). The total scores for each of the learning modes were calculated for each student. Each of these scores were then used to generate scores for a combination of learning modes. The higher the score the learners gained for a combination of learning modes, for instance when CE-RO dominant, the more likely those learners were to be dominant for diverging learning style, AC-RO dominant for assimilating learning style, AC-AE dominant for converging learning style, and CE-AE dominant for accommodating learning style preferences (Kolb & Kolb, 2017). The four basic types of learning styles are created by considering Learning Style Type grid (Kolb, 1999). The Accommodating type was identified when the AC-CE raw score is ≤ 7 and an AE- RO score ≥ 7. The Diverging style is identified when AC-CE ≤ 7 and AE-RO ≤ 6, the Converging style by AC-CE ≥ 8 and AE-RO ≥ 7 and the Assimilating style AC-CE ≥ 8 and AE-RO ≤ 6 (Kolb & Kolb, 2017).

Frequency statistics simply counts the number of times that each variable occurs, such as the numbers of males and females within a sample (Boston et al., 2011). This statistic was used to analyse the frequency and distribution of respondents based on their preferred learning styles (Diverger, Assimilator, Converger and Accommodator) as well as the number of males and females within the sample. Cronbach alpha was used to check the mathematics achievement tests for reliability, while item-total correlations statistical analysis was used to refine the test post hoc to improve the reliability statistics and evaluate or analyse the strength of the relationship between learning style preferences. Boston et al. (2011) stated that, correlation analysis is a powerful and useful statistical method that allows researchers to examine or establish if there is a possible association between two or more variables of interest in the quantitative phase of a study.

To measure the mathematical achievements of the participants, multiple choice questions in mathematics numbering from 1-20 were administered on the participants, as well as five other open-ended questions numbering from 1-5. The test was designed by a mathematics teacher from Nigeria and checked by two other experts. However, during the scoring process, four items were eliminated from the multiple-choice items because three of them did not have a correct option while for one item, the group obtained on average 0 for that item.

The second part of the test was the open-ended items of which there were eight items originally. Two items were deleted because of the large number of zeroes on those items. Hence the open-ended items were calculated out of a total of 22 marks. In chapter 5, I considered three possible measures for mathematics achievement- the whole test, the multiple-choice part only and the open-ended items only.

I used a Cronbach -alpha statistic to test for the reliability or internal consistency, which is the extent to which all the items in a scale contribute to the same underlying construct (Field, 2013). A popular method for evaluating internal consistency in research is to calculate the alpha coefficient. Although there are several interpretations of Cronbach's alpha coefficient in the literature, the commonly accepted method is shown in the table below (Field, 2013).

Table 4.4: The Classification of Cronbach's Alpha Coefficient

Cronbach's Alpha Coefficient	Interpretation of Cronbach's Alpha Coefficient
$\alpha \geq 0.9$	The scale's internal consistency is excellent or high.
$0.7 \leq \alpha \geq 0.9$	The scale has internal consistency.
$0.6 \leq \alpha < 0.7$	The scale's internal consistency is acceptable.
$0.5 \leq \alpha < 0.6$	The scale's internal consistency is poor.
$\alpha < 0.5$	The scale is inconsistent internally.

In terms of judging how well the items in the mathematics test were functioning and contributing to the overall score, I also considered the correlation of the individual items with the total score. Low values less than 0.3, may indicate that the item is measuring something else that is different from what the other items are measuring as a whole. I also checked if Cronbach's alpha of the instrument increased or decreased if the item was deleted. If it increased then it meant that the item was not working very well and I then decided about whether to remove the item or not (Field, 2013; Pallant, 2011).

In order to understand the influence of learning style preferences on mathematics achievement of learners, the variables were first checked for normality, using the Kolgomorov-Smirnov statistic. If it is significant then it indicates that the variable is not normal (Pallant, 2011). If it indicates normality, then parametric tests can be used to test for differences between subgroups. If it indicates that the variable is not normal, then it is advised that non-parametric tests should be used to check for differences.

In this study, the Kruskal-Wallis's test was first used to check for differences in mathematics achievement taken as a continuous variable according to the learners' learning style preferences. The Kruskal-Wallis's test is a non-parametric alternative to a one-way between groups analysis of variance. If the significance level is less than 0.05, then one can assume that there is a significant difference in the measure variable across the groups.

In a further step, learners were coded according to high and low achievers, thus taking achievement in terms of two categories. To test whether there was a difference according to learning style preferences using these categories, I used a chi-square test. This is a test that is used when the variable in question is a categorical variable, and it makes no assumption of the distribution of the variable. The chi-square test was also used to check for differences in mathematics achievement categories according to gender, school and age groups. For age groups, the learners were categorised according to whether they were at the normal age or over-age.

4.10.2 Analysis of the Individual Interviews

Making sure researchers use the language of participants in a significant way is one strategy to maintain the integrity of actions and meaning (Wellington & Szczerbinski, 2007). According to Wellington and Szczerbinski's advice, the analysis of the individual interviews was carried out in the following steps:

- Immersion - To get a general idea or grasp of the data, the researcher immersed himself in it. This involved listening to the tapes, reading the transcripts aloud and again, underlining and analysing the transcripts. In the transcripts, the researcher looked for certain words as well as other frequently used words and phrases.
- Reflecting - after immersing himself in the data, the researcher 'stood back' from the data and literally 'slept on it'.
- Analysing the data - the researcher began categorising the information in an attempt to identify trends or recurrent themes that could be used to make sense of the data. Coding is the process of analysing qualitative text data by taking them apart to see what they yield before putting the data back together in a meaningful way (Creswell, 2015; Mourby et al., 2018). Richards et al., (2015), argues that coding should always be for a purpose, and not an end in itself.

In a way, the coding was deductive because the interview schedule showed the categories that were created (Schulze & Bosman, 2015).

A code in a qualitative phase of a mixed method research is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or suggestive attribute for a portion of language-based or visual data (Green et al. 2007). The learners' responses emerged from open-ended questions and were coded qualitatively in order to examine the types of learning style preferences reported by learners in terms of how they engaged in learning mathematics and the extent to which their mathematics achievement was influenced by their learning style preferences. In this case, coding was done independently by grouping the answers that had similar meaning. After reviewing the coding, I came to an agreement on any discrepancies. This procedure was carried out with the goal of enhancing the coding's validity and reliability, two crucial components of trustworthiness in the qualitative stage of a mixed method study (Golafshani, 2003). The details of qualitative codes are briefly summarised below.

In this respect, the following categories were selected:

- How learners engage in learning mathematics in the classroom?
- What types of instructional practices are required for teaching learners in the mathematics classes?
- What types of instructional practices do not work well for learners in the mathematics classes?

However, the data analysis was inductive within each category.

Recombining and synthesising the data entailed looking for themes and patterns in the categories. In this regard, the researcher saw specific actions, processes, or routines that were pertinent to the study's concerns. Five themes related to participants' perspective of learning and teaching of mathematics emerged in the analysis of each student's responses and across all responses:

- quality of reflective observation;
- effective listening;
- constant practice;
- effective discussion; and
- teacher's explanations.

The above themes were found to be common for all the participants but differed in the number of and similarity of subthemes and categories comprising them. There were more similarities between the participants and effective discussions in learning and teaching of mathematics in the classroom, although at different stages, than those who preferred constant practice in learning and teaching of mathematics. However, the qualitative findings revealed that reflective observation, effective listening, constant practice, collaborative discussion and teacher's explanations of mathematics concepts were essential predictors of learners' learning and mathematics achievement. In this respect, the researcher observed detailed acts or behaviours, activities or practices pertinent to the research questions.

- Relating and identifying data – at this stage, the researcher analysed the findings by contrasting and comparing the data to the findings of the literature review. This gave the researcher the chance to consider the data, interpret it, and then talk about it.

- Presenting qualitative data - the researcher tried to convey the data as fairly, clearly, and logically as he could at this final stage of data analysis. To gain a comprehensive understanding of what the data meant, the researcher combined the qualitative and quantitative data. This actually allowed the researcher the opportunity to solve the key study problem (see sections 1.2 and 4.2).

In the next section, the ethical considerations used in this study are explained in detail.

4.11 ETHICAL CONSIDERATIONS

One of the most important criteria considered for selecting participants was ethical consideration. Ethics refers to a body of principles of right and good conduct and assures the persons responding to the questionnaire during a research study, of their right to give information willingly; to be informed of the results; the right to seclusion and confidentiality; and not to be stigmatised (Cohen & Swerdlik, 2010). Prior research has indicated that ethics are the norms or standards for conduct that distinguish between right and wrong and also help researchers to prevent fabrication or falsification of data and, therefore, promote the pursuit of knowledge and truth which is the primary goal of research (Wilson, 2011). Given this orientation, steps were taken to ensure that ethical issues were followed in this study. For instance, all ethical considerations stipulated by the University of KwaZulu-Natal were adhered to. Out of the group of 200 learners and 5 teachers who were approached to take part in the study, only 171 learners and 3 teachers opted to participate. The participants were guaranteed anonymity and were given the choice to withdraw from the research if they wanted to. I also informed the participating learners and teachers that all data and everything emanating from the data would be used only for research purposes and that it would not affect their studies and jobs in any way. Permission to carry out the research was granted by the UKZN with the protocol reference number HSS/1583/016D.

4.11.1 Informed Consent

Informed consent is described in ethical codes and regulations for human subjects' research and the goal of the informed consent process in a research undertaking is to provide sufficient information so that a participant can make an informed decision about whether or not to partake in a study or to continue participation (Cohen & Swerdlik, 2010). Wilson (2011) asserts that securing informed consent involves providing adequate information on the purpose of the research and the nature of confidentiality to the participants.

In this study, I started by applying for ethical clearance and obtained a letter of identification from the college of humanities, school of education at the University of KwaZulu-Natal (UKZN) in South Africa and attached consent letters to the Ministry of Education and school authorities of the research site of the study in Delta State in Nigeria for consideration. The purpose of this was that issues of consent are particularly important when conducting research with children (under 18 years of age) and the participants of this study were in this category (Cohen et al., 2013).

Consequently, Wilson (2011) refers to the imbalance of power between the researcher and the child in the relationship. In order to respect the dignity of the participants, assent from the participants as well as the parent/guardian is advocated by some (Cohen et al., 2013; Wilson, 2011). This can be complicated and requires clear information to be provided to the parent on the purpose of the study and the child's involvement that is age appropriate and easily understandable (Cohen et al., 2013). Based on the above reasons, learners or participants were required to have a signed Parent/Guardian Consent Form (see Appendix), a signed Student Assent Form (see Appendix), and to be present in the classroom at the time both learning style inventories were administered by the researcher.

4.11.2 Confidentiality and Anonymity

The basic human need of a right to privacy can be violated during the course of a research study, or afterwards, thereby making the participant "extremely vulnerable" (Cohen et al., 2013. p. 91). Cohen et al. (2013) stress that privacy is much more than confidentiality as it pertains to the right of the participant not to take part in any or all of the research study. Therefore, I informed the participants of their right to refuse, and obtained permission for them to take part in the study. Thorne, (2016) provides clear definitions for the two terms, anonymity and confidentiality, which are central to the protection of participants. Anonymity means that no uniquely identifying information is attached to the data and thus no one, not even the researcher, can trace the data back to the individual providing them. Confidentiality means that the privacy of individuals must be protected in that the data they provide will be handled and reported in such a way that they cannot personally be associated with them.

In this respect, I preserved anonymity by applying the use of pseudonyms and codes for identifying participants and avoided the use of names or any other vital personal information about the participants to ensure confidentiality of their identities. Whilst anonymity is easier to guarantee in questionnaire design (Cohen et al., 2013; Thorne, 2016), this cannot be expected in face-to-face interviews (Cohen et al., 2013).

4.12 SUMMARY

The research paradigm utilised in this study was the that of interpretivism. Sequential explanatory mixed method research design was deemed most appropriate for the current study. This chapter's primary goal was to describe the research design and methods that was employed in this study.

The context of the study was outlined at the beginning of the chapter followed by the research questions. This was followed by details of the selection of participants in the main study. Thereafter both the quantitative and qualitative research approaches used in the sequential explanatory mixed methods study design were presented. Following this, I focused on the data collection methods and instrument as well as the procedures used in the data analysis as well as a discussion of the validity and reliability of the various measuring tools employed. I then explained how an ethical approach and consideration were protected. In the next chapter the results and findings of the research are analysed and presented.

CHAPTER FIVE: RESULTS OF THE QUANTITATIVE ANALYSIS

5.1 INTRODUCTION

The research technique and design were covered in Chapter 4. This study used a mixed methods methodology that followed the sequential explanatory model approach.

I present the findings of the quantitative analysis in this chapter. By presenting the findings from the quantitative phase, I provide answers to the research questions. To improve the reader's comprehension of the data and statistical analysis, pertinent figures are given. The participant demographic information and the answers to the quantitative research questions are shown in the tables and figures that follow.

5.2 RESTATEMENT OF PURPOSE OF THE STUDY

The purpose of the study was to explore the student learning style preferences and the instructional practices used by mathematics teachers, and to look for associations between various variables such as learning style preference, gender, age as well as school, and that of mathematics achievement of graduating senior secondary school learners in a district in Nigeria. The quantitative phase of the study intended to answer the following: What are the learning style preferences of the participants' learners? What is the relationship between the preferred learning style dimensions and the mathematics achievement of the participant learners? To what extent is there an association between the participant learners' mathematics achievement and their gender and age? The qualitative phase of the study also intended to answer the following questions: What are learners' and teachers' perceptions of effective learning practices? What are learners' and teachers' perceptions of effective instructional practices? What are learners' and teachers' perceptions of effective learning practices?

5.3 DATA ANALYSIS

5.3.1 Demographics

I first present some demographic details of the learners according to gender, age and schools.

5.3.2 Gender Details

In terms of the gender breakdown, Table 5.1 shows that there were more females than males in the sample.

Table 5.1: Details of gender of learners.

Gender	Frequency	Percent
Male	82	48.0
Female	89	52.0
Total	171	100.0

A total of 171 learners completed the questionnaire in 2018, so the response rate of the current study was 85.5%. From this group, 89 learners (52.05%) were female learners while 82 learners (47.95%) were male learners. Overall, female learners made up the bulk of the study participants.

5.3.3 Details of Age

The mean age of the learners was 16 years. As noted in Chapter 4, I considered the age of the learners who were 17 and under as age appropriate for their grade, while those who were over 17 were taken as over-age.

Table 5.2: Details of Age

Age Bracket	Frequency	Percent
Appropriate Age	132	77.2
Over-Age	39	22.8
Total	171	100.0

Out of 171 graduating senior secondary school learners, 132 learners were appropriately aged whereas 39 learners were over 17 years old. These figures confirm that the majority of the learners who participated in the study were of the appropriate age for the grade and a quarter were over-age.

5.3.4 Details of Schools

There were participants from three schools in the district. School one, had the least number, 44 participants, ~~44,~~ while School 3 had the most, 70 participants.

Table 5.3: Details of schools.

Number of School	Frequency	Percent
School 1	44	25.7
School 2	57	33.3
School 3	70	40.0
Total	171	100.0

5.4 Learning Style Preferences of learners

The first objective of this study was to explore the learning style preferences of graduating senior secondary school learners in Delta North Senatorial District of Delta State in Nigeria. To achieve this, a questionnaire containing Kolb's Learning Style Inventory was used. Based on their responses to the KLSI and as described in Chapter 4, learners were classified in terms of their preferred learning style. Below is a presentation of the findings of the study.

Table 5.4: Preferred Learning style of participants

Learning Style	**Frequency**	**Percent**
Accommodator	23	13.5
Assimilator	8	4.7
Converger	6	3.5
Diverger	134	78.4
Total	171	100.0

From the KLSI, the study as captured in Table 5.4 found that an overwhelming number of 134 learners identified their preferred learning style as diverger, while 8 others indicated that their preferred learning style was 'Assimilator'. Additionally, 6 and 23 agreed that their preferred learning styles were Converger' and 'Accommodator' respectively. This study, therefore, confirms that most learners' preferred learning style in the three schools sampled was "Diverger".

5.4.1 Learning styles by school

It is important to also consider the distribution of the learning style preferences according to the schools. Across all three schools, learners overwhelmingly identified themselves as preferring the Diverger Learning style. Note that for School 2 there were no learners who identified converger learning style as their preferential learning style.

Table 5.5: Distribution of learner styles preferences by school.

School	Accommodator	Assimilator	Converger	Diverger	Total
School 1	7	2	2	33	44
School 2	9	3	0	45	57
School 3	7	3	4	56	70
Total	23	8	6	134	171

These findings show that the learners' preferred learning styles were overwhelmingly dominated by the diverger learning style. There are very few learners who opted for the other three styles. Figure 5.1 shows this distribution as a bar graph:

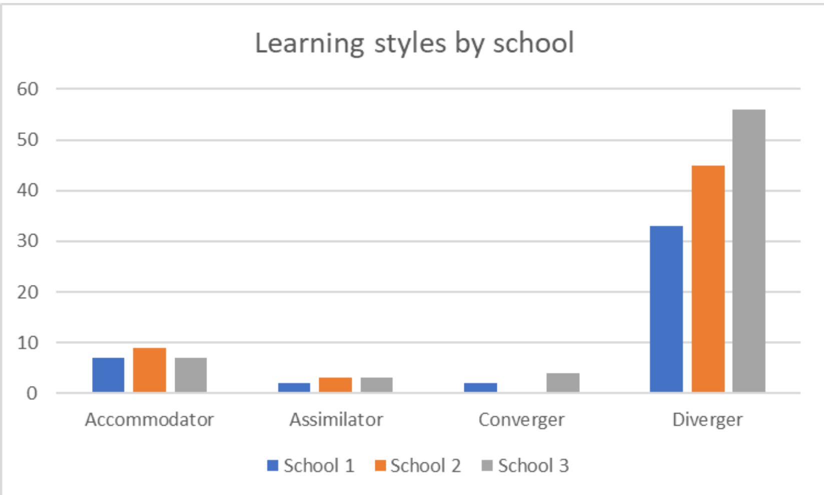


Figure 5.1. Bar graph showing distribution of learners learning styles by school.

The graph in Figure 3 shows that the patterns of learning styles across the schools are similar, however there are no learners who identified themselves as Convergers in School 2. Thirteen percent (13%) of the learners identified traits related to Accommodators; 5% as assimilator; 4% as converger and 78% as Divergers. This distribution is different from that reported by Bharti and Bhatt (2013) where only 25 % identified as Divergers while the style with the most number was Assimilators. However, the study by Bharti and Bhatt was conducted with philosophy learners who seemed to favour the assimilator learning style. In another study with grade eight science learners, the results were found to be similar to this study, where Divergers were the dominant group.

5.4.2 Learning styles Preference by gender

Some studies report different distributions of learning styles according to gender (Bharti & Bhatt, 2013) however in this study Figure 5.2 shows similar patterns of learning styles according to gender.

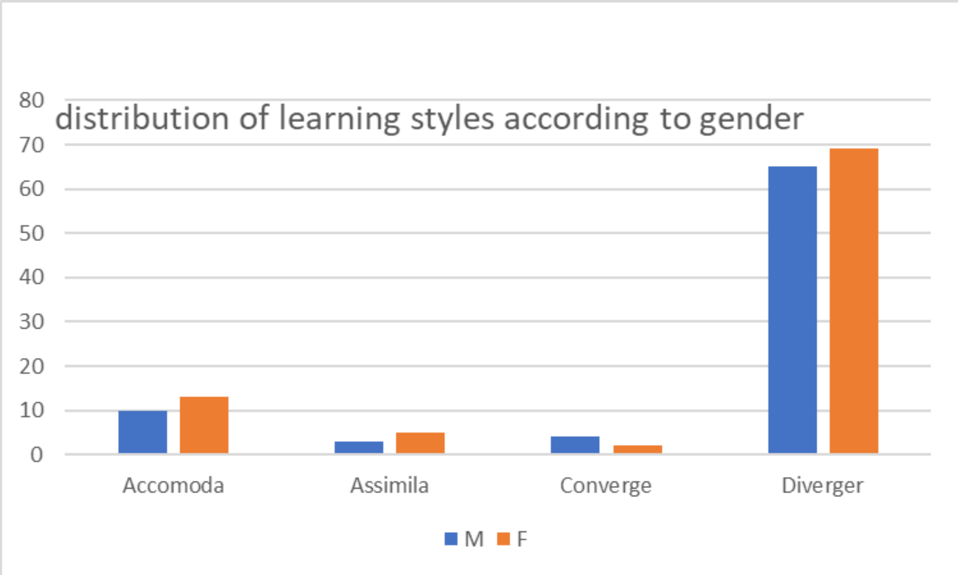


Figure 5.2: Learning styles preferences according to gender.

Table 5.6 shows the exact numbers of learning styles according to gender and it can be seen from the table that more females prefer the diverger, assimilator and accommodator learning styles compared to male learners, while the converger learning style has more males than females, although both groups are very small.

Table 5.6: Learning styles by gender

Learning Style Preferences by Gender					
Gender	**Accommodator**	**Assimilator**	**Converger**	**Diverger**	**Total**
M	10	3	4	65	82
F	13	5	2	69	89
Total	23	8	6	134	171

5.5 Exploring the relationship between learning style preferences and mathematics achievement.

The second objective of this study was to determine the relationship between learning style preference on mathematics achievement of graduating senior secondary school learners in Delta North Senatorial District of Delta State in Nigeria. I first briefly detail how the achievement test instrument was refined to improve its reliability.

5 5.1 Refining the mathematics achievement test.

To ascertain the mathematical achievements of the participants, multiple choice questions in mathematics were administered to the participants, as well as eight additional open-ended questions. The two parts of the test were designed by a mathematics teacher from Nigeria and checked by two other experts. On the one hand, the reason for using multiple choice questions was that it enabled me to set a larger number of questions than would be possible if the test consisted of only open or free response questions. On the other hand, the reason for including open- ended questions was to ensure that there was a limited opportunity for guessing as a common reaction by learners when faced with multiple choice questions.

In this section we report on how the instrument was examined and how the reliability was improved. The two parts of the test were used to generate three measures of achievement, one for the multiple choice only, one for the open items only, and the third was the total score on both the parts. In the next three subsections, I examine the refinement of the two tests and the reliability statistics of the three scales.

5.5.1.1 Reliability of the multiple-choice scale

As noted in Chapter 4, the scoring of the tests was done by an expert mathematician from Nigeria, who was based at the South African university where my study was enrolled. During the scoring process of the multiple-choice items, it was discovered that three of them did not have a correct option, hence these were deleted from scoring. Furthermore, it was found that for one item, the group obtained on average 0 for that item. This result suggested that the item may have been too difficult for the entire cohort,-it may have been phrased ambiguously or perhaps it was based on content that had not been studied.

Table 5.7: Refinement of the mathematics achievement test.

Cronbach's Alpha	Number Items
.775	16

From Table 5.7 we see that alpha = 0.775, for the 16-item multiple achievement test, which is considered as acceptable and shows that the instrument has internal consistency (Fields, 2013).

5.5.1.2 Reliability of the open-ended item scale

The second part of the test was the open-ended items of which there were eight items originally. Three items were deleted because of the large number of zeroes on those items. Hence there were five open-ended items that were considered and were calculated out of a total of 22 marks.

From Table 5.8 we see that the standardised alpha = 0.681, for the 5-item open-ended test, which is considered as acceptable. Furthermore, since there are only 5 items, we expect the alpha-Cronbach to be lower than that for instruments made up of more items.

Table 5.8: Reliability Statistics for the open items.

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	Number of Items
.636	.681	5

5.5.1.3 Reliability for the combined instrument

A third variable for measuring the achievement was calculated by adding up the totals for each of the two tests, called final total of combined instrument. By combining the two tests, there were 21 items, however Item 1.1 was deleted.

Table 5.9: Reliability Statistics for the combined test instrument of 20 items.

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	Number of Items
.771	.801	20

Accordingly, Table 5.9 shows that Alpha based N standardised items = 0.801, for the combined test, with item 1.1 removed, which is considered as good. A closer look shows that the mean item correlations are not high, after item 1.1 was removed.

Table 5.10: Summary Item Statistics for combined 20-item instrument.

	Mean	Minimum	Maximum	Range	Maximum/Minimum	Variance	Number of Items
Inter-Item Correlations	.168	-.432	.886	1.318	-2.051	.046	20

This set of 20 items was then examined to see if the items were functioning well as a whole. The item-total correlation matrix was used to provide more insight into items which are not functioning as well as they could have, and appears below in Table 5.11:

Table 5.11: Item-Total Statistics for the initial instrument, with item 1.1 removed.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q2_1_rsc	16.3860	11.991	.678	.	.733
Q2_3rsc	16.8246	11.576	.380	.	.769
Q2_4a_rsc	16.4912	13.183	.280	.	.767
Q2_5a_rsc	17.2807	13.170	.426	.	.755
Q2_5b_rsc	16.5088	11.790	.540	.	.743
Q1.3rec	17.2982	14.177	.089	.	.777
Q1.6rec	17.1579	13.278	.569	.	.751
Q1.10rec	17.6491	14.268	.039	.	.783
Q1.15rec	17.1404	13.659	.435	.	.759
Q1.20rec	17.1228	13.574	.536	.	.756
Q1.2rec	17.0877	14.260	.259	.	.768
Q1.7rec	17.1754	13.719	.338	.	.762
Q1.9rec	17.6667	12.798	.461	.	.752
Q1.11rec	17.1579	14.635	-.031	.	.779
Q1.12rec	17.6491	12.946	.412	.	.756
Q1.18rec	17.1930	13.266	.497	.	.753
Q1.4rec	17.8070	14.551	-.025	.	.785

Q1.14rec	17.1579	13.385	.519	.	.754
Q1.5rec	17.1404	13.480	.523	.	.755
Q1.17rec	17.1053	14.060	.324	.	.765

It can be seen that items 1.3 and 1.10 had very low item-total correlations. I then removed items 1.3 and 1.10 because of the low correlations with the total and if they are deleted the Cronbach alpha increases. Items 1.11 and 1.4 were also deleted because these had a negative correlation with the total and would lead to a higher Cronbach alpha if deleted. Hence there were five additional items that were deleted, leaving a total of 16 items in the final total variable. The tables below show a much-improved scale as the standardised Cronbach alpha has improved to 0.843.

Table 5.12: Reliability statistics for the final refined instrument with 16 items.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.812	.843	16

Table 5.13 below shows the mean of the inter item-total correlations for the refined 16-item instrument as now being 0.252, up from 0.168.

Table 5.13: Summary of item statistics in 16-item final instrument.

	Mean	Minimum	Maximum	Range	Maximum /Minimum	Variance	Number of Items
Inter-Item Correlations	.252	-.121	.886	1.007	-7.347	.0347	16

However, Table 5.14 shows the item-total statistics for the 16-item scale:

Table 5.14: Item-total statistics for the final instrument

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q2_1_rsc	14.1000	10.634	.680	.782
Q2_3rsc	14.5667	10.114	.410	.819
Q2_4a_rsc	14.2333	11.470	.348	.809
Q2_5a_rsc	15.0000	11.797	.404	.803
Q2_5b_rsc	14.2167	10.410	.549	.792
Q1.6rec	14.9167	11.806	.508	.798
Q1.15rec	14.8667	12.219	.423	.804
Q1.20rec	14.8500	12.062	.570	.799
Q1.2rec	14.8167	12.729	.279	.811
Q1.7rec	14.9000	12.329	.303	.809
Q1.9rec	15.4000	11.329	.470	.798
Q1.12rec	15.3833	11.664	.360	.806
Q1.18rec	14.9167	11.806	.508	.798
Q1.14rec	14.8833	11.935	.524	.799
Q1.5rec	14.8667	11.948	.569	.798
Q1.17rec	14.8333	12.582	.315	.809

5.6 Exploring achievement and their relationship to learning styles

The results from the previous section suggest that the refined version of the 16-item instrument could have been used as our final achievement measure. However, in searching for possible associations between achievement and learning styles, I considered three achievement variables, to see whether any of them would lead to significant results when the relationships between achievement and learning styles were considered. The three variables are achievement scores for open items only (five items), achievement scores for multiple choice items only (11 items) and achievement scores for all the open and multiple-choice items considered together (16 items). These are referred to as open items, mc items only and combined items respectively. I firstly note that the three sets of scores are strongly correlated.

Paired Samples Correlations

Table 5.15: Correlations between three variables

Pairs	Items	Number	Correlation	Sig.
Pair 1	Open item & mc items	171	.703	.000
Pair 2	Open items & combined items	171	.919	.000
Pair 3	Mc items & combined items	171	.927	.000

Table 5.15 shows that the correlation between the mc items and open items was 0.703 which is a strong correlation, and the correlations between the mc and the combined as well as the open and combined items were even higher, above 0.9. This shows that learners who achieved high marks in one of the sets of items were likely to achieve high marks in the other sets as well.

The table below provides the means for the three achievement variables:

Table 5.16: Means for each test according to learning style.

	Learning Styles	Open items Mean	Mc items Mean	Combined total Mean
Ls_4 code	Diverger	3.93	6.20	10.13
	Converger	5.00	7.00	12.00
	Assimilator	4.13	7.50	11.63
	Accommodator	3.91	5.87	9.78

A brief glance of Table 5.16 shows that the highest mean for the open items was attained by the group whose preferred learning style was the Converger. For the multiple-choice items, it was the Assimilator group which achieved the highest mean, while for the combined total, it was the Convergers who achieved the highest means. In terms of the lowest means, the accommodator group got the lowest total in each case.

In order to use statistical tests to see if there were any significant differences between the achievements across the groups, I first checked if the distribution of each of the three variables were normal.

Table 5.17: Results for tests of normality on the three test variables.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Open total	.191	171	.000	.897	171	.000
Mc 16 items	.122	171	.000	.955	171	.000
Combined total	.109	171	.000	.945	171	.000

[a] Lilliefors Significance Correction

From the table we see that the Kolmogorov-Mirnov and Shapiro-Wilk statistics are both significant, showing that there is a violation of the assumption of normality. Hence all three variables in Table 5.17 are not normally distributed. Since none of the three achievement measure variables were normal, we carried out a Kruskal- Wallis test to check if there were any differences in any of the achievement scores in terms of the four learning styles.

Table 5.18: Testing for normality on three achievement variables.

	Open Total	**Mc items**	**New totals**
Kruskal-Wallis H[a]	.544	4.100	2.164
Df			
Df	.909	.251	.539

[a] Kruskal Wallis Test   [b] Grouping Variable: LS_4 code

From the table above (Table 5.18), it is seen that none of the three achievement variables have any statistically significant difference according to the learning styles. Hence, irrespective of which of the three achievement variables were considered, none of them were significantly associated with learning style preferences of the learners.

5.6.1 Exploring details of achievement according to learning style preferences.

The previous section showed that no relationships between learning styles could be established using the Kruskal =Wallis test, when the mathematics achievement was measured using the open items only, the multiple-choice items only as well as the combination of the multiple choice and open items, when the variable was continuous.

In my investigations about possible relationships, I went further and decided to check if there were differences according to whether learners were in a high achieving group compared to those in a low achieving group. For this, I also used the three sets of measures used in the previous section, but in this case, the achievement measure was taken as categorical. The details appear below:

Firstly, I looked at the distribution of the scores in the combined test. I then divided the learners into two groups, according to their achievement scores. I coded learners who got 10 marks or less as low achievers and those who got above 10 as the high achievers. The cross tabulation of the low/ high achievers against the learning styles is presented below;

Table 5.19: Cross tabulation of learning styles according to high/low achievement in the combined test.

Learning Style	Low achievement	High achievement	Total
Diverger	82	52	134
Converger	3	3	6
Assimilator	5	3	8
Accommodator	13	10	23
Total	103	68	171

Table 5.19 shows that Divergers have the highest number of high achievers, although there are very small numbers in the group. I then checked to see if the high and low values differ significantly with the achieving learners according to learning style, using a chi-square test, the results of which are presented in Table 5.20 below.

Table 5.20: Results of chi-square test for the high/low achievers per learning style using the open item test.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.463[a]	3	.927
Likelihood Ratio	.457	3	.928
Linear-by-Linear Association	.167	1	.683
N of Valid Cases	171		

4 cells (50.0%) have an expected count of less than 5. The minimum expected count is 2.39.

The chi-square test did not reveal any significant differences in terms of the number of high and low achieving learners per learning style in the combined test.

So once again, the chi-square tests show that there is no significant association between learning styles and achievement groups. Hence despite searching for relationships between achievement and learning styles, using the study instruments, no significant relationship could be identified.

5.7 OTHER ANALYSIS

In this section, I look more closely at gender and the age factor. I first explore the relationship between gender and learning styles as well as gender and achievement. This is followed by an examination of the relationship between age and learning styles as well as age and achievement.

Table 5.21: Cross tabulation of gender by learning styles.

Gender	Diverger	Converger	Assimilator	Accommodator	Total
M	65	4	3	10	82
F	134	2	5	13	89
Total	134	6	8	23	171

5.7.1 Relationship between Gender and Preferred Learning Styles

The numbers in Table 5.21 above shows that there are more females than males who prefer the diverger, assimilator and accommodator styles. However, more males showed a preference for the converger than females. The results of the chi-square test found that there was no significant association between gender and learning style as revealed in Table 5.22 below.

Table 5.22: Results of chi-square test for gender according to learning style preferences.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.393[a]	3	.707
Likelihood Ratio	1.410	3	.703
N of Valid Cases	171		

[a] 4 cells (50.0%) have an expected count of less than 5. The minimum expected count is 2.88.

5.7.2 Relationship between gender and achievement

In exploring the relationship between gender and achievement, I considered the overall combined test as the dependent variable measuring achievement.

Table 5.23 below shows that the means by gender are very close, with females obtaining a slightly higher mean than that for males. I then used an independent samples t- test to check if these slight differences were statistically significant, since t-tests are robust when N> 30, even when the distribution of the dependent variable is not normal. The tests confirmed that the differences were not significant (t=0.35; p=0.486, df= 169).

Table 5.23: Means by gender for the total combined test.

Gender	N	Mean	Std. Deviation	Std. Error Mean
To16items M	82	10.21	5.067	.560
F	89	10.24	5.608	.594

Looking for differences between the numbers of high and low achieving learners by gender as shown in Table 5.24, I then used the combined test to form two groups of low and high achievers, according to whether they got below 50% or above 50% in the test. However, as captured in Table 5.25, again there were no significant differences according to the chi-square tests conducted using the combined test.

Table 5.24: Cross tabulation of gender by achievement in the combined test.

Gender	Low achievement	High Achievement	Total
M	48	34	82
F	55	34	89
Total	103	68	171

Table 5.25: Results of the chi-square test for achievement according to gender, for the multiple-choice item.

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided	Exact Sig. (1-sided)
Pearson Chi-Square	.189[a]	1	.663		
Continuity Correction[b]	.078	1	.780		
Likelihood Ratio	.189	1	.663		
Fisher's Exact Test				.755	.390
N of Valid Cases	171				

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 32.61.
[b] Computed only for a 2x2 table

5.7.3 Relationship between age and learning styles

Across all four learning styles, it was evident that over-age learners were in the minority as shown in Table 5.26 below:

Table 5.26: Cross tabulation of age by learning styles.

Learning Style	Normal Age	Over-Age	Total
Diverger	101	33	134
Converger	4	2	6
Assimilator	6	2	8
Accommodator	21	2	23
Total	132	39	171

5.7.4 Relationship between age and achievement

In terms of achievement and age, since t- tests are robust when N> 30. I first tried the independent samples t- test to check if there were differences in the mean score according to age. The mean scores for the total test, were 10.14 and 10.5 for the age appropriate and the over-aged learners, suggesting that there were no real differences in the mean by the age categories.

I also looked at the distribution of high and low achievers according to age using the combined test total to see if there were any differences. The cross tabulation below in Table 5.27, shows that for both sets of learners who were of normal age and over-age, there were more lower achievers than high achievers, when I used the combined test as the achievement variable. For the over-age group, 46% of them were high achievers while for the learners who were of normal age, only 36% were high achievers, as shown in table.

Table 5.27: Cross tabulation of high/low achievers according to age in the combined test.

	Low achievement	High achievement	Total
Normal Age	82	50	132
Over-Age	21	18	39
Total	103	68	171

Although it seems that a greater percentage of the over-age learners were high achievers compared to learners of normal age, this difference is not statistically significant as shown in Table 5.28:

Table 5.28: Results of chi-square test for the high/low achievers per age category using the combined test.

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.861[a]	1	.354		
Continuity Correction[b]	.550	1	.458		
Likelihood Ratio	.852	1	.356		
Fisher's Exact Test				.359	.228
N of Valid Cases	171				

[a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.51.
[b] Computed only for a 2x2 table

The results of the chi square test shown in the Table 5.28, indicated no significant association between age and achievement.

In trying to identify if there were differences in achievement between the schools, we first looked at the means of the schools in the combined test total. This is captured in Table 5.29 below:

Table 5.29: Mean scores attained in the combined test by schools.

School	To 16 items
OMSS	
Mean	7.57
N	44
Std. Deviation	2.815
OSS	
Mean	6.63
N	57
Std. Deviation	3.658
IOSS	

Mean	14.81
N	70
Std. Deviation	4.233
Total	
Mean	10.22
N	171
Std. Deviation	5.340

Accordingly, Table 5.29 shows school IOSS performed much better than the other two other schools, while the means obtained by school OMSS was higher than that of OSS. I then set out to test if these differences in achievement by schools were statistically significant using independent t – tests, noting that t-tests can be robust when the size of the sample is large that is, when N>30.).

The t-test results for the differences between schools OSS and IOSS, show a strong statistically significant results (t= 11.681; p <0.001; df=125). This is a strong effect size of Cohen's d= 2, 053. This represents a difference of more than two standard deviations between the scores of the schools.

the means obtained by school OMSS was higher than that of OSS. I then set out to test if these differences in achievement by schools were statistically significant using independent t – tests, noting that t-tests can be robust when the size of the sample is large that is, when N>30.).

The t-test results for the differences between schools OSS and IOSS, show a strong statistically significant results (t= 11.681; p <0.001; df=125). This is a strong effect size of Cohen's d= 2, 053. This represents a difference of more than two standard deviations between the scores of the schools.

The t-test results for the differences between schools OMSS and IOSS, show a strong statistically significant results (t= 10.972; p <0.001; df=112). This difference is also a strong effect size of Cohen's d= 1.931. Similar to the case of OSS and IOSS, this represents a difference of more than two standard deviations between the scores of the schools.

In investigating the differences between schools OSS and OMSS, Table 34 showed that the mean obtained by OMSS was higher than that of OSS, however the difference is not statistically significant (t= 1.407; p =0.081; df=99).

5.8 CONCLUSION

The results of the quantitative data analysis of the current study provided no significant association regarding the relationship between student learning style preferences and mathematics achievement of graduating senior secondary school learners. The analysis that we conducted did not produce statistically significant results. Nevertheless, the quantitative results of the current study provided vital information regarding the field of learning styles and have valuable implications for mathematics teachers and educators. The following chapter provides the qualitative results of the current study.

CHAPTER SIX: LEARNERS' PERCEPTIONS OF LEARNING STYLE PREFERENCES AND MATHEMATICS ACHIEVEMENT

6.1 INTRODUCTION

The outcomes of the participant interviews are reported in this chapter's section with regard to the research questions on learners' perceptions of preferred learning styles and mathematical achievement. To make the quantitative data more understandable and obvious, individual interviews were primarily conducted.

6.2 DETAILS OF THE LEARNERS WHO WERE INTERVIEWED.

Table 6.1, first presented in chapter 4, provides information about the learners who took part in the study's individual interview phase.

Table 6.1: Student participants who were interviewed.

Participants	Gender	Age	School
p1	F	16	S1
p2	F	17	S1
p3	M	17	S3
p4	M	18	S1
p5	F	17	S2
p6	F	16	S2
p7	M	16	S3
p8	F	17	S1
p9	M	16	S3
p10	F	17	S3
p11	M	16	S3
p12	M	18	S2
p13	F	17	S1
p14	M	18	S2
p15	M	18	S1
p16	F	16	S3
Total	F(8), M(8)	16(6), 17(6), 18(4)	S1(6), S2(4), S3(6)

According to Table 6.1, both male and female learners were equally represented from the three (3) schools. Six (6) out of the 16 participants were from school 1, 4 from school 2, and 6 from school 3 respectively.

6.2.1 Details of the mathematics teachers who were interviewed.

Details of mathematics teachers who participated in the individual interview phase of the study are given in Table 6.2.

Table 6.2: Teacher information

Participants	Gender	Age	School
TA	M	38	S1
TB	F	55	S2
TC	M	57	S3

Table 6.2, shows that two male teachers and one female teacher participated in the individual interviews comprising one mathematics teacher from each of the three schools selected for the study.

6.3 LEARNERS' DESCRIPTIONS OF LEARNING STYLE PREFERENCES

During the interview, learners shared descriptions of how they preferred to learn and many of these descriptions could be aligned to particular learning style preferences of KLSI. We discuss each of these categories in more detail. Note that quotes from student participants are presented in italics followed by the participant number e.g *I said this…(p1)*

6.3.1 Descriptions Aligned to the assimilator learning style.

There were some learners who, when probed on how they engaged in learning mathematics in the class, indicated that they rely profoundly on assimilator learning style preferences.

Assimilators perceive information through Abstract Conceptualization and transform that information through Reflective observation. Assimilators tend to be rational, unemotional, and more interested in abstract concepts than in people. They are solitary and avoid practical activities. To learn mathematics, they mainly engaged in the following activities or practices:

> Listening effectively and watching their mathematics teachers when solving challenging mathematics problems; examining their experiences of mathematics activities from the teacher and the viewpoint of their fellow classmates; Reflecting,

observing and critically examining their understandings of the mathematics activities or problems.

For instance, some learners reported as follows:

When I'm learning mathematics in the class, I like to listen attentively to the mathematics teacher's instructions and examples. I also try to take my time before asking questions or communicating my ideas in the class. I like to get along with the teacher before trying my effort through her examples and asking questions as well for a better understanding of the areas I want explanations and also very interested to see what my classmates has done on the particular mathematics task… (p3)

When I'm learning mathematics in the class, I like to watch and listen carefully to my mathematics teacher and gather enough information before I can use my feelings to solve mathematics problems …(p15)

These learners stated that when learning mathematics in the class, they prefer to step back and reflect on the mathematics task which allows the learners to ask questions and discuss their experience with the fellow classmates during mathematics lesson. These are characteristic features of learners who identify with the assimilator learning style. Eight (8) out of the sixteen (16) interview participants identified 'assimilator learning style' as their influence in learning mathematics. Three (3) male participants and four (4) female participants seemed to apply assimilator learning style preferences when learning mathematics in the class.

6.3.2 Descriptions Aligned to the Diverger Learning Style.

Divergers prefer learning through concrete experience and reflective observation. Divergers absorb information best through group discussions with a focus on creative ideas in developing mathematical competence both in problem-solving in the classroom (Kablan & Kaya, 2013). Divergers are motivated to discover the relevance or "why" of a situation and prefer to reason from concrete information (Cox, 2013).

In the interviews some of the learners stated that they think about how the new mathematics experience in the classroom connects to what they already know about the topic in the past and helping their reflections to lead to new understanding as they share ideas together during mathematics lesson. Some of the learners indicated that their learning style preferences were similar to characteristic features of the Diverger learning style as seen in the following quotes:

When I'm learning mathematics, I also like to practice solving mathematics problem during whole class mathematics discussions and follow several classroom examples of my mathematics teacher. I always engage in classroom discussions and participate actively as we work on any mathematics problem solving together as a team… (p4).

I feel personally involved with my learning process. I also engage myself in group work or class discussions to generate ideas through personal interactions and going through the explanations or examples and ask questions also to gain a better understanding of the problem in the class or among group members… (p9)

When I'm learning mathematics in the class, I like to go through all the areas of the problem and the examples of the teacher before asking questions or discussing my ideas in the class. I learn mathematics by being open to new information… (p12)

Similar to the above responses, four (4) participants identified 'diverger learning style' practices as their influence in learning mathematics. In this respect, three (3) male learners and one (1) female student seemed to apply diverger learning style preferences when learning mathematics in the class.

6.3.3 Descriptions Aligned to the Converger Learning Style.

Converger learners learn through abstract conceptualisation and active experimentation (Kolb & Kolb, 2017). Research indicates that the strength of converger learners lies in practical applications of ideas both in mathematics classroom (Ng'eno & Chesimet, 2016). Some other researchers argue that converger learners are good at finding practical ideas and theories leading to solution to problems particularly in mathematics. Some learners specified that when learning mathematics, they could be considered Converger learners as they consistently make attempts to solve mathematics task, and work well as individuals. For instance, some learners stated as follows:

When I'm learning mathematics, I prefer the environment to be very quiet so I can gather enough information as I pay adequate attention to the instructions of the teacher. I also like to practice the knowledge I acquired during the mathematics class. But I must listen and watch carefully to the examples of the teacher before attempting to solve mathematics questions from the information I've received in the class …(p1)

I learn mathematics by concentrating, listening and watching the instructions of my teacher and also avoiding my friends during mathematics instruction to escape distraction because I'm easily distracted when I'm learning especially in the means of too much noise in *the class, I can lose focus or concentration and it affects me so much. I prefer to pay attention and concentrate on my meaningful ideas and write down my answers waiting till the teacher gives room for questions and answers. I don't benefit from noise in the class, but others do… (p2)*

When I'm learning mathematics in class, I like to practice answering mathematics problems in several ways. I also engage in learning mathematics by constant practicing and taking responsibility for my own ideas. I also learn mathematics by seeking an opportunity to attempt solving mathematics problems using my idea without disturbing the teacher or asking neither my mathematics teacher nor classmates any question or the task… (p14).

From the above comments, these three (3) out of the sixteen (16) participants identified characteristic features of the converger learning style as their influence in learning mathematics. The three (3) participants who identified as their learning style in mathematics class were female learners.

6.3.4 Descriptions Aligned to the Accommodator Learning Style

Accommodators are skilled at concrete experience and active experimentation as their dominant learning modes (Kolb & Kolb, 2017). Some studies indicates that, accommodator learners depend profoundly on experimentation. learners in this learning style preference are interested in hands-on experience especially in mathematics activities both at senior secondary school level (Buaraphan, 2015). Kablan and Kaya (2013) also argue that the learners with such learning style preference are likely to rely on their feelings rather than logical analysis when it comes to problem solving both in mathematics. Accommodators prefer to always engage in new and challenging mathematics problems as well as activities using different approaches in completing the task (Kablan & Kaya, 2013).

Two learners who took part in the interview phase of study indicated that when learning mathematics in the class they could be considered as accommodators as they preferred to typically apply the use of a trial-and-error approach in learning mathematics. The learners stated that when learning mathematics in the class, they tried to put his knowledge into practice by attempting to solve mathematics problems always.

When I'm learning mathematics in the class, I like to work on my own in search of solution to the mathematics questions or problems on the examples provided by my mathematics teacher on the chalk board. I always like to be given a chance to try out my ideas *and take charge of my own learning. I am very practical and interested in coming up with my idea and a chance to try out my effort and practice solving mathematics. I like to get involved in mathematics class at all times, and would want to see results from the target mathematics problems step by step on my own… (p11).*

I understand mathematics the best way when I'm solving mathematics problem alone and always in the class and meditating on my ideas in the process. It helps me so much in gaining a better understanding on mathematics questions or task in the classroom… (p16).

6.3.5 More than one learning style.

An interesting finding from the interviews were that some learners indicated features from different learning styles during the interview. This suggests that there are certain features of the learning styles that some learners take up at different points or when they are engaged in activities which require different processes.

For example, student P1, at one point expressed a statement that can be seen to be typical of a converger who prefers to work on her own:

I learn mathematics by concentrating, listening and watching the instructions of my teacher and also avoiding my friends during mathematics instruction to escape distraction…(p1)

Yet at another time she expressed a typical diverger statement: *It is a good idea to study mathematics with classmates who you can look up to…(p1)*

Similarly, with student P11, who noted that he was very practical, suggesting that he took on accommodator characteristics at another point noted that "I always like to practice solving mathematics alone" suggesting some traits of the converger.

These are not the only learners. Many others when their statements were analyzed rigorously showed different learning style preferences at different points. It seems that learners have described different traits that they take on at different points. Hence it suggests that the Kolb's learning style inventor may not have been as accurate in identifying the particular learning style preference for this group of learners since their preferences seem to vary across different settings. These differences also suggest that the test- retest reliability of the instrument should be investigated for learners from a similar context. Recall in the methodology section, the test- retest reliability of the instrument was not examined since this was not within the scope of this study. The reliability was inferred from other studies which used the KLSI. However, the qualitative data from the interviews suggest that these learners may have understood the phrases used in the KLSI in different ways at different times.

6.4. LEARNERS' PERCEPTIONS OF LEARNING STYLE PRACTICES WITHIN KOLB'S MODEL AND ACHIEVEMENT

I now look in more detail about learners' perceptions of how particular characteristics of learning have contributed to their achievement. This is all while noting the important point made in Section 6.3.4 that there were some learners who took on characteristics from more than one learning style, hence their preferred learning style may encompass more than one of Kolb's (1984) learning styles. Hence, we focus on the learning style practices that they describe without dictating that they identify solely with one learning style. In this section we analysed learners' responses to the following question about learning styles practices and Mathematics Achievement: *Please explain to us how your preferred learning style has impacted your mathematics achievement?*

This question was designed to probe learners on whether they perceive any influence that their styles of learning may have had on their actual performance in their mathematics assessments. This is to explore the impression that a student's learning style can influence a learners' performance in mathematics specifically at secondary school level. Note that I am more interested in exploring the practices embedded within the learning styles as described by Kolb's model (1984) that contribute to improving mathematics outcomes, so the discussion is about learning style practices.

6.4.1 Diverger Learning Style Practices and Mathematics Achievement

Diverging learning style refers to learners who have the dominant ability to learn through the existing classroom experience and able to reflect continuously on the information received in the class. They learn best when they are carefully informed and can carry out meaningful observation on the subject to be learned. In the mathematics class for instance, they learn best by watching and listening carefully to the instructions of the teacher and when they take part in class discussions or group work. They are more interested in brainstorming with classmates in solving mathematics problems, and they require detailed explanations from the teacher before they can engage in solving mathematics problems. According to some learners, mathematics achievement among graduating senior secondary school is vital because without a credit pass in mathematics at their level, they cannot proceed to tertiary institutions of their choice despite their perceived career interest areas.

Student *P2* explained that her performance in mathematics has been okay ever since she started to learn mathematics by participating in class discussion and teamwork. Diverger learners are those learners who try to engage in learning mathematics through active participation in class discussion and group work, where learners are given mathematics task or problem to solve in group. According to P2, when group members are connected together in such a way that they cannot succeed unless everyone succeed, they will actively assist each other to make sure that the mathematics task or assignment is done, and the purpose of the group will be achieved. She observed that cooperative learning had an impact on understanding mathematics concept since group members keep providing help to each other, sharing ideas, and encouraging each other's efforts in learning mathematics concepts in the class. This in her view will result to good performance in mathematics. She commented:

It is a good idea to study mathematics with classmates who you can look up to and remain focused on the explanations so that your performance on mathematics can improve… (p2)

Another participant (P6(16f)) echoed a similar feeling that they get help and support from group members in understanding mathematics concept which leads to better performance in mathematics, He (P6) explained that his mathematics achievement improved through his active participation in group discussions in solving mathematics in the class as explained below.

discussing my ideas in the class with my mathematics teacher and fellow classmates in the class has contributed to my positive achievement in mathematics… (p6)

From this data, it shows that learners perceive that cooperative learning has a positive impact on learners' mathematics achievement. The data from the interview provide evidence that participants endorse the diverging learning style. Diverging style of learning consist of concrete experience and reflective observation skills. Learners or learners with this learning style prefer to learn through observing the teachers and thinking about the explanations with constant class discussions or teamwork. They like to focus on their own feelings and thoughts in the learning process. In other words, some participants expressed that constant group discussion and careful reflection on the experiences they acquire in the class helps learners to attain better performance in mathematics at secondary school level. The participants also expressed that their mathematics teacher inspires them to take part in group work. For instance;

my mathematics teacher is always telling us to work in group in solving mathematics problem so that we can have better achievement in mathematics… (p11).

Student P11 explained that teamwork is necessary between learners, between learners and teachers particularly mathematics teachers for greater achievement in mathematics at their level. In supporting the opinion of Student P11 *o*n the importance of teamwork in the learning and better achievement of mathematics among secondary school learners, (P2) commented that more opportunity exists for learners to learn the vital skills in mathematics at secondary school level and enhance their performance through collaboration.

our mathematics teacher gives us group task to work on and will insist that we all must take part in solving mathematics task together so that we can have good test scores in mathematics…(p2).

The view of the participants shows that some mathematics teachers inspire their learners to engage in cooperative or collaborative learning in the classroom, because they are aware of the positive effect of cooperative or collaborative learning style on mathematics achievement of learners.

6.4.2 Assimilator Learning Style Practices and Mathematics Achievement

Assimilator learners are learners who perceive information or problems through personal effort to understand the concept but also to try to engage in generating ideas in order to have a better understanding of the examples of the teacher and their individual experiences or observations matter especially in mathematics. In the class, assimilators tend to be rational, reserved, quiet, and more interested in generating ideas than engaging in class discussions or teamwork. They tend to be very attentive to the instructions of the teacher and avoid distractions for an effective understanding of the subject matter or mathematics concept. These categories believe that full comprehension of mathematics concepts requires learners to grasp information by effective listening and concentration in the classroom while trying to avoid practical work or group discussion or teamwork.

For some learners or participants, the level of mathematics achievement is one of the most important factors which indicate the success of their perceived learning style. For instance, one student believes that his mathematics achievement is improving because of his ability to comprehend and transform comprehensive information into a meaningful whole in the mathematics class. Below is his comment;

my mathematics performance is getting better now because of my ability to think reasonably and problem-solving skills in learning mathematics the class… (p12).

From the above comment, the student feels that effective reasoning ability and problem-solving skills seems to be the key to learners' academic achievement especially in mathematics.

In a similar way, another participant supported the above comment:

my mathematics performance was not very good that is why I started to pay more attention in class and avoiding distractions from classmates so that I can try to do very well in mathematics and perform well also… (*p2*)

The student believes that there are distractions in the class which stops them from maintaining a focus on mathematics class. The learner concluded that his mathematics achievement was better now because she liked to focus on the task at hand and eliminate distractions in the mathematics class. Below is her comment on the impact of his learning style on mathematics achievement at his level.

my mathematics performance has significantly improved even since I started to avoid my friends during mathematics lesson and concentrating more on my reasonable ideas in learning mathematics in the class...(p2)

Other participants mentioned the words reasonable thinking and effective concentration in learning mathematics and their performance in the class, for example.

my mathematics achievement is better now because I pay much attention to the instructions of my teacher and concentrate on the ideas in solving mathematics problems in the class… (p3).

From the above view of the participant, effective listening and concentration skills might lead to improved student's achievement in mathematics, in other words, learners' performance in mathematics could be influenced by their preferred way of learning mathematics in the class. To further support the view or opinion or feelings as indicated by the learner above, another participant or learner also had confidence that the best way to enhance mathematics performance as a major subject at their level is to pay adequate attention and concentration on important ideas received in the class. The learner emphasized that learners need to pay adequate attention for a better retention of mathematics concept so as to enhance their mathematics achievement in secondary school.

These are her words:

my mathematics achievement has improved certainly because I listen carefully and get involved and focused with my mathematics teacher's ideas in solving mathematics problems in the class…(p15)

The student felt that effective listening in mathematics classes improves conceptual understanding of mathematics concepts for many learners which improves performance in mathematics**.** Further evidence or explanation from another learner indicates that effective listening in mathematics class could enhance mathematics achievement of secondary school learners particularly the graduating senior secondary school learners. The learner felt that her mathematics achievement was currently improving due to her ability to listen to the teacher's instructions in the class:

my mathematics performance is gradually improving because I try to gather a lot of information and interested in my ideas from my mathematics teacher on any mathematics concept…(p5)

Another learner felt that effective listening improves mathematical knowledge thus facilitating mathematics achievement at their level based on learners' understanding of the concept. She explained that:

…..I consider my observation and explanation from the teacher and that of classmates. I enjoy team work also to come up with new ideas in solving mathematics problems. I also try to gain a better understanding of and skill in mathematics through observation and explanation of my mathematics teacher and the ideas I gather from classmates during classwork…(p10)

Some learners believed that knowledge of learners and how they learn mathematics including a general knowledge of how various mathematical ideas develop in them over time which encompasses their learning styles, could influence learners' thinking and learning achievement.

6.4.3. Convergent Learning Style Practices and Mathematics Achievement.

The converging learning style involves learners who can use practical procedures in solving new mathematics problems in the class. The strengths of this category of learners as observed by some participants, lie in their ability to set goals, solve problems and make decisions using practical applications for what they have learned in the class. They believe in constant practice of solving mathematics problems. Some participants felt that constant practice is an important factor that improves their performance in mathematics at secondary school level. Converger learners feel that constant practice in learning mathematics and an ability to try out their ideas in learning mathematics in the class have a significant role in mathematics performance at secondary school level. For instance, one student explained that his mathematics performance has improved because of his ability to use his knowledge in practicing solving mathematics problem on his own in the class.

I always practice solving mathematics alone and my mathematics performance is fine… (p11).

The participant felt that personal effort in learning mathematics might help learners in understanding several mathematics concepts and predicted her performance in mathematics as well. To support the view of the above learner., P12, also thought that learners or learners who are very interested to learn and willing to apply personal effort in completing mathematics task could also improve their performance in mathematics at secondary school level;

I think there is an improvement on my mathematics performance because I'm regularly practicing solving mathematics problem on my own in the class… (p12).

The student felt that the ability to engage in learning mathematics through constant practice could be reflected in the realm of mathematics education which helps learners to remain focused in achieving a desirable outcome and a means to enhance understanding of mathematics concepts at secondary school level.

Another student also explained that his mathematics performance has improved due to her involvement in constant practice in learning mathematics in the class:

my mathematics performance is better now because I always learn mathematics through practicing solving mathematics problems alone… (p14).

Form the above comment, it is noticeable that some learners felt that constant practice in solving mathematics problems in class could have an impact on learners' mathematics performance at secondary school level. While comments from participant (p14) shows that personal ability and effort in learning mathematics in the class could enhance learners' achievement in mathematics, another student was also specific with her comment that:

my best way of learning mathematics is through solving mathematics problems or taskusing my ideas and effort and my mathematics performance is improved right now… (p15)

The above student also emphasized personal effort in solving mathematics problem or task would impact on their achievement in mathematics at secondary school level.

Some other participants mentioned the word practice in learning mathematics and the effect of it on their academic achievement but the comments were not specific enough about how it impacted on learning mathematics. For instance: Students *(p1), (p4), (p7), and (p10)* mentioned that they liked to practice solving mathematics but preferred to work in group in learning mathematics concepts. They explained that they understand mathematics concept better by listening to the teacher's instruction and participating in class discussion in learning mathematics in the class. They also claimed that they are happy with their mathematics achievement by paying adequate attention, watching and listening to the teacher and participating in class discussion in learning mathematics.

> *my performance in mathematics has been okay ever since I started to learn mathematics by practicing solving mathematics problems with my classmates in the class… (p1)*
>
> *My mathematics achievement has improved and my understanding of Mathematics knowledge has also improved presently because I'm always practicing solving mathematics problem in the class along with my teacher and fellow classmates… (p4).*
>
> *my mathematics performance is becoming okay, and I will continue to engage in constant practice in learning mathematics concepts with my teacher and classmates through class discussions… (p16).*

6.4.4. Accommodator Learning Style Practices and Mathematics Achievement

Accommodator learners are learners who rely more on the teacher's information than trying their effort and ability in learning mathematics tasks. Accommodator learners can be very dependent on their teachers to grasp information and prefer not to share ideas in the class but are solely focused on their teacher's explanations and expectations on mathematics concepts. They see their teachers as the critical resources through which they acquire meaningful understanding of mathematics concepts and use the knowledge acquired to facilitate their achievement in mathematics at secondary school level. This category of learners is also good at acquiring new information in mathematics classes through the teacher and fellow classmates. Their feelings towards mathematics concepts and teachers' explanations on the mathematics concepts play a vital role on their achievement in mathematics. In other words, one could say that the better the attitude of the learner towards the teacher or task, willingness to learn and the explanations of the mathematics teacher, the higher the achievement or performance level in mathematics. For instance, *one student* stated that his mathematics performance or scores was great because he relied so much on his mathematics teacher's examples and explanations:

> *very considerate on my mathematics teacher's instructions in learning mathematics in the class and my performance in mathematics is getting better… (p9).*

The participant felt that he trusted and relied on the teachers' examples so that he could have a good performance in mathematics. Another participant P2 also mentioned that she engaged in learning mathematics by considering the examples of her teacher with much concentration on her teachers' explanations, but her mathematics performance was not too good:

> *my best method of learning mathematics is to concentrate on the examples of my mathematics teacher and follow her explanations but my performance on mathematics is not too good for me now…(p2).*

The student felt that she preferred to regularly engage in practising solving mathematics tasks in the class and was very sure of possible improvement and better performance in mathematics at her level.

Some other participants also mentioned that they relied a lot on their mathematics teachers' explanations or examples but also engaged in personal interactions and constant practice in learning mathematics in the class and their performance in mathematics has improved.

6.4.5 More than one learning style.

An interesting finding from the interviews was that some learners indicated features of different learning styles during the interview. This suggests that there are certain features of the learning styles that some learners take up at different points or when they are engaged in activities which require different processes. For example, student P1, at one point expressed a statement that can be seen to be typical of a converger who prefers to work on her own:

> *I learn mathematics by concentrating, listening and watching the instructions of my teacher and also by avoiding my friends during mathematics instruction to escape distraction…(p1)*

Yet at another time, student P1 expressed a typical diverger statement**:** *It is a good idea to study mathematics with classmates who you can look up to.*

Similarly, student P11, who noted that he was very practical, suggesting that he took on accommodator characteristics at another point noted that "I always like to practice solving mathematics alone" suggesting some traits of the converger.

These are not the only learners. Many others, when their statements were rigorously analyzed showed different learning style preferences at different points. It seems that learners have described different traits that they take on at different points. Hence, it suggests that the Kolb's learning style inventor may not have been as accurate in identifying the particular learning style preference for this group of learners since their preferences seem to vary across different settings. These differences also suggest that the test- retest reliability of the instrument should be investigated for learners from a similar context. Recall that in the methodology section, the test- retest reliability of the instrument was not examined since this was not within the scope of this study. The reliability was inferred from other studies which used the KLSI. However, the qualitative data from the interviews suggest that these learners may have understood the phrases used in the KLSI in different ways at different times.

6.5 GENERAL STUDENT LEARNING PRACTICES ENDORSED AS BEING EFFECTIVE FOR LEARNING.

In this section I take on a broader perspective by exploring learners' perceptions about effective learning in general. The analysis of the interviews revealed seven practices that were endorsed by the learners as well as some teachers, as improving learning. Firstly, learners identified that by asking questions in the classroom, they were able to improve their understanding. A second one was related to the important area of collaboration, followed by the importance of listening and reflecting before going on to do the work. A related theme was the importance of listening to teacher explanations for better guidance. Learners also identified the importance of doing practical work, practising hard and being able to link previous work to new knowledge. These seven themes are explored in greater detail in the sub-sections below:

6.5.1 Learner questioning helps improve understanding.

Many learners felt that when they were given the opportunity to ask questions in the classroom, it helped them to understand better. Teachers also expressed that when learners asked questions, it increased their participation and hence improved their understanding of the concepts.

The teachers wanted to know more about the ways learners were learning mathematics in the class. TA explained that questioning *"helps the learners to do a lot of work either individually or as a group in the mathematics class"*.

Emphasising how strongly he felt about the role of questions and answers in the class, one teacher commented:

> *it is good because we come to know whether the learners understand the mathematics concept or not through question and answer…(TA).*

In the above view, the teacher saw questions and answers as very important in the teaching and learning of mathematics because the teacher gives the learners a task and then allows the learners to either work individually or in groups based on what he has discovered about the ways his learners work in the mathematics class.

TB in her words explained that student questioning helps the teacher to investigate whether the learners understood the mathematics concept in the class. This view was also captured in the comments below:

> *I encourage my learners to ask questions as they attempt solving mathematics question or task on the chalkboard to know if they understand the mathematics concept that was taught*…(TB)

In the above view, the teacher saw the use of questioning by learners as an important strategy to stimulate learners' thinking and learning in the class.

Another teacher was a little more specific on the role of questioning in the teaching and learning of mathematics by saying that questioning could help in getting immediate feedback on learners' understanding of mathematics concept and it is also used by teachers to evaluate their teaching. TC said that:

> *questioning makes me as a mathematics teacher to know if the learners are following up or not and also help me to evaluate my lesson…(TC)*

This comment of TC revealed that questioning in the class could prompt the teacher's assessment of whether learners understand what has been taught. The teacher took the view that questioning gives him feedback about whether his lesson is successful or not. A similar point was raised by another teacher:

> *Questioning helps me to judge my lesson to be successful or not because if learners are not allowed to ask questions or I fail to ask the learners questions, I may not know if they are gaining a better understanding of the concept or mathematics problem or following up with the examples…(TB)*

This feedback from the learners could help teachers plan their lessons more effectively around deep mathematical ideas.

Hence in the above excerpts, the teachers shared that student questioning provides immediate feedback to them on the extent to which the mathematics concepts were understood and could help them improve their planning. They also felt that questioning stimulates learners' thinking and learning, while also providing them with things to think about.

Learners were also positive about the role of student questioning in their own learning.

To ensure the effectiveness of questioning on learners' commitment in mathematics class, P1 said that they are encouraged to ask and answer questions that could help them to work together with their mathematics teacher and make sense of mathematics concepts. She said:

> *I try to ask questions and solve the mathematics task given to us in the class and also work together with my teacher to gain a better understanding of the mathematics problem in class…(p1).*

The comment of the student seems to reveal that questioning could probably help learners to construct mathematics ideas in the class and gain better understanding of mathematics concepts.

One of the learners revealed that asking and answering questions in the class gives him the opportunity to share his ideas on the mathematics concept. He said:

> *also help me to share my idea on the mathematics concept to see if my understanding of the concept is right or wrong… (p12)***.**

The student who made the comment believes that questions and answers in mathematics classes keep learners engaged by motivating them to build upon and improve their present knowledge as they provide explanations that assist them in solving the maths assignment at hand. In the above comment, the student feels that question and answer in the mathematics class keeps learners engaged in encouraging them to build on and improve their current knowledge as they construct explanations that help them solve the mathematics task at hand through questions and answer in the class.

One student also explained that asking questions and answering questions in the class helped him to understand mathematics problems: *I ask questions for better understanding of mathematics problems(p8).*

The student felt that it is important that they have a chance to explain their ideas in mathematics class. For instance, when the learners ask questions, they are developing personal understanding of a mathematics concepts**.**

Another student said questioning played a key role in helping learners generate mathematics idea through explanation:

> *questioning helps me to gain a better understanding of mathematics problems in the class… (p9)***.**

The student also felt that the act of asking questions focused the attention of learners on the concept or main ideas which helped them check if the concept was understood.

An important aspect of questioning is that it allows learners to increase their participation in class as noted by one student:

> *I learn mathematics by asking and answering questions in the class because it allows me to be very active in the class and makes me to understand mathematics concepts very well… (p6).*

Thus, the comment by P6 explains how opportunities for student questioning leads to greater participation and leads to improved understanding of the concepts.

From the above explanation of both the teachers and learners, the use of questioning could positively impact learners' learning and while also making the teaching more effective.

To ensure the effectiveness of questioning on learners' commitment in mathematics class, P1said that they are encouraged to ask and answer questions that could help them to work together with their mathematics teacher and make sense of mathematics concepts:

> *I try to ask questions and solve the mathematics task given to us in the class and work together with my teacher to gain a better understanding of the mathematics problem in class… (p1)*

The comment of the student suggests that questioning could probably help learners to construct mathematics ideas in the class and gain better understanding of mathematics concepts.

6.5.2. Collaborative Practices and Group Discussion helps make learning more effective.

Both teachers and learners emphasised that one of the important benefits of using student- centred learning activities, was the sharing of ideas and discussions that take place amongst the peers as evident from this comment:

> *I give mathematics activities to my learners to work on either individually or in group work and encourage the learners to participate by sharing ideas on the mathematics task or problem. (TC)*

When teachers take on the role of facilitators in the teaching and learning of maths lessons, this enables learners to take a more active role in their learning by participating in meaningful conversation and individual effort to study mathematics in the class. Below are the responses from learners describing their active participation:

> *I participate in class discussion during mathematics lesson… (p4)*
>
> *I participate in group discussion in mathematics class to share ideas with my fellow learners… (p5).*
>
> *I discuss my ideas with my fellow classmates during mathematics lesson… (p6)*
>
> *I engage in constant group discussion in learning mathematics in the class… (p7).*

Learners were also able to list some benefits of engaging in group discussions. Many learners noted that a benefit of group work was that learners got the opportunity to share ideas with each other, as seen in the comments below:

> *I share my ideas during group work or discussion class…(p10)*
>
> *I prefer to try out my effort in solving the maths task given to us in the class…(p11)*
>
> *I share my ideas with my fellow classmates and mathematics teacher in the class…(p12)*
>
> *I share and discuss my ideas with fellow learners and mathematics teacher…(p13)*

A further benefit of group work is the support system offered by the members of the group. According to one of the student's experiences**,** when group members are connected together in such a way that they cannot succeed unless everyone succeed, they will actively assist each other to make sure that the mathematics task or assignment is done and the purpose of the group will be achieved. She further expressed her observation that group members provide assistance to each other, sharing ideas, and encouraging each other's efforts in learning mathematics concepts in the class:

It is a good idea to study mathematics with classmates who you can look up to and remain focused on the explanations so that your performance on mathematics can improve… (p2)

Some student explained that taking part in groups helped them to gauge whether they understood the work or not as seen in the comment below:

the reason I participate in the group work or class discussions is to find out if I have gathered enough knowledge so much or not in a particular mathematics problem or task… (p12).

An important advantage offered by groups is that learners share different approaches to solving problems. This gives learners exposure to the different methods of solving problems instead of sticking to the one method. The comment below explains this perspective".

I prefer to work as a team … because it will help me to see different approaches or methods used by different learners in arriving at the solution to the same problem… (p6).

6.5.3 Some learners prefer individual work to group work.

Although most learners spoke about the benefits associated with group work, there was a small number who preferred individual work. Some learners expressed that they preferred working alone and this helped them improve as shown in the comments below:

my mathematics performance is better now because I always learn mathematics through practicing solving mathematics problems alone… (p14).

I think there is an improvement on my mathematics performance because I'm regularly practicing solving mathematics problem on my own in the class…(p12.)

Student P11, below explained that his mathematics performance has improved because of his ability to use his knowledge in practicing solving mathematics problem on his own in the class.

I always practice solving mathematics alone and my mathematics performance is fine… (p11)

The participant P11, felt that personal effort in learning mathematics might help learners in understanding several mathematics concepts and predicts their performance in mathematics as well. One student complained that it was the noise from group work that was a problem. He would not work in a situation where there was lot of noise and tried to work on his own as seen in the comments below:

> *[I avoid] my friends during mathematics instruction to escape distraction because I'm easily confused when I'm learning especially in the means of too much noise in the class, I can lose focus or concentration… (p1).*

6.5.4. Listening carefully and reflecting improves understanding.

There was strong agreement by most learners, and teachers as well, that learners needed to listen carefully in order to understand the teacher. This is an aspect that depends on learners' interest in working on mathematics task on their own to gather (assimilate) information through effective listening and thinking about reasonable ideas on the mathematic concepts. The interview comments revealed that some participants felt that learners need to learn mathematics concept by listening attentively and thinking about ideas on mathematics task. The role of reflecting as part of an individual's own learning is recognised in many studies. As learners are introduced to new content, an important part of their learning involves making links to what they already know based on how a person perceives and internalizes information. Some of the participants felt that effective listening and generating ideas during mathematics lesson when allowed by the teacher seems to enhance individual's process of absorbing information and understanding of mathematics problems in the class. This can then impact on their achievement in mathematics at secondary school level. Some of the participants reported that learners gained a lot when they were engaged and focused on the mathematics activities in the class by listening and thinking about ideas:

> *I listen and think about my ideas before attempting to solve mathematics activities or problems… (p1).*
>
> *I listen carefully and generate ideas during mathematics lesson…(p2).*
>
> *I like to listen attentively before asking questions…(p3).*
>
> *I listen carefully and generate ideas on mathematics problems…(p13).*
>
> *I watch and listen carefully to gather enough information in the class…(p15).*

The above comments show that the participants tried to pay attention to the details so they could understand it better before they attempted the problems. Some comments show that by listening carefully they could then reflect and then generate their own meaning of what was being discussed. This is an important process described in learning theories such as constructivism. Piaget wrote about the idea of reflective abstraction, which involves two steps, the first is about reflecting on the knowledge and the second is the reflection of the knowledge on a higher plane which in when individuals construct their own knowledge by linking it to other ideas in mathematics (Bansilal, Brijlall, & Trigueros, 2017).

Some of the teachers also believed that listening could help student gain a better understanding of mathematics before they try the problems. They feel that one of the contributing factors that could enhance learners' competence in mathematics concept is to listen carefully in the class. In support of this expressed concern, some teachers says that learners who are exposed to instructions that emphasize flexible listening and thinking could also develop competence in mathematics. For instance, one teacher felt that instructional practices that focus on learners' learning and developing understanding on mathematics concept must allow learners to listen and think about these ideas:

strategy gives the learners the opportunity to listen and question one another's thinking on the mathematics problem… (TB).

The teacher's belief was that learners are able to develop their own personal strategies to learn mathematics when instructional support allows learners to listen and think about ideas in learning mathematics, as noted by a student:

I listen and think about my ideas before attempting to solve mathematics activities or problems… (p1)

Another teacher emphasized that there are learners who prefer to learn mathematics in the class through effective listening and generating ideas instead of discussing ideas without adequate information on the concept. The teacher reported that those learners do not waste time asking a lot of questions on the mathematics activities or task in the class to gain better understanding of the concept;

some learners prefer to listen quietly and thinking about ideas on the examples presented on the chalk board and are very good at asking questions in the class…(TA).

The teacher feels that effective listening and reasonable thinking could also allow learners to construct mathematical knowledge through meaningful experiences in the class. The above comment was supported by another teacher's statement:

Some learners prefer to listen proficiently and relies on their reasonable thinking in learning mathematics in the class…(TC).

The teacher who made the comment further stated that learners can understand information best when they listen carefully and are given time for internal reflection of the information they have gathered.

Some learners prefer to listen and think about peculiar ideas before attempting to solve real problems using different formulas on the mathematics task presented in the class…(TC).

The teacher recognized that learners perceive and internalizes or takes in information through effective listening and reflective thinking on the mathematics idea. A student also explained his reflection on mathematics idea through effective listening and thinking:

I like to listen to my teacher and gather information and think about ideas through his examples in solving mathematics problems or task…(p9).

The comment of both the learners and teachers shows that when learners are given the opportunities to generate ideas through effective listening and reflective thinking on mathematics concept in the class.

6.5.5. Engaging in practical activities improves learning.

There were a few learners who referred to the value of doing mathematics practically in order to understand it better. It is very important for learners to get a chance to investigate relationships and properties of figures by doing practical activities and the learners in this study clearly agree that learning by doing practical work is an important aspect of learning mathematics Some comments in this regard are shown below:

I learn mathematics best through practical method.. (p1).

I prefer to use the practical process or method in learning mathematics because it makes me to understand better and when I'm learning mathematics in the class, I solve the mathematics task or question along with the teacher… (p6).

Watching and listening to her practical methods in the class always help me so much in understanding topics on mathematics… (p3).

My mathematics aunty encourages us to add effort in learning mathematics by using practical method… (p12).

What I mean is that I'm very practical and responsible for my own ideas. I prefer Practical method or solving mathematics problems always and alone…(p14).

These comments show that these learners prefer to solve problems using practical methods which also helps them understand the mathematics better. One teacher also alluded to the value of using practical work which she referred to as exploratory techniques:

Exploratory teaching strategy for mathematics instruction gives the learners the opportunity to be active participants in the process of learning mathematics in the class. I came to understand that the more they can 'do' or solve mathematics problems while learning, the better they understand the concepts… (TA).

The above comment by the teacher is very clear that by allowing learners to learn by doing, the better they understand the mathematics.

6.5.6 Practice is important in improving understanding.

Many learners as well as teachers spoke about the value of practice in learning mathematics. They felt that constant practice was an important feature of learning mathematics and making the effort to practice consistently has significant impact in mathematics performance at secondary school level. Some of these comments are:

Again, I like to practice the knowledge I learned during the mathematics class…(p1).

I like to always practice solving mathematics in the class. It makes me to learn faster… (p13).

I have to continue to practice solving mathematics all the time…(p6).

When I am learning I think about my own knowledge so far and like to be doing things like practice solving mathematics questions alone… (p11).

The student is clear that he prefers to practice alone so that he is able to think about what he understands. Furthermore, the student explained that his mathematics performance has improved because of his constant attention to practice:

I always practice solving mathematics alone and my mathematics performance is fine…(p11).

The participant P11 felt that personal effort in learning mathematics helps learners in understanding several mathematics concepts.

Another student explained that by practicing he was able to consolidate the new work that he learnt.

> *my mathematics performance is better now because I always learn mathematics through practicing solving mathematics problems alone…(p14).*

Form the above comment, it is noticeable that some learners feel that constant practice in solving mathematics problems in class could have an impact on learners' mathematics performance at secondary school level. While comments from participant P14 (18m) shows that personal ability and effort in learning mathematics in the class could enhance learners' achievement in mathematics, another student emphasised the value of practice:

> *my best way of learning mathematics is through solving mathematics problems or task using my ideas and effort and my mathematics performance is improved right now…(p15).*

The comment by the above student suggests that the main activity that contributes to learning is doing the practice and solving problems by themselves.

Teachers too, spoke about the benefits of practice as seen in the following comments:

> *I get the learners to practice solving the mathematics question…(TA).*

> *I think that giving the learners the opportunity to practice what has been taught in the class enhances their knowledge of mathematics concepts and also impart mathematics achievement… (TB).*

6.4.6 Linking new work to previous knowledge is important for effective learning.

One of the crucial contributors to success in mathematics is student's previous knowledge and how they link it to the new knowledge. Constructivism is premised on the theory that previous learning acts as important building blocks for future learning. Hence it is important that prerequisite concepts are understood before applying it to new work (Kazunga & Bansilal, 2020). Another teacher noted that one strategy that was useful was to help learners recall previously errant concepts by *repeating and reviewing previous formulas, lessons and information, to help learners better comprehend concepts at a faster rate (TC).*

In some of the comments made by learners, it seemed that they recognised the importance of making connections between prior concepts and the ones they were being currently introduced to. Here are some comments to this effect:

I do not find it hard to recall the formulas by remembering some of the arguments we engage on that topic in the past. In other words, it enhances my retaining abilities and I go straight to my work without delay, and it has been favourable on my mathematics achievement… (p8).

I like to bring my previous ideas to always class and continue to practice solving mathematics…(p6).

When I am learning I think about my own knowledge so far and like to be doing things like practice solving mathematics questions alone…(p11).

These learners and the teachers have realized the importance of linking previously learnt concepts to new knowledge so that they have a connected understanding of the mathematics.

6.6 LEARNERS AND TEACHERS' PERCEPTIONS OF EFFECTIVE INSTRUCTIONAL STRATEGIES

In this section of the chapter, the results of the learners and teachers' interviews are presented with respects to answering the question about the instructional practice they prefer most in learning and teaching of mathematics in the class. Most researchers agree that the nature of classroom mathematics teaching significantly influences the nature and level of learners' learning and achievement in mathematics. Though, teaching maybe seen as any activity on the part of one person which is intended to facilitate learning by another. But in reality, instructions could consist on interactions among teachers and learners because, a single method of teaching may not be effective in achieving all types of learning goals particularly in mathematics class. Perhaps some methods of teaching maybe more effective for, say, memorizing number facts whereas other methods of teaching could be more effective for deepening conceptual understanding and still other methods may also be more effective for acquiring smooth performance of complex procedures particularly in mathematics classroom. Hence it is important to explore the learners and teachers' perceptions of what they view as important in the learning of mathematics.

A shared opinion on classroom practices in learning and teaching of mathematics which was highlighted through the learners and teachers' responses was that they liked to share the focus of mathematics concept together in the class and interact equally with emphasis on the following. This implied that some mathematics teachers applied instructional practices that allowed learners the opportunity to be active participants in the process of learning mathematics in the class. In this respect, they conveyed the impression that they were highly influenced by student-centred instructional practices which allowed the learners to learn mathematics with understanding, actively building new knowledge from experience and previous knowledge, and taking an active role in the learning process rather than being passive recipients of knowledge or information from the teacher. This was emphasized in a statement provided by one teacher who also provided some reference to group work or discussions:

> *Instead of attending to my teachings totally, my learners and I interact equally. Sometimes I give group work and encourage the learners to participate by sharing ideas and opinions, and most of my learners learnt to collaborate and communicate with one another in finding solutions to the mathematics task or problems…(TA).*

Many of the interviews with learners and teachers referred to ideas about student – centred learning and this is now discussed in more detail. Further analysis revealed that the teachers were actually very much focused on setting up teacher centred classrooms. They emphasised the role of teacher explanations and teacher questioning which they use to direct the lessons. In this scenario, the role of the learner is to listen carefully to the explanations and then work out the examples that the teachers showed them.

I now go into more detail about the themes related to teacher's instructional techniques.

6.6.1. The teachers believed that they were engaging in learner- centred teaching approaches.

Student-centred instruction incorporates teaching strategies which allow for the student to construct knowledge through meaningful experiences in the class, for instance, group discussions, effective listening, questioning, explanation, giving the learners a chance to try out personal effort in the class.

According to one of the teachers, student-centred instructional strategies allow both the learners and teachers to share focus in the class. This view was captured in his comment below.

> *I believe that when a classroom or mathematics classroom operates with student-centred teaching, learners and teachers share the focus… (TC).*

Emphasising how strong the teacher felt in his view on the role of student-centred learning in mathematics class, he further added this comment:

Instead of listening to my teachings totally, my learners and I interact equally on a mathematics concept introduced…(TC).

In the above view, the teacher has confidence that interaction between teachers and learners could be a quality instructional strategy that promotes opportunity for learners to learn mathematics concepts and impact learners' mathematics achievement gains. The teacher also went further to explain that some of the learners in the class share ideas and opinions together during mathematics instructions:

Sometimes I give group work and encourage the learners to participate by sharing ideas and opinions, and most of learners now collaborate and communicate with one another in finding solutions to the mathematics task or problems…(TC).

From the above view, the teacher felt that student-centred learning promotes learners' interaction with each other on mathematics task or content and the interaction with the teacher for a greater impact on learners' learning.

From the view of the above teachers, student-centred learning is a strategy that encourages the use of cooperative learning in teaching mathematics which gives the learners the opportunity to listen, share ideas on a topic in the class and question one another's thinking on the mathematics problem. Another teacher said that:

the use of cooperative learning in teaching mathematics allows for a more learner-centred classroom and moves learners away from the teacher-centred approach to learning that gives the learners the opportunity to learn independently, listen, share ideas on a topic in the class and question one another's thinking on the mathematics problem…(TB).

To the teacher, it seems obvious that learners should be involved in activities that promote learning and the construction of knowledge in the class.

Though the learners and some of the teachers did not mention the word 'student-centred learning' but a lot of learners said that they participate in classroom discussions in solving mathematics task or problems in the class and pay adequate attention in the class, while some of the teachers also emphasize that they allow learners to participate in group discussion during mathematics lesson to share ideas together.

In a student- centred lesson, the teacher takes on the role of a facilitator, and the next theme explore this aspect of student- centred teaching.

6.6.2 The teachers emphasised that they were facilitators of student learning.

For some participants student-centred instruction or learning gives teachers opportunity to take on the role of a facilitator in the teaching and learning of mathematics. Facilitating student learning while teaching secondary mathematics activities could help engage learners in the learning process by tapping into their interests and abilities in learning. Some specific ways of facilitating student learning were identified such as offering learners questions to solve and providing opportunities for the learners to practice critical thinking, for instance, individual effort and participation in group work in solving mathematics problems in the class, one of the teachers explained that he plays the role of a facilitator in the class by

> *giving learners class work so that they can do a lot of work either individually or as a group that is how you see whether they understand the concept or not, but now, a lot of them have develop self-confidence and can work on their own. Before now, I believed that the success of the learners depends on the teacher, but since I started to allow learners to work on their own in finding solution to mathematics problems in the class, I realized that it's upon the learners, I was not giving them the opportunity to explore on their own in solving mathematics in the class. Maybe it is the reason some of them were not doing well in mathematics…(TA).*

The comment from the teacher above highlights that when mathematics teachers can take on the role of a facilitator, this enhances learners' knowledge and understanding of mathematics concepts and could impact mathematics achievement of learners. As a facilitator of learning, the role of the teacher changes from a person who transfer knowledge to one who can promote self-learning and help learners develop critical thinking skills and construct knowledge in mathematics that could impact achievement in mathematics. The teacher has described the development of his own thinking with respect to facilitating student learning. He states that in the beginning he felt he was the main person responsible for learners' success. However, he has shifted in his thinking and realises that learners must take responsibility for their own learning. It is only at the stage when they have developed the confidence that they can work on their own that they are ready to take up that responsibility. The teacher seems to be comfortable with granting the learners the opportunity to explore the mathematics on their own.

Some participants said in their understanding that they prefer to learn mathematics by actively participating in the task given to them by their mathematics teachers in the class. They feel that it supports learners to construct new understandings of mathematical concepts rather than allow the teacher to solve the mathematics problem for them in the class. This view was captured in the comments from one student as stated below:

> *I always try to solve mathematics task given to us by our teacher in the class because it helps me so much in applying my own reasoning…(p14)*

Highlighting the importance of facilitating student learning the student also said that "*sometimes our mathematics teacher gives us a chance to work on the task both individually and in group in the class"[p14].* In the above view, the learners perceived that there are some learners in the class who prefer to work alone, while others prefer working cooperatively in learning mathematics concepts in the class and the teacher gives the learners a chance to work on any given task based on their choices in learning mathematics.

Some participants think that for teachers to be effective in taking the role of a facilitator in the teaching and learning of mathematics they must possess an understanding of the mathematics they are teaching and learners' learning in mathematics classroom lessons. They emphasize that learners can learn mathematics best by constructing their knowledge individually or in group during mathematics activities:

> *I introduce the topic and present the example on the chalkboard and ask the learners to practice solving the mathematics question and allow those who prefer to work in group or individually in solving the mathematics activities or question to do so… (TB).*

These first two themes imply that the teachers were progressive in their vision of teaching, however we now look at other themes which emerged which showed that the teachers drew upon traditional teaching styles.

6.6.3 The teachers used questioning in the classroom to engage their learners.

The teachers noted that they used questioning because they want to know more about the way the learners are learning mathematics in the class. The teacher explained that questioning

> *helps the learners to do a lot of work either individually or as a group in the mathematics class…(TA).*

Emphasising how strong the above teacher felt about his view on the role of question and answers in the class he further added this comment, "*it is good because we come to know whether the learners understand the mathematics concept or not through question and answer" (TA)***.** In the above view, the teacher sees questions and answers as very important in the teaching and learning of mathematics because the teacher gives the learners a task, and then gauges the extent to which they understand the work based on their responses. One of the teachers was a little more specific on the role of questioning in the teaching and learning of mathematics by saying that questioning could help in getting immediate feedback on learners' understanding of mathematics concept and used by the teacher to evaluate his/her teaching. TC said that *"questioning makes me as a mathematics teacher to know if the learners are following up or not and also help me to evaluate my lesson" (TC).* The comment of the teacher gives the impression that questioning in the class could prompt teacher's assessment of whether learners understand what has been taught. The teacher takes the view that questioning gives him feedback about whether his lesson was successful or not. A similar point was raised by one of the teachers who explained that questioning:

> *helps me to judge my lesson to be successful or not because if learners are not allowed to ask questions or I fail to ask the learners questions, I may not know if they are gaining a better understanding of the concept or mathematics problem or following up with the examples… (TB).*

This feedback from the learners can prompt teachers to plan their lessons more effectively around deep mathematical ideas. Although there were comments from both learners and teachers on the use of questioning as an instructional practice in teaching and learning of mathematics in the classroom, the learners and teachers had different views of the use of questioning in the mathematics classroom. For instance, some learners emphasised that by asking and answering questions in the mathematics classroom, their own understanding of mathematics concepts improve. Teachers provided different reasons compared to learners ~~of~~ for using questioning in the mathematics classroom. Teachers indicated that they applied the use of questioning techniques to stimulate learners' mathematics thinking in the class. For instance, the teachers reported as follows:

> *I ask learners questions to know what they understand and their progress with the mathematics problem and achieve at least one solution… (TB).*

> *Questioning and explaining have aided my understanding of how learners think and reason mathematically in the class and have also guided and informed my instruction in mathematics…(TC).*

> *When I teach mathematics concept or solve any mathematics problem in the class, I ask the learners questions. It allowed the learners to think about the mathematics task*

or problem and also offer their opinions and explanations for each task and give learners time to think and prepare answers… (TA).

Emphasising how strongly *TA* felt about his view on the use of questioning in teaching and learning of mathematics in the classroom he further added:

The use of questioning is good because I am able to determine whether the learners understand the mathematics concept or not through questioning in the classroom…(TA)

Some of the teachers believed that the use of questioning helped them to increase their teaching effectiveness by helping them see the different ways in which learners learn mathematics (learning style). In one example, a teacher explained:

One way I teach mathematics in the classroom is by questioning learners on relevant aspect of the mathematics concept taught. It makes me to be aware of what learners know and helps me to understand how learners learn mathematics. I start by asking learners questions… (TC).

It appeared that the kind of knowledge learners construct and communicate in the mathematics lesson or classroom may be dependent on the teacher's questioning and their learning style preferences. In order to better understand the importance of teacher questioning in teaching and learning of mathematics, the learners were asked what the influence of teacher questioning was in the mathematics class. There seemed to be evidence from some learners' responses that teacher questioning does not only impact on the mathematics achievement of learners, but also helped teachers to understand how learners engage in learning mathematics in the classroom. Some learners indicated that they liked mathematics teachers who gave them opportunities to ask and answer questions in the classroom. This implies that these learners liked the sharing of ideas in mathematics class through questioning and answering practices. In fact, they relied heavily on their class discussions as a way of learning mathematics in the class.

When one student was asked what the influence of teacher questioning ~~are~~ was in the mathematics class, he replied:

Asking and answering questions in the mathematics classroom gave me the opportunity to share my ideas on the mathematics concept and to know if my understanding of the mathematics concept is right or wrong…(P12)

In the above views, questioning seems to be important for both learners and mathematics teachers. One teacher was honest in his appraisal of how questioning was used. The teacher said:

> *to increase teacher effectiveness and student success achievement in mathematics, a self-assessment of teacher questioning techniques is essential…(TA).*

This shows the willingness of the teacher to critically examine his own practices.

6.6.4 Teachers and learners believed that teacher explanations were an important feature of teaching.

Generally, the teachers and learners believed that learners required detailed explanation of concept before getting involved in mathematics activities in the class. The teachers also emphasized that teacher explanations were an effective tool which facilitated the teaching and learning of mathematics in the classroom. Responses from some mathematics teachers revealed that explanation is an instructional practice used for describing relevant mathematics concept, developing learners' logical thinking and guiding learners as they share mathematics ideas together in the classroom.

Some of the responses of learners regarding the role of teacher explanations appear below:

> *I need a lot of explanation from my teacher or classmates to gain mathematical knowledge well enough… (p3).*
>
> *I also gain deep understanding of mathematics concept or problems through the explanation of mathematics problem by my teacher and classmates… (p7).*
>
> *I'm very much interested in explanation from both my teacher and classmate in learning mathematics… (p9).*
>
> *I rely so much on explanation from both the teacher and classmates in learning mathematics… (P10).*

From the above responses, it appears that explanations are used as a primary means of communicating the information to learners. They believe that they first need an explanation by the teacher before they can proceed any further.

One mathematics teacher emphasized that it helped to facilitate learners' comprehension, and the explanations also provide feedback to learners about the correctness of their work. The teacher said that:

I complete example of mathematics concepts with explanations and allow learners to ask questions so I could explain further what they don't know… explaining mathematics concepts gives learners the opportunity to make corrections on their work… (TB).

From the above statement, it seemed that it is important for teachers of mathematics to explain mathematics concepts through their examples on the chalkboard. The above comment was also reaffirmed in a statement presented by another mathematics teacher who emphasized that explanation was used to display mathematics problem-solving procedures. One teacher said that:

I start my lesson by presenting examples on the chalkboard and explain mathematics concept to the learners and how to find solutions to the mathematics problems before giving class work to the learners …(TC).

The teacher in the above excerpt clearly describes the set-up of her classroom as being in the traditional teacher- centred mode. The teacher firsts present the example and then learners follow her lead and work out the other problems following her approach. The same teacher believes that for learners to achieve success in mathematics at school, effective explanation of mathematics concepts during mathematics lesson in classroom is necessary. For instance, the teacher said that:

When I teach mathematics concept or solve any mathematics problem in the class, I do explain the concept to the learners in detail and give the learners opportunity to explain what they know on each task so that they can apply their own understandings…(TC).

The above mathematics teacher also seemed to have deep confidence that the use of explanation in learning and teaching of mathematics could help teachers to facilitate learners' understanding of mathematical knowledge for problem solving and challenge learners to apply their own understandings and learning style in learning mathematics in the classroom.

The above learners and teachers believe that the use of explanation as an effective instructional practice in learning and teaching of mathematics in the classroom. In other words, they believe that effective teachers of mathematics could directly address the specific misunderstanding that learners may have through explanation of mathematics concept.

It is important to note that research in mathematics education suggest that teaching which is dominated by teacher talk and explanations is not very effective. The more time spent on teachers talking, mean that the learners' role is shifted to that of receiver of information instead of being active participants in the construction of their own knowledge Furthermore when learners have misconceptions, it is highly unlikely that more teacher talk will fix the problem. Research (Kazunga & Bansilal, 2019; Mutambara & Bansilal, 2022) suggests that learners need carefully designed and sequenced activities which will help them to recognize their error and allow them to deepen their understanding.

6.7 RESPONDENTS' GENERAL SUGGESTIONS FOR THE OVERALL IMPROVEMENT OF LEARNING AND TEACHING OF MATHEMATICS AT SECONDARY SCHOOL LEVEL

When respondents were asked how the learning and teaching of mathematics could be improved considering the past achievement of learners in mathematics in national examinations, they recommended areas where the learning and teaching of mathematics could be improved. They recommended that productive relationships between learners and learners and between learners and teachers be encouraged so that learners would be motivated to seek assistance from fellow classmates as well as to seek help from their teachers. Learners also suggested that efforts should be made to help teachers recognise diverse learning style preferences of learners in the classrooms to improve the selection of instructional practices appropriate to student learning. This could be done by providing training for teachers on practical implementation of learning style theories in their instructional practices in the classrooms. They also suggested that achieving higher scores in mathematics was ~~very~~ possible and important to them, but this was dependent to some extent, on teachers' effective instructional practices adopted in the teaching and learning process.

During the interview process, one of the learners was asked how he engaged in learning mathematics, and he then narrated the following influential academic story of his learning and achievement:

> *I just pay good attention in the class and observe the examples during problem solving in the class. I also liked to practice solving mathematics problem during class mathematics discussions and follow some classroom examples of my mathematics teacher. I always engage in classroom discussions and participate actively as we work on any mathematics problem solving together as a team. My achievement in mathematics is improving. I have represented my school several times on mathematics competitions, and I have come back with success from the competitions appeared… (P4)*

Some teachers suggested that in order to facilitate academic achievement of learners in mathematics, teacher questioning, and explanations be used as an important diagnostic tool of learners' learning style preferences as well as measuring academic development and achievement of learners in the mathematics classroom. They recommended that to improve the effectiveness of teachers and learners' achievement in mathematics, instructional practices to keep learners engaged in the learning process were essential although often not too easy for teachers to implement in the classroom. During the interview, one teacher suggested that the kind of knowledge learners construct and communicate during a mathematics lesson might be dependent on teachers' questioning and explanations. He narrated the following encouraging idea regarding the teaching and learning of mathematics in the classroom:

> *I believe that teaching and learning of mathematics using questioning and answering are important during mathematics lesson. It helped me to know if I am teaching well and helped in finding out if the learners are following up with the instructions and examples in the class. But when a student is being asked a question and could not give correct answers, then I assumed that the student was not following up with the instructions or examples and explained more again to the student or find out how the student could understand the mathematics concept…(TC)*

Teachers also suggested that in order to increase student achievement and engagement during mathematics lesson in the classroom, student-centred instructional practices needed urgent attention by the schools, teachers and young mathematics teachers. They recommended that teachers of mathematics or mathematics educators should move away from traditional instructional practices to student-centred instructional practices, which involves learners' engagement in appropriate practical work and group discussions during mathematics lesson.

One of the teachers narrated his teaching experiences during mathematics lesson:

> *During mathematics lesson, I usually allow my learners to think about the mathematics task or problem and offer their opinions and explanations for each task. Therefore, learners contribute a lot during the lesson. I believe that when a classroom or mathematics classroom operates with student-centred teaching, learners and teachers share the focus. Instead of listening to my teachings totally, my learners and I interact equally. Sometimes I present group work and encourage the learners to participate by sharing ideas and opinions, and most of learners have become more knowledgeable to collaborate and communicate with one another in finding solutions to the mathematics*

task or problems. I also allow learners to ask questions and some learners can even complete any task on their own. Most of them are happy when we interact together on a mathematics activity but not all of them. So sometimes, it is difficult for me to manage all their activities at once...(*TA)*

Both student D and the teachers displayed various characteristics that other learners and teachers alluded to in the interviews. The student demonstrated the traits of Assimilator learning style as he adequately took note of and observed his teacher's examples in mathematics lessons. Consequently, he was also able to engage in classroom discussions and participate actively in a team in finding solutions to mathematics problems, which was an element of the Diverger learning style preference. He had also represented his school several times ~~on~~ in mathematics competitions and recorded countless mathematics academic achievements both from the competitions attended and in the school. The teachers on the other hand, demonstrated some knowledgeable skills applicable to the use of student-centred instructional practices instead of allowing the learners to just listen to their instructions totally during mathematics lessons, they allowed the learners to share their ideas and opinions in the classroom. Therefore, both the learners and teachers shared ideas in the same way during mathematics lessons in the classroom. They also tried to understand the best ways in which learners preferred to learn mathematics in the classroom.

CHAPTER SEVEN: ANSWERS TO RESEARCH QUESTIONS, IMPLICATIONS OF STUDY AND CONCLUSIONS

7.1 INTRODUCTION

In this chapter I first analyse the learning style preferences of the participant learners and the relationship between preferred Learning style dimensions and mathematics achievement of the participant learners with regard to the association between the participants' mathematics achievement and their gender or age. To make the quantitative data more understandable

7.2 LEARNING STYLE PREFERENCES OF THE PARTICIPANT LEARNERS

In this sub-section I address the first research question: What are the learning style preferences of graduating senior secondary school learners?

To achieve the above objective in the study, the frequency and distribution of respondents on preferred learning styles (Diverger, Assimilator, Converger and Accommodator) as well as the number of males and females within the sample, was analysed. Table 2 (based on RQ1) of the test results revealed that an overwhelming number of 134 learners identified their preferred learning style as Diverger, while 8 others reported that their preferred learning style was Assimilator. Additionally, 6 and 23 agreed that their preferred learning styles were Converger and Accommodator respectively. This study, therefore, confirms that most learners' preferred learning style in the three schools sampled is Diverger. Since a total of 171 learners completed the questionnaire in 2018, the response rate of the current study was 85.5%. From this group 89 learner (52.05%) were female learners while 82 learners (47.95%) were male learners. Overall, the majority of the learners who participated in the study were female learners (see table 5.1 on details of gender of learners). Across all three schools, learners overwhelmingly identified themselves as preferring the Diverger Learning style. Note that for School 2 there were no learners who identified Converger learning style as their preferential learning style (see table 5.5 on distribution of learner styles preferences by school.

Diverger, Assimilator, Converger, and Accommodator respectively, were listed in order as the preferred learning styles by learners in mathematics classrooms according to one study by Bhatti and Bart, (2013). According to Kablan and Kayan, (2013) Diverger learners learn the best when they are carefully informed and are able to carry out meaningful observations on the subject to be learned. Divergers prefer learning through concrete experience and reflective observation (Akinyode & Khan, 2016; Kolb & Kolb, 1984; 2005; 2017; 2018). In this respect, senior secondary school learners who prefer the Diverger learning style, view mathematics situations or concepts from different perspectives (Akinyode & Khan, 2016; Kolb & Kolb, 2017; Ng'eno & Chesimet, 2016; Passarelli & Kolb, 2012). There is also evidence from research studies suggesting that Divergers absorb information best through group discussions with a focus on creative ideas in developing mathematical competence and problem-solving skills in the classroom (Kablan & Kaya, 2013; Kolb & Kolb, 2017; McLeod, 2017; Ng'eno & Chesimet, 2016).

Some studies suggest that Diverger learners spend longer hours watching and listening carefully to the instructions of the teacher and also take a greater part in class discussions or group work than their non-Diverger counterparts, similar to the participants deemed Diverger in Akinyode and Khan's (2016) study. They are more interested in brainstorming with classmates in solving mathematics problems and they require a detailed explanation from the teacher before they can engage in solving mathematics problems. The results of the quantitative study revealed that the Diverger learning style (followed by Assimilator, Converger, and Accommodator) was the learners' favoured learning method for studying mathematics (see section 5.4). In the qualitative portion of the survey, the divergent learning style, which was ranked first out of the four preferred learning styles (see section 5.4.1), was the most favoured by the learners.

When the preferred learning styles of learners in learning mathematics were further~~ed~~ examined according to the nature of the descriptions they gave about their learning style preferences in the interviews, some interesting findings emerged. Many learners' interview responses could be linked to the Diverger learning style. It was also found at other times that their descriptions could also fit into the Assimilator learning style (see section 6.3) which seemingly contradicts the results of the quantitative phase of the study. Some learners indicated features from different learning styles during the interview. It seems that there are certain features of the learning styles that some learners take up at different points or when they are engaged in activities which require different processes.

This suggests that the assumption behind the Kolb's learning style inventory that every learner has a single learning style, may not necessarily hold true. These differences also suggest that the test- retest reliability of the instrument should be investigated for learners from a similar context. Recall in the methodology section, the test- retest reliability of the instrument was not examined since this was not within the scope of this study. The reliability was inferred from other studies which used the KLSI. However, the qualitative data from the interviews suggest that these learners may have understood the phrases used in the KLSI in different ways at different times.

In the qualitative phase of the study, more details about the learners' use of the Diverger learning style were explored. Most of the learners who were interviewed indicated that they use the Diverger learning style in learning mathematics in the classroom (see section 6.3). Some very interesting observations and implications can be made right here. For instance, the findings support the idea that learning style preferences are an effective and interesting way to learn in the classroom. This is so because, the study found a specific significant learning style preference for learners in learning and teaching of mathematics in the classroom context. Studies previously mentioned which looked at the learners learning style preferences, found that the majority of the learners preferred Assimilator learning style followed by the Diverger. My study shows the Diverger and Assimilator learning styles to be the most common in learning and teaching of mathematics in the classroom setting from the interviews. These results are in line with the views of Cox (2013); Kolb and Boyatzis (1999); and Kolb and Kolb (2009). According to them, learners with the Diverger and Assimilator learning styles prefer mathematics and chemistry subjects respectively. Cox, (2013) further revealed that Diverger learners perceive mathematics concepts concretely and think reflectively and imaginatively (i.e. the ability to produce multiple ideas rapidly in response to a task). In contrast to a study conducted in Indonesia on mathematical problem solving based on Kolb's learning style, the results show that learners with Converger and Accommodator learning styles are better than Diverger and Assimilator learning styles in mathematical problem solving (Rohmanawati, et al., 2021). In the theory, learners who prefer the Converger learning style have dominant learning abilities of abstract conceptualisation and active experimentation. They tend to focus on practical application of ideas and concepts and quickly decide or obtain one correct answer.

The study of Kolb's learning style also has been done by Jones, Othman, Dowswell, Alfirevic, Gates, Newburn, & Neilson, (2012).

Their research shows that the preferred learning style preferences of the learners is Converger learning style (31.66%), then Accommodator (26.67%), next Diverger (21.67%), and Assimilator (20%). That study differs significantly from this study, where the dominant type of Kolb's learning style from the questionnaire is Diverger learning style, then Assimilator, next Converger, and lastly Accommodator.

7.3 THE RELATIONSHIP BETWEEN PREFERRED LEARNING STYLE DIMENSIONS AND MATHEMATICS ACHIEVEMENT OF THE PARTICIPANT LEARNERS.

In this sub-section I address the second research question as stated: *What is the relationship between preferred learning style dimensions and mathematics achievement of the participant learners*?

The second objective of this study was to determine the relationship between preferred learning style dimensions and mathematics achievement of the participant learners. In Chapter Six, I briefly detailed how the achievement test instrument was refined to improve its reliability. To ascertain the mathematical achievements of the participants, multiple choice questions in mathematics numbering from 1-20 were administered on the participants, as well as five other open-ended questions numbering from 1-5. The test was designed by a mathematics teacher from Nigeria and checked by two other experts. However, during the scoring process, four items were eliminated from the multiple-choice items because three of them did not have a correct option while for one item, the group obtained on average 0 for that item.

The second part of the test was the open-ended items of which there were eight items originally. Two items were deleted because of the large number of zeroes on those items. Hence the open-ended items were calculated out of a total of 22 marks. A third variable for measuring the achievement was calculated by adding up the totals for each of the two tests, called the final total. The Chi-square tests show that there is no significant relationship between learning style preferences and academic achievement of the learners in mathematics. To the knowledge of the researcher, no research has been done on learning style preferences and mathematics academic achievement of graduating senior secondary school learners in Nigeria using Kolb's Learning style Inventory (KLSI). Therefore, no inference can be made about the absence of the studies that supports the current findings for graduating senior secondary school learners.

The findings of this research do not show any relationship or correlation between learning style preferences and mathematics academic achievement of learners which was the main objective of the study. When evaluating the findings of the current study, utmost caution must be used due to the lack of statistical significance. The issue of scientific control while conducting studies, is a key difficulty in the field of learning style preferences research (Wilson, 2011), and critics have argued that pertinent research has typically lacked the essential accuracy or failed to provide results that were overwhelmingly positive (Bishka, 2010; Donner et al., 2011; Hall & Moseley, 2005; Pashler et al., 2008). As a result, the current study is not the only one to lack substantial empirical support; nonetheless, this does not indicate that the current study's conclusions are irrelevant or unimportant in the area of education.

Several studies which investigated learners learning style preferences and academic achievement using Kolb's learning style inventory (KLSI), found that although learners have different learning style preferences, learning styles are not found to be an initial predictor of mathematics achievement of learners (Ignacio & Reyes, 2017). In some literature reports, the four learning style preferences are represented but the dominant learning preferences vary from study to study with significant levels of academic achievement in mathematics (Bhatti & Bart, 2013). However, many studies have also indicated no relationship exist between learning style and academic achievement of learners in mathematics. Yilmaz-Soylu and Akkoyunlu (2009) reported that learning style preferences have no effects on learners' achievement and cannot be a potential tool for the improvement of student achievement both in mathematics (Ahmad et al., 2014; Ignacio & Reyes, 2017).

A particular study from the literature also revealed that, despite the fact that the field of learning styles continues to attract significant interest and attention from educational professionals, it is argued that there is a dearth of compelling empirical data supporting the effectiveness of such models in enhancing academic achievement (Wilson, 2012). The vast majority of published resources, especially those promoting various techniques and tools for the relationship between learners' learning preferences and academic achievement, with a focus on mathematics, did not provide empirical evidence in favour of the efficiency of learners' learning preferences and academic achievement (Knupsky, 2016; Pashler at el., 2008). Pashler, et al. (2008) claimed that the majority of sources purporting to offer such evidence about the relationship between learning style preferences and academic achievement relied on unfavourable research designs and did not merit attention as indicators of the influence of learning style preferences on student achievement in mathematics. Wilson (2012) went on to say that only modifications to the way that pupils were taught will raise their levels of academic achievement. Some studies pointed out that the interpretations of learning style preference theory involving learners' academic achievement, will not result to improved learning as related to mathematics achievement (Rohrer & Pashler, 2012).

Another study also emphasised that despite the spread of learning style theories and learning style models, the instruments still appear to retain several weaknesses which limit their use, including low predictive powers with particular reference to learners' achievement (Manolis et al, 2013; Pashler & Rohrer, 2012).

In contrast, the qualitative portion of the study, showed that learners primarily used the Assimilator learning style when learning mathematics. Most of the learners interviewed indicated that they preferred the Assimilator learning style during mathematics lessons in the class which influence their mathematics achievement. Assimilators prefer abstract assignments, such as coming up with action problems to answer mathematics problems, according to the research review ((Akinyode & Khan, 2016) and are also not interested in the actual application of ideas (Kolb & Kolb, 2017).

Some of the learners interviewed also indicated that they used some practices aligned to the Diverger learning style preferences in learning mathematics in the class and this has greatly enhanced their learning and achievement in mathematics. In the literature review, it was also revealed that Diverger learners prefers learning through concrete experiences and reflective observations (Akinyode & Khan, 2016; Kolb & Kolb, 1984; 2005; 2017; 2018).

Some of the learners interviewed also indicated that they draw upon practices aligned to the Converger style which has positively influenced their achievement in mathematics. In the literature, Converger learners learn through abstract conceptualisation and active experimentation (Akinyode & Khan, 2016; Kolb, 1984; Kolb & Kolb, 2005; 2009; 2017; 2018; Passarelli & Kolb, 2012), and their strength lies in practical applications of ideas in mathematics classrooms (Kolb & Kolb, 2017; Ng'eno & Chesimet, 2016; Orhun, 2013). Some researchers from the literature review posit that Convergers are good at finding practical ideas and theories leading to solutions to problems particularly in mathematics (Kablan, 2016; Orhun, 2013; Akinyode & Khan, 2016; Passarelli & Kolb, 2012). Some studies from the literature review also indicated that Converger learners perform better when given opportunities to try out individual efforts in solving mathematics problems during mathematics lessons (Kablan & Kaya, 2013; Kolb & Kolb, 2017; Ng'eno & Chesimet, 2016).

Another important finding was that Assimilator learners achieved the highest marks in the multiple-choice test, but not in the overall results. There were many learners who preferred the Assimilator learning style preference in the learning of mathematics in the classroom, which they felt had an impact on academic achievement in mathematics (see section 5.6). So, many learners indicated that they liked to listen carefully to the teachers' explanation of mathematics concepts during mathematics lessons. This allowed the learners to construct mathematics knowledge from teachers' knowledge and explanations (Tuncer et al., 2018). One student suggested that in order to improve her academic achievement in mathematics, she should listen attentively to the teachers' explanation of mathematics concepts before attempting to share her ideas in the classroom (see section 6.3.1). These categories of learners liked to focus on abstract concepts and ideas in search of opportunities to construct mathematics knowledge in the class and exhibit highest levels of academic achievement in mathematics (Tuncer et al., 2018). The teachers interviewed also revealed that some learners preferred to pay attention to their explanations before they engaged in mathematics lessons in the classroom (see section 6.6).

In conclusion, it can be specified that that Kolb's learning style preference was not statistically significantly related to mathematics achievement of learners. The result of the qualitative study showed that learners applied various learning style preferences during mathematics lessons in the classroom such as Assimilator, Diverger, Converger and Accommodator. The Diverger learning style preference was found to be the dominant learning style amongst learners according to the quantitative results. The study did not find any relationship between learning style preferences as determined by Kolb's model, and mathematics achievement as measured by the tests that were administered to the learners. It is possible that mathematics achievement is different than achievement in other content areas, but it is also possible that learners and their academic achievement may not be dramatically linked to LSI subscale preferences.

Consistencies. Most learners referred to class discussions, class participation, working in groups or teamwork. Irrespective of the learners' mathematics achievement level, these learners indicated a preference for group work, active participation and class discussions during mathematics lessons and did not mention age or gender as factors impacting their ability to learn new and difficult mathematics tasks in the classroom. The interview response from P2, the average achieving student, was the most consistent with her LSI profile. She reflected her preferences for sharing ideas, group work, classroom participation and encouraging each other's efforts in learning mathematics concepts in the class. Her only conflict was with solving mathematics problems alone in the classroom without paying attention to the teacher's explanations and fellow learners' points of view.

Inconsistencies. Generally, many of the learners who were interviewed, presented learning style preferences and practices which were inconsistent when compared to their LSI profile. Some learners contradicted themselves during the interview referring to the need for constant practice in solving mathematics problem individually both in the classroom and at home.

Some participants consistently claimed and believe that full comprehension of mathematics concepts requires learners to grasp information best by improvement of thinking abilities, effective listening and concentration in the classroom. This could enhance learners' performance in mathematics. Of note is that they always try to avoid practical participation in learning mathematics, ~~or~~ group discussion or teamwork. For some learners or participants in this category, the level of mathematics achievement is one of the most important factors which indicate the success of their perceived learning style profile. To be more specific, P12 felt that effective reasoning ability and problem-solving skills seem to be the key to learners' academic achievement especially in mathematics.

Four learners believed in constant practice of solving mathematics problems and two participant learners were very dependent on their teachers to grasp information and did not like to share ideas in the class but were very concerned about their teacher's explanations and expectations on mathematics concepts. All the learners reported that their mathematics achievement had improved.

In the next section, the influence in which gender, age and school have on learning style preferences and mathematics achievement of learners will be examined in depth.

7.4 TO WHAT EXTENT IS THERE AN ASSOCIATION BETWEEN THE PARTICIPANT LEARNERS' MATHEMATICS ACHIEVEMENT AND THEIR GENDER OR AGE?

The answers to the above research question is reported in various subheadings based on the results of the figures and tables in Chapter 5 (see section 5.3.1 to section 5.7.4). The results are reported as follows:

7.4.1 Learning Style Preferences according to Gender

The result of the analysis shows the exact numbers of learning styles according to gender and it was seen from Table 5.21 and Figure 4 that more females prefer the Diverger, Assimilator and Accommodator learning styles compared to male learners, while the Converger learning style has more males than females, although both groups are very small (see section 5.4.2). However the results do not indicate a statistically significant relationship between learning style preferences and gender. Another significant finding from the results is that the dominant learning style preference of female learners during mathematics lessons in the classroom is Diverger, and female learners expressed more positive views towards the learning of mathematics than their male counterparts had. Divergers absorb information best through group discussions with a focus on creative ideas in developing mathematical competence in problem solving in the classroom (Kolb, 2005).

Some prior studies conducted on this relationship correlation provided mixed findings. For instance, Barkatsas et al.; (2009) investigated the relationship between learning style preferences and attitudes of male and female learners towards mathematics in Greece. The findings of the study indicated that boys expressed more positive views towards mathematics and more positive views towards the use of Kolb's learning style inventory in mathematics, compared to girls (Barkatsas et al., 2009). The findings of the current study are also in line with the study conducted by Bhatti and Bart, (2013) whose findings showed that male and female learners had different learning style preferences and learned differently. This means that although male learners preferred to experience new material through abstract conceptualisation (Converger) female learners tended to prefer to experience new information concretely (Diverger) which is consistent with the results of the current study as revealed in Table 5.21 and Figure 4 (see section 5.4.2).

This study has not been able to establish any direct links between gender and the Kolb's learning style preferences. It may be that there could be an interaction between these variables but numbers in each learning style category were not large enough to carry out the statistics test to detect any interactions.

7.4.2 Gender and Learners Academic Achievement

In exploring the relationship between gender and achievement, I considered the overall combined test as the dependent variable measuring achievement. The result of the analysis indicates that there is no significant difference in mathematics achievement scores of learners based on gender (see Table 5.23 in section 5.7.2). The results listed above are in line with the results of Obiefuna and Oruwari (2015) who conducted a study using Kolb's LSI to evaluate the relationship between learning style preferences and the academic achievement of senior secondary school learners in Nigeria. The findings of the study indicated that learners' gender variable had no significant impact on learners' learning style preferences and academic achievement of learners in mathematics (Obiefuna & Oruwari, 2015). Bansilal and Lephoto, (2022) in their study explained that some contextual elements must be considered in order to fully comprehend gender inequalities in learning on achievement scores of learners. The authors further argue that the effectiveness of instruction and the calibre of learning chances must be improved in order to mitigate the impact of these contextual elements in order to increase the equality of the academic achievement of learners based on gender (Bansilal &

Lephoto, 2022). The findings of the above study are also consistent with the findings reported by Fatokun and Adeniji, (2015) on learners' learning style preferences and memory improvement strategies for effective learning of mathematics and science at tertiary level in Nigeria. The findings of the study indicated that learning style preferences based on gender did not have an influence on learners' achievement in mathematics (Fatokun & Adeniji, 2015).

In contrast, Schulze and Bosman (2018) investigated the association between South African learners' preferences for learning styles and their academic achievement in mathematics and English. The study's conclusions showed that gender had an impact on learners' learning styles and achievement in both mathematics and English (Schulze & Bosman, 2018). The results listed above are also in line with the results of Middleton et al.; (2013) who examined the relationship between learning style preferences and attitudes of male and female learners towards mathematics in a high school in the United States of America and reported that gender did influence learning style preferences of learners in mathematics. Buaraphan; (2015) investigated grade 1-12 male and female learners' learning style preferences in Thailand using Kolb's Model. The findings of the study indicated that the female learners, the grade level 1 learners and the learners from large schools had significantly different mean scores in the four learning style preferences (Diverger, Assimilator, Converger and Accommodator), higher than male learners in other grade levels and learners from small-size and medium-size schools respectively (Buaraphan, 2015). The author suggested that learners' learning style preferences and academic achievement are related to their gender.

Although this study did not find a significant relationship between learning style preferences and academic achievement of learners according to Gender, the researcher could not conclude that learning style preferences according to gender impact academic achievement of learners in mathematics as revealed in the literature. It may be that gender on its own may not related to achievement, but it could be intertwined with other factors. In a study based on the TIMSS 2015 Grade 9 mathematics it was found that when factors such as age appropriateness, school location and degree of familiarity with the test language were considered, boys achieved significantly higher marks than girls in the TIMSS 2015 results for South Africa (Bansilal & Lephoto, 2022). Yet when the overall averages were calculated the girls achieved a higher mean than the boys.

7.4.3 Age and Learning Style Preferences

The findings of the results on age and learning style preferences of learners indicates that over-aged learners were in the minority based on their learning style preferences. Table

5.26 shows that 76. 61 % of the participants across the four-learning style preferences (Diverger, Converger, Assimilator and Accommodator) are of the normal school age of learners while 22.81% of the participants are over-aged learners (see section 5.7.3). Another significant finding of the study is that 59.06% of the participants who are of normal age are Diverger learners. Note that table 2 (based on RQ1) on the test results also revealed that an overwhelming number of learners (78.36%) identified their preferred learning style as Diverger. Therefore, the findings of this current study consistently confirm that most learners' preferred learning style in the three schools sampled is "Diverger" both from the gender perspective and age factor (see table 5.4). Learners from all three schools also overwhelmingly identified themselves as preferring the Diverger Learning style (see table 5.5 on distribution of learner styles preferences by school).

According to Kablan and Kayan; (2013) Diverger learners have a dominant ability to learn through the existing classroom experience and are able to reflect continuously on the information received in the class. They learn best when they are carefully informed and are able to carry out meaningful observation on the content to be learned. Diverger learners prefer learning through concrete experiences and reflective observations (Akinyode & Khan, 2016; Kolb & Kolb, 1984; 2005; 2017; 2018). In this respect, senior secondary school learners who are Divergers view mathematics situations or concepts from different perspectives (Akinyode & Khan, 2016; Kablan & Kaya, 2013; Kolb & Kolb, 2017; Ng'eno & Chesimet, 2016; Passarelli & Kolb, 2012). There is also evidence from research studies suggesting that Divergers absorb information best through group discussions which focus on creative ideas in developing mathematical competence and problem-solving skills in the classroom (Kablan & Kaya, 2013; Kolb & Kolb, 2017; McLeod, 2017; Ng'eno & Chesimet, 2016).

In the mathematics class for instance, it is also possible that Diverger learners spend longer hours watching and listening carefully to the instructions of the teacher and also take a greater part in class discussions or group work than their non-Diverger counterparts, similar to the participants deemed Divergers in Akinyode and Khan's (2016) study. They are more interested in brainstorming with classmates in solving mathematics problems and require detailed explanations from the teacher before they can engage in solving mathematics problems. A critical review and analysis of literature reveal that learners generally prefer to listen effectively and watch carefully before engaging in mathematics tasks (Akinyode & Khan, 2016; Passarelli & Kolb, 2012, Kablan & Kayan, 2013).

7.4.4 Age and Mathematics Achievement.

In terms of achievement and age, I looked at the distribution of high and low achievers according to age using the combined test total to see if there were any differences. For the over-aged group, 46% of them were high achievers while for the learners who were of normal age, only 36% were high achievers (see Table 5.19). Although the results indicate that there is no statistically significant association between age and mathematics achievement, it seems that a greater percentage of the over-aged learners were high achievers compared to learners of normal age (see Table 5.27). Using regression analysis, Bansilal and Lephoto; (2022) in their research on learner factors associated with South African Learners' mathematics achievement, found that in terms of the age effect, over-aged learners scored lower points in a given test than the learners who were at the appropriate age (normal age) in the same classroom. The authors argue that repeating grade learners seem to be the over-aged learners in the specific classroom or grade and suggested that for repeating grade learners to achieve the necessary levels of mathematical ability, they need more support (Bansilal & Lephoto, 2022).

7.5 PERCEPTIONS OF EFFECTIVE LEARNING PRACTICES

This sub-section addresses the fourth research question: What are learners' and teachers' perceptions of effective learning practices?

Most researchers agree that the nature of classroom mathematics teaching significantly influences the nature and level of learners' learning and achievement in mathematics. The interviews with learners and teachers revealed what they felt was effective learning practices (see section 6.5). The findings elated to this research question are arranged according to four themes expressed in the headings of the sub-sections

7.5.1 When learners ask questions, it can enhance their understanding.

Firstly, learners and teachers believed that learner questioning helps improve understanding. For instance, some learners felt that by participating and asking questions, their own understanding of mathematics concepts would improve. On the other hand, teachers wanted to know more about the ways learners were learning mathematics in the class and when learners asked questions, it helped teachers to see what learners needed help with.

All three of the teachers' comments in Section 6.5 emphasised the importance about the role of learner questioning in the class Teacher A saw questions as important when the teacher gives the learners a task and then allows the learners to either work individually or in groups. Teacher C raised the point that learner questioning helps provide immediate feedback on learners' understanding of mathematics concepts and it is also used by teachers to evaluate their teaching, that is, whether learners understand what has been taught. The teacher took the view that questioning gives him feedback about whether his lesson is successful or not. Teacher B in Section 6.5.1 also explained that student questioning helps the teacher to investigate whether the learners understood the mathematics concept in the class. A similar point was raised by teacher B who mentioned that feedback from the learners could help teachers plan their lessons more effectively around deep mathematical ideas.

In the above views of the teachers, questioning seems to be important for both learners and mathematics teachers. For instance, it could help learners to learn and understand mathematics concepts and help teachers evaluate the objectives of the lesson**.**

Learners themselves also had views about the importance of them posing questions. One of the learners (P12) in Section 6.5.1 revealed that asking and answering questions in the class gives him the opportunity to share his ideas on the mathematics concept: The learner believed that questions and answers in mathematics classes keep learners engaged by motivating them to build upon and improve their present knowledge as they provide explanations that assist them in solving the maths assignment at hand (P12). A similar comment of P1 (16f) was that questioning could probably help learners to construct mathematics ideas in the class and gain better understanding of mathematics concepts.

Student P8, in Section 6.5.1explained that asking and answering questions in the class makes him to understand mathematics problems. The learner felt that it was important that they have a chance to explain their ideas in a mathematics class. For instance, when the learners ask questions, they are developing personal understanding of a mathematics concepts ***(P8).***

A learner (P9) also felt that the act of asking questions focuses the attention of learners on concepts, main ideas, and checking if concepts are understood and clarifying doubt while learning mathematics in the class. This view was also captured in the comments below:

Both learners and teachers displayed positive views about the value of learners posing questioning. As presented in the literature review in chapter two, the argument is made that teachers or mathematics teachers at senior secondary school level need more opportunities to increase their content knowledge in mathematics before they can successfully incorporate student-centred instructional practices in the classroom (Bansilal, 2012). Umugiraneza et al.;

(2017) call for more research into student-centred instructional practices which includes: teacher questioning and explanation, co-operative learning, and problem-based instructional practices in teaching and learning of mathematics. They further argue that incorporating a variety of instructional practices in the teaching and learning of mathematics, can accommodate a range of learners' learning style preferences which can also contribute to learners' achievement in mathematics. Umugiraneza et al.; (2017) also emphasise that some instructors or mathematics teachers are familiar with progressive teaching techniques such as group projects, experiments, and classroom discussions, but they tend to place more emphasis on expository, chalk-and-talk, and question-and-answer techniques. Yet, active teaching techniques like problem-solving, exploration, the discovery method, and collaborative learning are more effective than conventional methods in the teaching of mathematics because they help learners develop a deeper conceptual understanding (Ndlovu, 2019).

Vygotsky (1978) asserts that a person's mental operations are started by active social interaction with adults and more capable peers. Thus, an excellent instructor is required for effective learning. Clements and Battista (1990) also maintain that a constructivist classroom is one in which learners actively participate in knowledge exchange while interacting socially with one another under the direction and supervision of a constructivist instructor. The constructivist teacher should also give assignments that are relevant and suitable and provide opportunity for student discussion (Clements & Battista, 1990).

Teachers or mathematics teachers should ensure that their instructional practices should promote student learning in a constructivist classroom and build up mathematical knowledge by observing and reflecting on the teaching and learning in the classroom (Bansilal, 2012). Sofroniou and Poutos (2016) comment that student-centred instructional practices allow learners to develop a variety of analytical, communicative, and critical thinking abilities, encourage active learning and boost learners' achievement in mathematics.

7.5.2 Learner-Centred Classrooms Facilitate Learning.

For some participants, student-centred instruction gives teachers the opportunity to take on the role of a facilitator in the teaching and learning of mathematics. Some participants also believed that in order for teachers to effectively play the role of a facilitator in the teaching and learning of mathematics, they needed to have a thorough awareness of both the subject matter they were teaching and the learning and understanding of their learners. For instance, Teacher A in Section 6.5.1 explained that a teacher needs to find opportunities to allow learners to work on their own and this helps them develop the confidence to work on their own he plays the role of a facilitator in the class:

The teacher's comment highlights that when mathematics teachers take on the role of a facilitator, this enhances learners' knowledge, understanding and confidence of mathematics concepts. As a learning facilitator, the teacher's job shifts from imparting knowledge to encouraging self-learning, supporting the growth of learners' critical-thinking abilities, and assisting them in building mathematical knowledge that may have an impact on mathematics achievement. TA described the development of his own thinking with respect to facilitating student learning. He stated that in the beginning he felt that he was the main person responsible for learners' success. He has since changed his mind and understands that learners must be accountable for their own learning. It is only at the stage when they have developed the confidence that they can work on their own, that they are ready to take up that responsibility. The teacher seemed to be comfortable with granting the learners the opportunity to explore the mathematics tasks by themselves.

Some participants believed that in order for teachers to effectively play the role of a facilitator in the teaching and learning of mathematics, they needed to have a thorough awareness of both the subject matter they were instructing and the learning and understanding of their learners. Teacher B in Section 6.5.1 emphasised that learners can learn mathematics best by constructing their knowledge individually or in group as seen in this response:

The teachers' responses show that developing the skills to plan and implement learner-centred teaching takes a long time and much effort. It is often the invisible work behind the teaching that makes it work. A study by Ndlovu (2019) in Swaziland found that teachers believed they were using learner- centred teaching, but in fact all they did was give learners a task to work on, while they sat in groups. There was no other planning- hence some learners worked on their own and solved the problem while the others just looked around and were not engaged meaningfully. Implementing learner- centred teaching requires a big shift in their mind-set and courage to allow their learners the space to work on their own. As teachers engage in reflection about how learners can be supported in their learning, they start making this shift. From the literature it is also very clear that consistent reflection will not only positively impact learners' achievement in mathematics but will also bring to light issues that need attention and provide opportunities for both learners and teachers to reflect on their basic ideas in mathematics activities and interact with each other in finding solutions to mathematics problems (Bansilal, 2015; Passarelli & Kolb, 2012) revealed that learning occurs through reflective connected experiences in which knowledge or mathematics knowledge is constructed based on teacher effectiveness, as well as effective practices and learning experiences in the classroom.

7.5.3 Importance of sharing ideas and having discussions amongst peers

Both teachers and learners emphasised in Section 6.5.2 That one of the important benefits of using student- centred learning activities, was the sharing of ideas and discussions that take place amongst the peers.

Alegre et al.; (2019) observed that co-operative learning improves achievement of learners, and the authors also suggest that instructional practices used by teachers provide opportunities for learning in the classroom setting. The authors also interestingly reveal that collaborative learning approaches are useful to enable learners to take part in discussion, reflection, feedback and to combine learning, clarify understanding and explore ideas and concepts. A review by Alegre et al; (2019) focused on studies about collaborative learning and learners' achievement in mathematics and identified practices which could facilitate more effective group work be more effective in learning. The authors revealed that group work is most useful when learners are taught how to work in groups, to present, to provide and to accept assistance. These conditions for successful group work are important for teachers to consider, because one cannot just form groups and expect that learners will automatically learn if they sit in groups. As seen in this study, learners and teachers endorse group work, however they do need to go beyond just class discussions and actually plan the organisation and activities of the group (Alegre et al.; 2019). However, as pointed out in Section 7.4.2, the success of collaborative work is largely dependent on the planning and organising that takes place beforehand. The role and duties of the group members need to be spelt put and the teacher has to carefully select and sequence the tasks.

7.5.4 The importance of listening and reflecting on mathematics content.

One other important aspect of learning mathematics is learners' interest in working on mathematics tasks on their own, to gather (assimilate) information on mathematics activities through effective listening and thinking about reasonable ideas on the mathematic concepts. The number of research studies carried out over recent years has increased noticeably in this field of mathematics particularly at the secondary school levels (Johnson & Johnson, 2014). Sofroniou and Poutos (2016) agree that substantial research within the mathematics education sector indicates that employing student-centred instructional practices for various activities and exercises does lead to constructive and beneficial achievement for learners. Bansilal and

Rosenberg (2011) argue that reflection has been a guiding principle in the conceptualisation of instructional practices within mathematics classrooms. They contend that teachers' reflections provide learners with insights into reflective instruction practices needed in learning and teaching of mathematics (Bansilal & Rosenberg, 2011). Agoro; (2013) asserts that reflective instruction is important specifically in teaching graduating senior secondary school learners in a developing country like Nigeria, where textbooks are not available and the available ones are beyond the reach of many teachers who have little or no access to professional benefits and adequate instructional materials (Agoro 2013) Thus, the transformation tool in enhancing mathematics competencies and mathematics academic achievement of learners is reflective instructional practice (Agoro, 2013; Bansilal & Rosenberg, 2011).

7.6 LEARNERS AND TEACHERS' PERCEPTIONS OF INSTRUCTIONAL STRATEGIES AND MATHEMATICS ACHIEVEMENT

In this sub section, the discussion from the interviews with learners and teachers are addresses the fourth research question: What are learners' and teachers' perceptions of effective instructional practices?

The findings elated to this research question are arranged according to three themes expressed in the headings of the sub-sections

7.6.1 Teacher questioning practices in the mathematics classroom

During the interviews teachers and learners were asked about the instructional practice they preferred in the learning and teaching of mathematics in the class. Both learners and teachers revealed that they liked to share the focus of mathematics concepts together and interact equally with emphasis on the teacher questioning practices, active listening practices, and teacher explanations in the mathematics classroom (See section 6.6.3).

According to Umugiraneza et al. (2017) teaching styles and assessment practices are key factors that contribute to the improvement of learners' academic achievement in mathematics. The authors further argued that teaching practices which are in general based totally on "teacher talk", do not involve a whole lot of questioning, discussions, or learner improvement of understanding. To accomplish the above goal, Umugiraneza et al. (2017) proposed that student-centred instructional practices remain effective pedagogical practices that support and enhance learners learning both in mathematical reasoning and problem-solving skills. It is important that teachers provide opportunities for learners to demonstrate what they have learned since the recognition of their intellectual growth and contributions to the learning and teaching of mathematics in the classroom can enhance their achievement in mathematics.

The facilitation of learning is also one of a teacher's responsibilities, as was covered in chapter two. The teacher must possess the following qualities to be effective in this role: the ability to inspire learners to study, to accept full responsibility for their education, to interact with learners, and to assist learners in their quest for meaning (Ndlovu, 2019). The author also stated that the adoption of proper questioning tactics that would allow for meaningful learning among learners, is central to all the qualities listed above. In other words, the teacher must select appropriate questions that are pertinent to the task at hand in order to support learners' constructions of mathematical knowledge (Ndlovu, 2019). To improve learners' achievement, the mathematics teacher needs to improve his or her ability to ask probing questions. Marzano et al., (2001) assert that teachers who use questioning in the classroom are more successful than those who do not. Learning is made possible as a result of the teacher's questions, which encourage learners' engagement and mathematical thinking. This implies, in a way, that good inquiry can result in worthwhile learning (Ndlovu, 2019). Classroom teachers can also employ four basic forms of questioning to encourage effective learning (Badham, 1994). One of the four types of questioning that the author identified is the simple inquiry, the initial type of questioning expected from the teacher or mathematics teacher. These inquiries essentially guide learners' thinking toward the new information, and they ask for a variety of responses from learners in order to spark a conversation (Badham, 1994).

7.6.2 Allowing learners to engage in Active listening practices in the mathematics classroom.

When both teachers and learners were asked what types of instructional practices and learning activities they preferred in teaching and learning mathematics, some learners and teachers stated that learning and teaching mathematics by listening is effective, and works well in generating ideas during mathematics lessons, making links to what they already know which enhances their engagement on mathematics activities in the class (see Section 6.4.4). Learner P3 made a comment about her ability to comprehend and construct mathematical ideas through active listening in the mathematics classroom:

> *Some learners also explained that to get the most from mathematics lessons, they had to listen and attend to what both teacher and other learners were saying so that they could understand the ideas shared and be able to respond with comments or questions to enhance their understanding of the mathematics concept…(p3)*

Some of the teachers also believed that active listening could help learners gain a better understanding of mathematics concepts. They articulated that one of the contributing factors that could enhance learners' competence in mathematics concepts, was to listen carefully in the class. In support of this expressed concern, some teachers said that learners who are exposed to instructions that emphasise flexible listening and thinking, can also develop competence in mathematics. For instance, Teacher B in Section 6.5.4 seemed to believe that instructional practices that focus on learners' learning and developing understanding on mathematics concepts, allow learners to listen and think about ideas in the teaching and learning of mathematics at secondary school level.

Teacher C in Section 6.5.4 emphasised that there are categories of learners who preferred to learn mathematics in the class through effective listening and generating ideas rather than discussing ideas without adequate information on the concept. The teacher reported that these learners did not waste time asking a lot of questions about the mathematics activities in class:

The comments made by the teachers and learners suggest that despite their descriptions about the effectiveness of learner- centred classrooms, both teachers and learners believe that the role of learners is to listen to what the teacher has to say. Research suggests that classrooms in many countries are still dominated by expository teaching (Chisholm & Leydendecker, 2008; Umugiraneza et al., 2017). This study which shows that teachers and learners believe that listening is a very important part of learning, suggests that the teachers also prioritise expository teaching in their classrooms.

7.6.3 Teacher explanations in the teaching and learning of mathematics.

Responses from some mathematics teachers revealed that explanation is an instructional practice used for describing relevant mathematics concepts, developing learners' logical thinking and guiding learners as they share mathematics ideas together in the classroom.

Umugiraneza et al. (2017) emphasised that teacher explanations helped to facilitate feedback about learners' comprehension in mathematics lessons. Good and Lavigne (2017) argued that teachers make more of an impact on learners than others do because teaching is demanding and requires many skills, much knowledge and ability to reflect and to improve instruction. Indeed, Farrell (2017) noted that teachers can gain a lot of insight related to their practice as a result of engaging in reflective practice in teaching and learning in mathematics. Such an approach requires teachers or mathematics teachers to have a range of skills, as well as a sound knowledge of mathematics content in teaching senior secondary school learners (Umugiraneza et al. 2017).

In conclusion, nearly all the learners interviewed specified that they preferred the Diverger learning style which emphasises comprehensive explanation of a mathematics concept by their teachers and classmates before they could construct their own understanding of mathematics concepts during mathematics lessons in the classroom. The teachers also emphasised that teacher explanations helped to facilitate learners' comprehension and also revealed feedback on learners' comprehension in mathematics lessons. Good and Lavigne, (2017) also argued that teachers make more of an impact on learners than others do because teaching is demanding and requires many skills, much knowledge, and ability to reflect and to improve instruction. Indeed, Farrell (2017), noted that teachers can gain a lot of insight regarding their practice as a result of engaging in reflective practice in teaching and learning in mathematics. Such an approach requires teachers or mathematics teachers to have a range of skills, as well as a sound knowledge of mathematics content in teaching senior secondary school learners (Umugiraneza et al., 2017).

The comments by the teachers and learners also suggest that expository teaching is a dominant feature of the classrooms in his study, supporting other studies that teachers seem to prefer to talk while learners listen (Umugiraneza et al., 2017; Chisholm & Leydendecker, 2008; Nodlovu, 2019). Yet research consistently points out the importance of more learner engagement in their own learning (Umgiraneza et al., 2017; Khuzwayo & Bansilal, 2012). Authors have called for teachers to be more alert to learners' needs by learning how to listen, rather than expecting learners to listen all the time (Khuzwayo & Bansilal, 2012). Granting a learner, a voice presupposes a willingness on the part of a teacher to listen which is hard for teachers since they are used to talking (Khuzwayo & Bansilal, 2012). Effective teaching by listening depends on learners trusting, respecting and valuing the teacher.

7.7 CONCLUSIONS

The current study did not conclusively rule out the possibility that there may be a relationship between preferred learning styles and the mathematics achievement of learners graduating from senior secondary school in a district of Delta State, Nigeria. However, the study did not offer strong evidence against the existence of such relationships. It did, however, make it abundantly clear that careful precautions must be taken in future studies examining learners' mathematics achievement and preferred learning styles to avoid bias caused by the research design and to avoid any missing or incorrect data which was discovered during this study's quantitative phase.

The results of this study support the realism, actuality, and efficacy of differences in learning style preferences and instructional practices, at the very least, and they highlight some crucial ways in which teachers might assess the processes. The Kolb's Learning Style Inventory (KLSI; Kolb, 1984) was a useful tool for assessing learners' learning style preferences and could easily provide teachers with informative data regarding both their learners' learning style preferences and their teachers. The teachers may start to consider how their instruction may or may not fulfil the needs of the learners under their supervision and then to initiate interventions as a result of this understanding, which could cause them to pay more attention to the instructional practices and delivery methods used in the classroom (Wilson, 2011).

The findings from the quantitative and qualitative phases are presented and analysed in this chapter. The findings provide explanations for the learners' preferred dominant learning styles, hence providing answers to research question one. The study also answered research question two, which examined the relationship between preferred learning style dimensions and mathematics achievement of the participant learners. Research question three was answered when the researcher examined the association between the participant learners' mathematics achievement and their gender, age and school they attended. The qualitative questions about how learners' and teachers' perceptions of successful learning practices impact mathematics learning as well as learners' and teachers' perceptions of effective instructional practices in mathematics learning and teaching were combined in the aforementioned section.

Based on the findings summarised earlier in this chapter, the following conclusions are made in the current study;

- The result of the qualitative study showed that learners applied various learning style preferences during mathematics lessons in the classroom such as Assimilator, Diverger, Converger and Accommodator. The Diverger learning style preference was found to be the dominant learning style amongst learners according to the quantitative results. The Diverging learning style refers to the ability to learn through existing classroom experience and the tendency to reflect continuously on the information received in the class.

- There is no significant difference between the learning styles of male and female learners.
- Some learners indicated features from different learning styles. It seems that there are certain features of the learning styles that some learners take up at different points. This suggests that the assumption behind the Kolb's learning style inventory that every learner has a single learning style, may not necessarily hold true.
- Kolb's learning style preferences as articulated by learners was not statistically significantly related to mathematics achievement of learners.
- The results do not indicate a statistically significant relationship between learning style preferences and gender.
- The results do not indicate any statistically significant association between age and mathematics achievement
- Teachers and learners suggested that certain classroom practices lead to effective learning such as learner questioning, learner -centred classrooms, collaborative learning practices as well as being able to listen and reflect on mathematics content.
- Teachers and learners also endorsed some instructional practices as being effective. These included teacher questioning, creating opportunities for engagement in active listening practices as well as sound teacher explanations

7.8 IMPLICATIONS OF THE STUDY

The idea of learning style preferences still appeals to educators despite the lack of empirical evidence reported in this study which is consistent with several earlier research investigations. A potential benefit of implementing learning style research in the classroom is that it helps teachers and learners gain a better knowledge of the distinctive qualities of each individual student. Other studies that acknowledge the multifaceted nature of learners' learning style preferences and the instructional practices required to promote student-centred learning rather than tailor instruction to a specific student learning style preference (Evans et al., 2011) confirm the complexity of learning style preferences (Wilson, 2010). The Kolb's learning style inventory characterises the modes by which learners can learn and understand concepts in mathematics. Then, teachers can utilise that information to keep an eye on their lessons, making sure they are using a range of instructional techniques.

An important consideration also is the teachers' style of teaching or instructional practices to accommodate learners' diverse learning style preferences. This consideration may help break the cycle of poor achievement by considering learners' learning style preferences in learning mathematics. In addition, these theories provide a framework that enables teachers to knowledgeably develop a variety of instructional practices to benefit all learners and enhance their achievement, particularly in mathematics.

7.9 DELIMITATIONS AND LIMITATIONS

The researcher tried to employ trustworthy sites and methods in the current study, with the learners and teachers adhering to their regular academic routines. However, this had a significant impact on the researcher's ability to manage the study's variables and led to substantial restrictions that had an impact on the outcome. Additionally, the researcher's restricted resources had an impact on the data and the conclusions that followed. The study's boundaries as well as its limitations in terms of research design and data were explored in the paragraphs that follow.

7.9.1 Delimitations

Around 171 senior school graduating learners from three schools in the Delta North Senatorial District of Nigeria's Delta State participated in the study, along with three teachers. These schools were chosen because of their close proximity to the researcher's house. The learning styles survey and the mathematics achievement test were administered to all participants who had submitted the required consent forms. After that, 16 learners and three teachers took part in the study's qualitative phase (individual interviews). No volunteers were accepted or rejected based on their gender, age, or any other demographic distinction.

7.9.2 Limitations in Design

The study's design had many flaws despite the effort to conduct rigorous research, principally because participants were selected through convenience sampling. Due to the researcher's decision to not apply a random technique for participant selection, there may be differences between the observed sample and the overall population (McDevitt et al., 2010; Wilson, 2011). I made an effort to maximise the resulting challenges to internal and external validity by incorporating a large sample size of around 171 learners and three mathematics teachers from the three public secondary schools from Delta North Senatorial District in Delta State, Nigeria. It is important to remember that only schools with comparable demographics and class systems may generalise the study's conclusions.

The instrumentation used to collect data on learners' mathematics achievement represents another risk to the study's internal validity. The researcher-made achievement test instrument subjected itself to lower levels of reliability than might be found in instruments using a more objective approach with prior testing in other studies (Boone & Boone, 2007). The study was therefore constrained by the learners' incapacity to attempt some of the questions, the criteria used to gauge the learners' achievement level, and the researcher's inability to compile the data objectively. In order to diminish this risk, teachers instructed learners on how to complete the learning style inventory and the mathematics achievement test. Despite the above effort, learners' responses could not provide enough evidence of their actual inclination towards learning style preferences in their mathematics achievement.

In conclusion, history and development could both have the potential to have an impact on the study because pupils were developing and changing over time (Wilson, 2011). Events at schools, homes, communities, and even on a national or international scale could have influenced learners' efforts or interest in school and achievement, changing the data collected and, consequently, the study's conclusions (Wilson, 2011). On the subject of learning style development, there is also disagreement. Some claim that learning style traits are fixed, while others argue that they are stable but not fixed, and still others assert that learning style traits are fluid and constantly change as people grow older and are exposed to different influences (Oki, et al., 2011; Wilson, 2011). In this study found that the learning styles are fluid.

7.9.3 Limitations in Data

There were some limitations affecting the precision and use of the data generated in addition to the design limitations. During the time that the study was conducted, preparations for the West African Senior Secondary School Certificate Examination (WASSSCE) leading to the end of secondary school education in Nigeria. Therefore, they may have been distracted by the thoughts of the examination and may not have given their full attention when responding to the questionnaires and the interviews. Another limitation was that the researcher was delayed in the USA because of the COVID pandemic and hence the analysis of the data and write-up of the thesis were delayed considerably.

The lack of understanding of the learning style survey by different learners engaged in the study is another limitation of the data (Gokalp, 2013; Wilson, 2011). Learners' lack of awareness of learning style preferences may have affected their responses to the learning style inventory and achievement test, possibly providing incorrect assessment of these variables Some components of the inventory like, "I tend to address problems using a step-by-step approach", were simple to identify, while others required considerably more effort for learners to connect with in relation to the rating scale..

Finally, obtaining consent and assent forms from each student who took part in the quantitative portion of the study, was another barrier for the researcher. This essential stage of the study took a longer time than originally anticipated.

The following section addresses the conclusions and recommendations that ~~was~~ were made in this study as a result of this research investigation.

7.10 RECOMMENDATIONS

The study has shown that learners use different learning styles when learning mathematics and not all of them have single preferences. Although the study was not able to determine any associations between learning style preferences and mathematics achievement, what was clear was that there are different learning practices that are used by learners. The study also found that some learners move between different learning styles.

7.10.1 Recommendations for teachers to enhance learning and teaching.

One of the things that teachers could do would be to discuss different practices that learners use for their learning and affirm that different learners have different preferences, and they should not feel compelled to follow a particular style. It may help if teachers can assist learners in identifying their learning style preference with learning style inventory - this would be informative for both learners and teachers. When this information is collected, the teachers will learn more about the range of learning practices that their learners use. Teachers could ask the learners to complete the learning style questionnaire in Appendix (B) and then study the different learning practices endorsed by each style. The teacher should make sure that there are opportunities to use the different practices as described in Table 7.1 and shown again below. It is the practices embedded within Kolb's learning styles that are important. Although this study did not find definitive findings related to achievement, it determined that there are a range of learning practices that learners use.

Table 7.1: Student learning style profile.

Learning Style	Associated Learning practices

Diverger (CE-RO)	Involve yourself fully, openly, and without bias in new experiences during lesson. Reflect on and observe those experiences from many perspectives. Focus on understanding the meaning of ideas and situations by carefully observing and describing them. Consider and reflect on your understanding and show concern to what is true and how things happen in the class. Attend classes regularly, discuss your ideas with fellow classmates, and participate in group discussions during lesson.
Assimilator (AC-RO)	Engage in learning by articulating why and how the concepts occurred. Try to reflect, observe, and critically examine both teachers' explanations and your experiences of the activities from all perspectives. Develop reasonable thoughts, verbalize these thoughts during lessons in classrooms. Relate to others in the group and compare experiences and opinions to achieve greater understanding of classroom instructions. Have confidence that your teachers are there to promote an atmosphere of acceptance of your diverse thinking. Relate the observations and reflection made during lessons and use both logic and ideas to understand learning activities in the classroom.
Converger (AC-AE)	Engage in practical applications of your ideas generated during classroom lessons. Try to be very reasonable and active in the classroom. Engage in activities such as projects, homework and small group discussions on learning activities. Apply logic and a systematic approach to solving problems. Develop an interest in finding practical ideas and theories leading to solutions to problems particularly in science subjects.
Accommodator (AE-CE)	Develop abilities in carrying out plans and experiments and always get involved in new experiences in the classroom. Have an interest in hands-on experiences especially in science-oriented activities. When learning, have confidence in your feelings rather than logical analysis when it comes to problem solving especially in science-oriented subjects.

It is difficult for even the most knowledgeable teachers to know the range of learning styles preferred by preference of their learners by observation alone, and the questionnaire may help teachers understand more about the range of practices used by their learners.

The study has also shown that there are various instructional practices that were endorsed by teachers and learners. Hence it is important for teachers to make use of relevant and effective instructional strategies in their mathematics classrooms.

7.10.2 Recommendations for educational management

School and district management should also try to help teachers to better understand the different learning practices that learners prefer while also emphasising the need for teachers to reflect on their instructional strategies. In order for teachers to improve their instructional strategies, they need support in the form of workshops as well as support in the form of suitable resources. It is recommended that schools and district managers endeavour to invest in their teachers so that the learning and the teaching environment can be improved. Some of the suggestions are that they:

- take steps to make sure that teachers are experienced, competent and have strong subject knowledge;
- ensure that teachers are encouraged to apply effective instructional practices capable of accommodating various learning style practices of learners during lessons in the classrooms;
- help teachers understand the substance of learner- centred classrooms;
- help teachers design and implement learner- centred activities;
- ensure that teachers are able to give attention to all learners and encourage learners to ask and answer questions in order to clear their difficulties;
- encourage teachers to apply the use of various teaching aids and resources beyond just the chalkboard;
- encourage teachers to introduce lessons to learners keeping in mind, individual differences, environment and experiences;
- encourage teachers to keep in mind the principle of reflective thinking during lessons, which would allow teachers to teach the learners in such a way that their previous knowledge can be connected to their new knowledge;
- ensure that teachers understand that the teaching and learning process should be a fun process, which requires learner-centred practices;

- encourage teachers to use group work in their classrooms effectively so learners can work collaboratively to achieve a common goal during lesson; and
- encourage teachers to make sure that learners in the group are responsible for sharing their opinions, ideas, and that they work together particularly during mathematics lessons.

7.10.3 Recommendations for learners

Learners are encouraged to:

- reflect on and observe the learning activities from many perspectives during lessons;
- engage in learning by articulating the concepts encountered during lessons;
- try to reflect, observe, and critically examine both teachers' explanations and their experiences of the activities from all perspectives in the classrooms;
- try to verbalise and share their thoughts during lessons in classroom;
- relate to others in the group and compare experiences and opinions to achieve greater understanding of classroom instructions;
- engage in practical applications of the ideas generated during classroom lessons; and
- have confidence about their feelings and thoughts rather than rely only on the teachers' explanations when solving problems.

7.10.4 Recommendations for further research

The purpose of this study was to explore the relationship between learning style preferences and instructional practices on academic achievement of graduating senior secondary school learners in some selected secondary schools. The specific populations under exploration were boys and girls in three mixed secondary schools and their mathematics teachers. The intention was that this study would inspire additional research in the learning and teaching of mathematics, to address the poor mathematics achievement of learners in West African Senior Secondary School Certificate Examination, as well as learners learning style preferences and instructional practices used during lessons in the classroom.

The quantitative portion of this study's findings revealed that there is no connection between preferred learning styles and achievement in mathematics. However, this study could be extended by considering items in the mathematics assessment which involve different levels of difficulty, and which include items requiring algebraic reasoning as well as geometric or visual reasoning. The items in this achievement test were taken from previous examination papers which have a focus on symbolic manipulations. Perhaps including other more open-ended questions may achieve a different result.

In the light of the results of this study about the ambiguity of learners learning style preferences according to the LSI, it would be interesting to administer the inventory at two different times and to then compare if learners fall into the same or different learning style groups on the two occasions.

A qualitative research strategy, like a case study, may advance knowledge in the area of learning style preferences by giving the researcher the chance to observe regular interactions between learners and teachers and the relationship between learning style preferences, instructional practices, and student achievement in the classrooms where learners may succeed academically or fail (Wilson, 2011). Furthermore, a multi-case research study would enable the researcher to observe student responses to the instructional practices used by the teacher as well as any additional effects that might come about as a result of such instructional practices during lessons. This type of thorough investigation is required to comprehend the daily practices of effective teachers (Ormrod, 2010; Wilson, 2011). Although less robust scientifically than a quantitative analysis, these techniques may be more useful for researching learning style preferences because it is by nature an individualisation-focused topic (Lauria, 2010; Leedy & Ormrod, 2010; Wilson, 2011).

This study has also shown the importance of qualitative research in trying to learn about learner and teacher preferences about learning practices and teacher instructional strategies. It is therefore recommended that further studies be conducted about learners' understandings of the LSI and their perceptions of effective teaching. Learners may articulate their perceptions differently from those captured in the LSI.

7.11 CONTRIBUTION OF THE STUDY TO NEW KNOWLEDGE

The study on learning style preferences, instructional practices and academic achievement of learners with a particular reference to mathematics in Nigeria is significant in various ways. An original inventory of the most widely known approach to assessing learners' learning style preferences (Kolb, 1984) was adapted and used to determine learning style preferences of learners. Although the quantitative phase of the study indicated no statistically significant relationship between learning style preferences and academic achievement, the qualitative phase of the study identified instructional practices teachers can utilise to enhance learning and academic achievement of learners at school.

The following are some of the discoveries that are particularly relevant:

- The most preferred learning style was Diverger, followed by the Assimilator, Accommodator and Converger. There were no statistically significant relationships between the four learning style preferences and mathematics academic achievement. While the current study did not provide conclusive evidence of any existing relationship it also did not provide conclusive evidence that such a relationship might not exist. It showed that additional studies examining learning style preferences need to be cautious in order to guard against the data issues identified in this study.
- Differences were found between the four learning style preferences. Knowing how learners learn could help teachers plan and introduce lessons to learners keeping in mind, individual difference, environment and experiences.
- The study also suggested instructional strategies based on the findings to improve learners' academic achievement and learning processes.

Consequently, the study contributes significantly to our understanding of how mathematics is learned and taught in Nigeria.

REFERENCES

Adamu, L. E. (2015). The Relationship between Scores of Mathematics Knowledge and Teaching Practice of Diploma Mathematics Learners: A Quest for Quality Assurance. *Journal of Education and Practice*, 6(19), 179-183.

Adnan, M., Abdullah, M. F. N. L., Ahmad, C. N. C., Puteh, M., Zawawi, Y. Z., & Maat, S. M. (2013). Learning style and mathematics achievement among high performance school students. *World Applied Sciences Journal*, *28*(3), 392-399.

Agoro, A. A. (2013). Effect of Reflective-Reciprocal Teaching Strategies on Pre-service Teachers' Achievement in Integrated Science and Science. Process Skills in Nigerian Colleges of Education (Doctoral dissertation).

Akinyode, B. F., & Khan, T. H. (2016). Learners' learning style among planning learners in Nigeria using Kolb's learning style inventory. *Indian Journal of Science and Technology*, 9(47), 1-13.

Alade, O.M., & Ogbo, A.C., (2014). A Comparative Study of Chemistry Learners' Learning Styles Preferences in Selected Public and Private Schools in Lagos Metropolis. *IOSR Journal of Research & Method in Education (IOSR-JRME)*. E-ISSN: 2320-7388.

Alegre, F., Moliner, L., Maroto, A., & Lorenzo-Valentin, G. (2019). Peer tutoring and mathematics in secondary education: literature review, effect sizes, moderators, and implications for practice. *Heliyon*, 5(9).

Alzain, A., Clark, S., Ireson, G., & Jwaid, A. (2018). Adaptive education based on learning styles: Are learning style instruments precise enough? *International Journal of Emerging Technologies in Learning, 13*(9), 41-52.

Andreou, C., Papastavrou, E., & Merkouris, A. (2014). Learning styles and critical thinking relationship in baccalaureate nursing education: a systematic review. *Nurse education today*, 34(3), 362-371.

Attard, C. (2017). Teaching mathematics through picture books. *Scan: The Journal for Educators*, *36*(4), 6-9.

Babbie, E. (2010). Research design. The practice of social research, 12, 90-123.Badham, V. (1994). what's the question? Primary Association for Mathematics (Vol. PA Mphlet 23). Australia.

Banaga, A., & Fabella, F. E. (2018). Learning Style and Mathematics Anxiety of Calawis National High School Students. *Available at SSRN 3277772*.

Bansilal, S & Lephoto, T. (2022) Exploring Particular Learner Factors Associated with South African Mathematics Learners' Achievement: Gender Gap or Not, *African Journal of Research in Mathematics, Science and Technology Education*, 26(2), 77-88 DOI: 10.1080/18117295.2022.2057730

Bansilal, S. (2010). How much freedom does a teacher have in designing a learning event when adhering to assessment prescription? *Education As Change, 14*(1), 77-90.

Bansilal, S. (2015). Exploring student teachers' perceptions of the influence of technology in learning and teaching mathematics. *South African Journal of Education*, On-line version ISSN 2076-3433 Print version ISSN 0256-0100 S. Afr. j. educ. vol.35 n.4 Pretoria Nov. 2015. http://dx.doi.org/10.15700/saje.v35n4a1217.

Bansilal, S. Webb, L. & James, A. (2015). Teacher training for mathematical literacy: A case study taking the past into the future. *South African Journal of Education*, *35*(1), 1-10

Bansilal, S., & Rosenberg, T. (2011). South African rural teachers' reflections on their problems of practice: Taking modest steps in professional development. *Mathematics Education Research Journal*, *23*(2), 107-127.

Bansilal, S., Brijlall, D., & Trigueros, M. (2017). An APOS study on pre-service teachers' understanding of injections and surjections. *The Journal of Mathematical Behavior*, *48*, 22-37.

Bansilal, S., Lephoto, T., North, D., & Zewotir, T. (2022). Exploring the association between teacher-related factors and Grade 9 mathematics achievement. *South African Journal of Education,* 42(Suppl. 1): Art. #2091. https://doi.org/10.15700/saje.v42ns1a2091

Barkatsas, A. T., Kasimatis, K., & Gialamas, V. (2009). Learning secondary mathematics with technology: Exploring the complex interrelationship between learners' attitudes, engagement, gender and achievement. *Computers & Education*, *52*(3), 562-570.

Bature, I. J., Jackson, J. J., Kemi, A., Shol, D. R., & Sabo, N. (2015). Introducing Productive Pedagogies to Nigerian Mathematics Classroom through Collaborative Action Research Using a Community of Practice Approach. *International Journal of Learning, Teaching and Educational Research*, 11(3).

Bethel-Eke, G. & Eremie, A. (2017). Learning Styles and Academic Performance of Junior Secondary School Student in Rivers State: Implications for Counselling. *International Journal of Innovative Development & Policy Studies 5*(3), 52-61.

Bhatti, R. U., & Bart, W. M. (2013). On the effect of learning style on scholastic achievement. *Current Issues in Education*, 16(2).

Biabani, M., & Izadpanah, S. (2019). The Study of Relationship between Kolb's Learning Styles, Gender and Learning American Slang by Iranian EFL Learners. *International Journal of Instruction*, *12*(2), 517-538.

Bishka, A. (2010). Learning styles fray: Brilliant or batty? *Performance Improvement*, *49*(10), 9-13.

Boone Jr, H. N., & Boone, D. A. (2007). Problems Faced by High School Agricultural Education Teachers. *Journal of Agricultural Education*, *48*(2), 36-45.

Boston, P., Bruce, A., & Schreiber, R. (2011). Existential suffering in the palliative care setting: an integrated literature review. *Journal of pain and symptom management, 41*(3), 604-618.

Boud, D. (2012). Relocating reflection in the context of practice. In Beyond reflective practice (pp. 25-36). Routledge.

Brodie, J. P., & Strader, J. (2006). Extragalactic globular clusters and galaxy formation. Annu. Rev. Astron. Astrophys., 44, 193-267.

Brodie, K., Lelliot, T., & Davis, H. (2002). Forms and substance in learner-centred teaching: Teachers' take-up from an in-service programme in South Africa. *Teaching and Teacher Education, 18*, 541-559.

Brookfield, S. (1995). Adult learning: An overview. *International encyclopedia of education*, *10*, 375-380.

Brün, H., Fisher, A., Von Foerster, H., Von Glaserfeld, E., Goldschmidt, H. L., Jones, C., ... & Rose, D. (1984). Book-Conference, First Installment, Summer 1984.

Buaraphan, K. (2015). Grades 1-12 Thai students' learning styles according to Kolb's model. *Asian Social Science*, *11*(10), 186.

Bussotti, L & Bussotti, P. (2017). Understanding mathematics teaching and learning "in their full complexity"; *Problems of Education in the 21st century.* *75*(5), 434- 451,

Chisholm, L., & Leyendecker, R. (2008). Curriculum reform in post-1990s sub-Saharan Africa. *International Journal of Educational Development*, *28*, 195–205.

Cohen, J. (2013). Statistical power analysis for the behavioral sciences. Routledge.

Cornwell, J. M., & Manfredo, P. A. (1994). Kolb's learning style theory revisited. *Educational and Psychological Measurement, 54*(2), 317-327.

Cox, R. (2013). Environmental communication and the public sphere. Sage.

Creswell, J. W. (2015). Revisiting mixed methods and advancing scientific practices.

Creswell, J.W. (2011). Educational research. New Delhi: PHI Learning Private Limited.

De Stavenga Jong, J. A., Wierstra, R. F., & Hermanussen, J. (2006). An exploration of the relationship between academic and experiential learning approaches in vocational education. *British Journal of Educational Psychology, 76*(1), 155-169.

DeLisi, L. E. (2016). 100 Questions & Answers about Schizophrenia. Jones & Bartlett Learning.

Di Napoli, R. (2004). *What is student-centred learning?*. Educational Initiative Centre. London

Dobson, J. L. (2009). Learning style preferences and course performance in an undergraduate physiology class. Advances in physiology education, 33(4), 308-314..

Donner, L. J., Wyman, B. L., Hemler, R. S., Horowitz, L. W., Ming, Y., Zhao, M., & Zeng, F. (2011). The dynamical core, physical parameterizations, and basic simulation characteristics of the atmospheric component AM3 of the GFDL global coupled model CM3. *Journal of Climate*, 24(13), 3484-3519.

DOROTHY, L. (1996). Function and intention in the calls of non-human primates. In *Proceedings of the British Academy* (Vol. 88, pp. 59-16).

Dossey, A. McCrone, S., & Halvorsen. K. (2016). Mathematics Education in the United States 2016: A Capsule Summary Fact Book (POD). National Council of Teachers of Mathematics, 2016 - Mathematics - 142 pages.

Dreyfus, T., Artigue, M., Potari, D., Prediger, S., & Ruthven, K. (2018). Developing research in mathematics education—Twenty years of communication, cooperation and collaboration in Europe. Oxon, UK: Routledge (ISBN: 978-1-138-08027-0).

Dunn, R., Griggs, S. A., Olson, J., Beasley, M., & Gorman, B. S. (1995). A meta-analytic validation of the Dunn and Dunn model of learning-style preferences. *The Journal of Educational Research*, *88*(6), 353-362.

Ellington, S., & Benders, D. (2012). Learning Style and its importance in Education. Accessed on 27th September 2019 https://www. Research gate. Net/publication/256022625_Learning_Style_and_it's_importance_in_Education.

Else-Quest, N., Hyde, J.S.,& Linn, M.C (2010). Cross-National Patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin,* 136(1), 103-127

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics, 5*(1), 1-4.

Evans, C., & Kozhevnikova, M. (2011). Styles of practice: How learning is affected by learners' and teachers' perceptions and beliefs, conceptions and approaches to learning. *Research Papers in Education*, 26(2), 133-148.

Farrell, T. S. (2017). Research on reflective practice in TESOL. Routledge.

Fatokun, V.F. & Adeniji, K. (2015). Investigating learners' learning styles and memory improvement strategies for effective learning of mathematics and science at tertiary level. *Journal of Research and Reflection in Educational Sciences*, *3*(5), 2056–5852.

Federal Republic of Nigeria (2008). National Policy on Education (4th edition). Lagos: NERDC Press.

Felder, R. M., & Silverman, L. K. (1988). Learning and Teaching Styles in Engineering Education. *Engineering Education*, *78*, 674-681.

Fenwick, T. (2010). Re-thinking the "thing" Sociomaterial approaches to understanding and researching learning in work. *Journal of workplace learning*, *22*(1/2), 104-116.

Field, A. (2013). Discovering statistics using IBM SPSS statistics. Sage.

Firmender, J. M., Gavin, M. K., & McCoach, D. B. (2014). Examining the relationship between teachers' instructional practices and learners' mathematics achievement. *Journal of Advanced Academics*, *25*(3), 214-236.

Garrick, J. (1998). *Informal learning in the workplace: Unmasking human resource development*. Psychology Press.

Geiger, M. A., Boyle, E. J., & Pinto, J. (1992). A factor analysis of Kolb's revised Learning Style Inventory. *Educational and Psychological Measurement, 52*(3), 753-759.

Gogusa, A., & Ertek, G. (2016). Learning and personal attributes of university learners in predicting and classifying the learning styles: Kolb's nine-region versus four-region learning styles. *Procedia-Social and Behavioral Sciences*, *217*, 779-789.

Gokalp, M. (2013). The effect of learners' learning styles to their academic success. *Creative education*, *4*(10), 627.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report,* 8(4), 597-607.

Good, T. L., & Lavigne, A. L. (2017). Looking in classrooms. Routledge.

Green, J., Willis, K., Hughes, E., Small, R., Welch, N., Gibbs, L., & Daly, J. (2007). Generating the best evidence from qualitative research: the role of data analysis. *Australian and New Zealand journal of public health*, 31(6), 545-550.

Greenwood, J. (1993). Reflective practice: a critique of the work of Argyris and Schön. *Journal of advanced nursing*, *18*(8), 1183-1187.

Hall, E., & Moseley, D. (2005). Is there a role for learning styles in personalized education and training? *International Journal of Lifelong Education*, *24*(3), 243-255.

Harden, Crosby, Howie, & Struthers. (2000). Task-based learning: the answer to integration and problem-based learning in the clinical years. *Medical education*, *34*(5), 391-397.

Harden, R. M., & Crosby, J. (2000). AMEE Guide No 20: The good teacher is more than a lecturer - the twelve roles of the teacher. *Medical Teacher*, *4*(22).

Hauserman, C. P., Ivankova, N. V., & Stick, S. L. (2013). Teacher perceptions of principals' leadership qualities: A mixed methods study. *Journal of school Leadership*, *23*(1), 34-63.

Hawk, T. F., & Shah, A. J. (2007). Using learning style instruments to enhance student learning. *Decision Sciences Journal of Innovative Education*, *5*(1), 1-19.

Hobbs, L., & Davis, R. (2013). Narrative Pedagogies in Science, Mathematics and Technology. *Research in Science Education*, *43*(3), 1289–1305.

Honey, P., & Mumford, A. (1986A). The Manual of Learning Styles. 10 Linden Avenue, Maidenhead: Peter Honey. Kolb, D. A. (1984). Experiential Learning: Experience as a Source of Learning and Development. Englewood Cliffs, NJ: Prentice-Hall.

Ibe, H. N. (2015). Effects of learning styles on the performances of senior secondary school biology students. African Research Review, *9*(1), 214-227.

Ignacio Jr, A. G., & Reyes, J. D. (2017). Exploring mathematics achievement goals using Kolb's learning style model. *Asia Pacific Journal of Multidisciplinary Research*, 5(1), 19-24.

Ishak, N., & Awang, M. M. (2017). The relationship of student learning styles and achievement in the history subject. *The International Journal of Social Sciences and Humanities Invention,* 4(3), 3372-3377.

Jahanbakhsh, R. (2012). Learning Styles and Academic Achievement: a Case Study of Iranian High School Girl's Learners. *Procedia - Social and Behavioral Sciences*, l (5). Retrieved from http://www.sciencedirect.com/science/article/pii/S1877042812034209.

Jamshed, S. (2014). Qualitative research method-interviewing and observation. Journal of basic and clinical pharmacy, 5(4), 87.

Jansen, J. D. (1999b). Why outcomes-based education will fail: Elaboration. In: Jansen J & Christie P(eds). Changing curriculum: Studies on outcomes-based education in South Africa (pp. 145- 156). Kenwyn: Juta & Co Ltd.

JilardiDamavandi, A., Mahyuddin, R., Elias, H., Daud, S. M., & Shabani, J. (2011). Academic achievement of students with different learning styles. *International journal of psychological studies*, 3(2), 186-192.

Johnson, D. W., & Johnson, R. T. (2014). Using technology to revolutionize cooperative learning: an opinion. *Frontiers in psychology*, 5, 1156.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. *Journal on Excellence in University Teaching*, 25(4), 1-26.

Jojo, Z. (2019). Mathematics education system in South Africa. Education systems around the world, 1, 129-140.

Jones, L., Othman, M., Dowswell, T., Alfirevic, Z., Gates, S., Newburn, M., & Neilson, J. P. (2012). Pain management for women in labour: an overview of systematic reviews. *Cochrane database of systematic reviews*, (3).

Kablan, Z. (2016). The effect of manipulatives on mathematics achievement across different learning styles. *Educational Psychology*, 36(2), 277-296.

Kablan, Z., & Kaya, S. (2013). Science Achievement in TIMSS Cognitive Domains Based on Learning Styles. *Eurasian Journal of Educational Research*, 53, 97-114.

Karim, M. E., Pang, M., & Platt, R. W. (2018). Can we train machine learning methods to outperform the high-dimensional propensity score algorithm? *Epidemiology*, *29*(2), 191-198.

Karue, N., & Amukowa, W. (2013). Analysis of factors that lead to poor performance in Kenya Certificate of Secondary Examinations in Embu District, Kenya.

Katz, N., & Heimann, N. (1991). Learning style of learners and practitioners in five health professions. *The occupational therapy journal of research*, 11(4), 238-244.

Kazu, I. Y. (2009). The effect of learning styles on education and the teaching process. *Journal of Social Sciences,* 5(2), 85-94.

Kazunga, C., & Bansilal, S. (2020). An APOS analysis of solving systems of equations using the inverse matrix method. *Educational Studies in Mathematics*, *103*(3), 339-358.

Kempen, E., & Kruger. B. (2019). Kolb's learning styles of optometry learners at the University of the Free State, South Africa. *African Vision and Eye Health*. 78(1) p454. DOI: https://doi.org/10.4102/aveh.v78i1.454.

Khalil, M., Farooq, R., ÇAKIROĞLU, E., Khalil, U., & Khan, D. (2018). The development of mathematical achievement in analytic geometry of grade-12 students through GeoGebra activities. *Eurasia Journal of Mathematics Science and Technology Education, 14*(4).

Khuzwayo, H.B. & Bansilal, S. (2012). Granting learners an authentic voice in the mathematics classroom for the benefit of both the teacher and the learner, *Pythagoras* 33(2), 88-94 http://dx.doi.org/10.4102/Pythagoras.v33i2.163

Kolb, Alice Y. and Kolb, David A. (2017) "Experiential Learning Theory as a Guide for Experiential Educators in Higher Education," Experiential Learning & Teaching in Higher Education: Vol. 1: No. 1, Article 7.

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.

Kolb. A & Kolb, D. (2018). Eight important things to know about The Experiential Learning Cycle: https://www.researchgate.net/publication/330993292.

Kozlova, K. (2018). Kolb's Learning Styles: Preferences among Male and Female Learners of English for Specific Purposes. Human and Social Studies. *Research and Practice*, 7(1).

Lau, W. W. F., & Yuen, A. H. K. (2010). Gender differences in learning styles: Nurturing a gender and style sensitive computer science classroom. *Australasian Journal of Educational Technology, 26*(7).

Lauria, G., Hsieh, S. T., Johansson, O., Kennedy, W. R., Leger, J. M., Mellgren, S. I. & Valls- Solé, J. (2010). European Federation of Neurological Societies/Peripheral Nerve Society Guideline on the use of skin biopsy in the diagnosis of small fiber neuropathy. Report of a joint task force of the European Fe-deration of Neurological Societies and the Peripheral Nerve Society. *European journal of neurology*, 17(7), 903-949.

Leedy, P. D., & Ormrod, J. E. (2013). The nature and tools of research. Practical research: *Planning and design*, 1, 1-26.

Leon, A. C., Davis, L. L., & Kraemer, H. C. (2011). The role and interpretation of pilot studies in clinical research. *Journal of psychiatric research*, 45(5), 626-629.

Li, Y., & Schoenfeld, A. H. (2019). Problematizing teaching and learning mathematics as "given" in STEM education. *International Journal of STEM Education*, 6(1), 1-13.

Lin, S. W., & Tai, W. C. (2015). Latent Class Analysis of Learners' Mathematics Learning Strategies and the Relationship between Learning Strategy and Mathematical Literacy. *Universal Journal of Educational Research*, 3(6), 390-395.

Loo, R. (1999). Confirmatory factor analyses of Kolb's Learning Style Inventory (LSI-1985). *British Journal of Educational Psychology*, 69(2), 213-219.

Macro International. Institute for Resource Development. Demographic, Health Surveys, Nigeria. Federal Office of Statistics, & Nigeria. National Population Commission. (2008). Nigeria Demographic and Health Survey. IRD/Macro Incorporated.

Madu, O. T., Ogbonnaya, N. P., Chikeme, P. C., & Omotola, N. J. (2019). A study to assess the learning style preference of undergraduate nursing learners in southeast, Nigeria. *Asian Journal of Nursing Education and Research*, 9(2), 177-184.

Manolis, C., Burns, D. J., Assudani, R., & Chinta, R. (2013). Assessing experiential learning styles: A methodological reconstruction and validation of the Kolb Learning Style Inventory. *Learning and individual differences*, 23, 44-52.

Marshall, J. C., & Merritt, S. L. (1985). Reliability and construct validity of alternate forms of the Learning Style Inventory. *Educational and Psychological Measurement*, 45(4), 931-937.

Marzano, R., Pickering, D., & Pollock, J. (2001). Classroom instruction that works: Research-based strategies for increasing student achievement. VA: Association for Supervision and Curriculum Development. Alexandria.

McDevitt, T. M., Ormrod, J. E., Cupit, G., Chandler, M., & Aloa, V. (2010). Child development and education. Upper Saddle River, NJ: Merrill.

McDonough, K. (2004). Learner-learner interaction during pair and small group activities in a Thai EFL context. *International Journal of STEM Education*, 32, 207–224.

McMillan, J. H., & Schumacher, S. (2014). Research in Education: Evidence-Based Inquiry (Pearson New International ed.). Pearson Publishing.

Metallidou, P., & Platsidou, M. (2008). Kolb's Learning Style Inventory-1985: Validity issues and relations with metacognitive knowledge about problem-solving strategies. *Learning and Individual Differences*, 18(1), 114-119.

Middleton, K., Ricks. E., Wright. P., & Grant. S. (2013). Examining the Relationship between Learning Style Preferences and Attitudes toward Mathematics among Learners in Higher Education. *Institute for Learning Styles Journal*. 1 p1.

MKHABELA, H. (2016). South African Local Elections 2016. From One Party Dominance to Effective Plural Democracy.

Mourby, M., Mackey, E., Elliot, M., Gowans, H., Wallace, S. E., Bell, J. & Kaye, J. (2018). Are 'pseudonymised'data always personal data? Implications of the GDPR for administrative data research in the UK. *Computer Law & Security Review*, 34(2), 222-233.

Mtika, P., & Gates, P. (2010). Developing learner-centred education among secondary trainee teachers in Malawi: The dilemma of appropriation and application. International *Journal of Educational Development*, 30(4), 396-404.

Mukaka, M. M. (2012). Statistics Corner: A Guide to Appropriate Use of Correlation Coefficient in Medical Research. *Malawi Medical Journal*, 24, 69-71.

Mutambara, L. H. N., & Bansilal, S. (2022). A case study of in-service teachers' errors and misconceptions in linear combinations. *International Journal of Mathematical Education in Science and Technology*, *53*(11), 2900-2918.

Naidoo, J. C. (Ed.). (2011). Celebrating cuentos: Promoting Latino children's literature and literacy in classrooms and libraries. ABC-CLIO.

National Academy of Sciences (2020). *From Research to Reward: Amazing GRACE: A Satellite Mission Helps Us Measure and Track Water Underground*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25754.

National Population Commission, & National Population Commission. (2008). Federal Republic of Nigeria. *Nigeria demographic and health survey*.

Ndlovu, H. C. M. (2019*). Mathematics teachers' constructions and enactments of learner-centred practices* (Doctoral dissertation), University of Kwazulu-Natal.

Newstead, S. E. (1992). A study of two "quick-and-easy" methods of assessing individual differences in student learning. *British Journal of Educational Psychology*, 62(3), 299-312.

Nuzhat, A., Salem, R. O., Quadri, M. S., & Al-Hamdan, N. (2011). Learning style preferences of medical learners: a single-institute experience from Saudi Arabia. *Int J Med Educ*, 2, 70-73.

Obiefuna, C. A. & Oruwari, J. (2015). Learners' learning styles and their performance in English language in senior secondary schools in Imo State. Nigeria. *African Educational Research Journal, 3*(4), 230–237.

Odebiyi, O. M., & Salami, I. A. (2015). Teachers' Instructional Style Preference and Pupils' Academic Achievement in Ibadan: Another Angle to the Knowledge. *Asian Journal of Education and e-learning, 3*(3).

Okigbo, E. C., & Okeke, S. O. C. (2011). Perceived difficulty in integrating educational objectives within the mathematics classroom: A comparison of beginner and experienced teachers. *Educational Research and Reviews*, 6(3), 292–298.

Oloyede, E. O., Adebowale, O. F., & Ojo, A. A. (2012). The effects of competitive, cooperative, and individualistic classroom interaction models on learning outcomes in mathematics in Nigerian senior secondary schools. *International Scholarly Research Notices*, 2012(1), 263891.

Olufunminiyi, A.A. (2015). Enhancing Transfer of Knowledge in Physics through Effective Teaching Strategies. *Journal of Education and Practice*, 6(16), 37-44.

Omeluzor, S. U., Bamidele, I. A., Ukangwa, C. C., & Amadi, H. U. (2013). The relevance of a library in the 21st Century: Students perception. *International journal of library and information science*, *5*(6), 160-166.

Onwuegbuzie, A. J., & Combs, J. P. (2011). Data analysis in mixed research: A primer.

Orhun, N. (2013). The effects of learning styles on high school learners' achievement on a mathematics course. Academic Journals 8(14), pp. 1158-1165, DOI: 10.5897/ERR2013.1478 ISSN 1990-3839. http://www.academicjournals.org/ER

Otoo, D., Iddrisu, W. A., Kessie, J. A., & Larbi, E. (2018). Structural Model of Students' Interest and Self-Motivation to Learning Mathematics. *Education Research International,* 1, 9417109.

Pallant, J. (2011). Survival manual. A step-by-step guide to data analysis using SPSS, 4.

Palys, T. (2008). Purposive sampling. The Sage encyclopedia of qualitative research methods, 2(1), 697-8.

Passarelli, A. M., & Kolb, D. A. (2012). Using experiential learning theory to promote student learning and development in programs of education abroad. In *Student learning abroad* (pp. 137-161). Routledge.

Patterson, M., Perry, E., Decker, C., Eckert, R., Klaus, S., Wendling, L., & Papanastasiou, E. (2003). Factors associated with high school mathematics performance in the United States. *Studies in Educational Evaluation*, *29*(2), 91-108.

Patterson, P. G., Scott, J., & Uncles, M. D. (2010). How the local competition defeated a global brand: The case of Starbucks. *Australasian Marketing Journal*, *18*(1), 41-47.

Pellegrino, J. W., & Hilton, M. L. (Eds.) (2012). Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century. National Research Council of the National Academes. Washington DC: The National Academies Press.

Piaget, J. (2013). The construction of reality in the child. Routledge.

Reddy, V., Visser, M., Winnaar, L., Arends, F., Juan, A. L., Prinsloo, C., & Isdale, K. (2016). TIMSS 2015: Highlights of mathematics and science achievement of grade 9 South African learners.

Remillard, H. A. (2015). The Effect of Cooperative Learning on Middle School Math Learners. Online Submission.

Rohmanawati, E., Kusmayadi, T. A., & Fitriana, L. (2021). Analysis of Learners' Mathematical Communication Ability Based on Kolb's Learning Styles of Converger and Diverger Type. In *Journal of Physics: Conference Series* (Vol. 1808, No. 1, p. 012050). IOP Publishing.

Rohrer, D., & Pashler, H. (2012). Learning Styles: Where's the Evidence? Online Submission, 46(7), 634-635.

Romanelli, F., Bird, E., & Ryan, M. (2009). Learning styles: a review of theory, application, and best practices. *American journal of pharmaceutical education*, 73(1).

Ruble, T. L., & Stout, D. E. (1991). Reliability, classification stability, and response-set bias of alternate forms of the Learning-Style Inventory (LSI-1985). *Educational and psychological measurement*, 51(2), 481-489.

Sa'ad, T. U., Adamu, A., & Sadiq, A. M. (2014). The causes of poor performance in mathematics among public senior secondary school students in Azare metropolis of Bauchi State, Nigeria. *Journal of Research & Method in Education*, 4(6), 32.

Saito, M. (2010). Has gender equality in reading and mathematics achievement improved. *SACMEQ Policy Issues Series*, *4*, 1-3.

Saylor, L. L., & Johnson, C. C. (2014). The role of reflection in elementary mathematics and science teachers' training and development: A meta-synthesis. *School Science and Mathematics,* 114(1), 30-39.

Schulze, S., & Bosman, A. (2018). Learning style preferences and Mathematics achievement of secondary school learners. *South African Journal of Education*, 38(1), 1-8.

Sengodan, V., & Iksan, Z. H. (2012). Learners' learning styles and intrinsic motivation in learning mathematics. *Asian Social Science*, 8(16), 17.

Shahrill, M. (2013). Review of Effective Teacher Questioning in Mathematics Classrooms. *International Journal of Humanities and Social Science*, 3(17), 224-231.

Singh, A. S., & Masuku, M. B. (2013). Fundamentals of applied research and sampling techniques. *International journal of medical and applied sciences*, 2(4), 124-132.

Skott, J, J (2019). Understanding mathematics teaching and learning "in their full complexity". *Journal of Mathematics Teacher Education,* 22(5), 427-431,

Sofowora, O. A., & Adekomi, B. (2012). Improving science, technology and mathematics education in Nigeria: A case study of Obafemi Awolowo University, Ile-Ife. African *Journal of Educational Studies in Mathematics and Sciences*, 10, 1-8.

Sofroniou, A., & Poutos, K. (2016). Investigating the effectiveness of group work in mathematics. *Education Sciences, 6*(3), 30.

Strydom, H. (2013). An evaluation of the purposes of research in social work. Social Work/Maatskaplike Werk, 49(2).

Stylianides, A. J., & Stylianides, G. J. (2022). Introducing students and prospective teachers to the notion of proof in mathematics. *The Journal of Mathematical Behavior*, *66*,

Syatriana, E., Akib, E., & Saiful, S. (2022). Kolb's learning Style Affect EFL Creativity of Indonesian Students. *Al-Ishlah: Jurnal Pendidikan*, 14(3), 3425-3436.

Tall, D. O. (2008). The transition to formal thinking in mathematics. *Mathematics Education Research Journal, 20*(2), 5-24.

Tan, M. L., & Laswad, F. (2011). Exploring the impact of students' learning style on performance in Taxation. *J. Australasian Tax Tchrs. Ass'n*, 6, 152.

Taylor, E. W. (1994). A learning model for becoming interculturally competent. *International journal of intercultural relations*, *18*(3), 389-408.

Teddlie, C., & Yu, F. (2007). Mixed methods sampling: A typology with examples. *Journal of mixed methods research*, 1(1), 77-100.

Thorne, S. (2016). Interpretive description: Qualitative research for applied practice. Routledge.

Timans, R., Wouters, P., & Heilbron, J. (2019). Mixed methods research: what it is and what it could be. *Theory and Society, 48(*2), 193-216.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection.

Tulbure, C. (2012). Investigating the Relationships between Teaching Strategies and Learning Styles in Higher Education. *Acta Didactica Napocensia*, 5(1), 65-74.

Tuncer, M., Dikmen, M., & Akmençe, A. E. (2018). Investigation of higher education students' learning styles and attitudes towards mobile learning according to various variables. *International Journal of Social Sciences and Education Research, 4*(3), 433-446.

Umugiraneza, O. Bansilal, S & North, D. (2018). Exploring teachers' practices in teaching Mathematics and Statistics in KwaZulu-Natal schools. *South African journal of education. 37*(2). http://dx.doi.org/10.15700/saje.v37n2a1306.

Veres III, J. G., Sims, R. R., & Locklear, T. S. (1991). Improving the reliability of Kolb's revised learning style inventory. *Educational and Psychological Measurement, 51*(1),43-150.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological process. Cambridge, MA: Harvard University Press

Webb, N. M., Franke, M. L., De, T., Chan, A. G., Freund, D., Shein, P., & Melkonian, D. K. (2009). 'Explain to your partner': teachers' instructional practices and learners' dialogue in small groups. *Cambridge Journal of Education, 39*(1), 49-70.

Wellington, J., & Szczerbinski, M. (2007). *Research methods for the social sciences*. A&C Black.

Willcoxson, L., & Prosser, M. (1996). Kolb's Learning Style Inventory (1985): review and further study of validity and reliability. *British journal of educational psychology, 66*(2), 247-257.

Wilson, M. L. (2011). Students' learning style preferences and teachers' instructional strategies: Correlations between matched styles and academic achievement. Liberty University.

Woodwell, D. (2013). Research Foundations: How Do We Know What We Know? Sage Publications.

Yilmaz-Soylu, M., & Akkoyunlu, B. (2009). The Effect of Learning Styles on Achievement in Different Learning Environments. *Turkish Online Journal of Educational Technology*- TOJET, 8(4), 43-50.

Zakaria, E., Chin, L. C., & Daud, M. Y. (2010). The effects of cooperative learning on learners' mathematics achievement and attitude towards mathematics. *Journal of social sciences,* 6(2), 272-275.

Zakaria, E., Zain, N. M., Ahmad, N. A. & Erlina, A. (2012). Mathematics Anxiety and Achievement among Secondary School Learners. *American Journal of Applied Sciences*, 9(11), 1828-1832. https://doi.org/10.3844/ajassp.2012.1828.1832.

Zakaria, S. A., Saad, S. A., & Azziz, N. H. A. (2016). Performance of undergraduate engineering students in mathematics according to gender. In *AIP Conference Proceedings* (Vol. 1750, No. 1). AIP Publishing.

Zhou, S. N., Zeng, H., Xu, S. R., Chen, L. C., & Xiao, H. (2019). Exploring Changes in Primary Students' Attitudes towards Science, Technology, Engineering and Mathematics (STEM) across Genders and Grade Levels. *Journal of Baltic Science Education, 18*(3), 466-480.

Zulkifli, F., Fadhlullah, A., Abu Bakar, N., Jahya, A., Ismail, N., Hashim, H., & Ahmad Ridzuan, A. N. A. (2014). A Comparative Analysis on Learning Preferences of Learners at Faculty of Computer & Mathematical Sciences (FSKM) and Faculty of Business Management (FPP) at Universiti Teknologi Mara (UiTM). Proceedings of the Kolokium Pengajaran dan Pembelajaran UiTM Ke-2.

APPENDICES

APPENDIX 1: Turnitin Report

Whole chapters reviewed

ORIGINALITY REPORT

16%

SIMILARITY INDEX

14% 8% %

INTERNET SOURCES PUBLICATIONS STUDENT PAPERS

PRIMARY SOURCES

uir.unisa.ac.za	1 Internet Source	2%
digitalcommons.liberty.edu	2 Internet Source	1%
hdl.handle.net	3 Internet Source	1%
docplayer.net	4 Internet Source	<1%
www.saarmste.org	5 Internet Source	<1%

edoc.pub 6 Internet Source	<1%
researchspace.ukzn.ac.za 7 Internet Source	<1%
www.researchgate.net 8 Internet Source	<1%
www.scribd.com 9 Internet Source	<1%

Appendices

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

6 October 2016

Mr Patrick Ojeme 215000108
School of Education
Edgewood Campus

Dear Mr Ojeme

Protocol reference number: HSS/1583/016D
Project title: Exploration of learning style preferences and instructional strategies on Mathematics Achievement and Graduating Secondary School Students in Delta State in Nigeria

Full Approval – Expedited Application

In response to your application received 23 September 2016, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

cc Supervisor: Prof Sarah Bansilal & Dr Khanare Fumane
cc. Academic Leader Research: Dr SB Khoza
cc. School Administrator: Ms Tyzer Khumalo

Appendix 3

UNIVERSITY OF
KWAZULU-NATAL

School of Education

Private Bag X03

Ashwood,3605

18 August 201

Dear Principal,

INFORMED CONSENT LETTER

I am a registered student for PhD study in the school of education at University of Kwazulu-Natal (UKZN) with student number 215000108. I am currently investigating the following topic; "Exploration of learning style preferences on mathematics achievement of graduating senior secondary school learners in Delta State in Nigeria". This study seeks to explore the effects of learning style preferences on mathematics achievement of graduating senior secondary school learners in Delta State in Nigeria.

I would like you to grant me the permission to conduct the study in your school. The study will be conducted in three sections. The first section will take approximately 30-40 minutes; the second section will take approximately one hour 30 minutes because it involves written test while the third section which involves individual interview and audiotape recording will take approximately one hour respectively. All the sessions of the study will not affect your school programme. It will be at your convenient time.

However, your name will not be mentioned in the study and the actual data from the research will only be used for the research purposes. Your participation in the study is voluntary and you are free to withdraw at any point. I will do everything to ensure that your anonymity is guaranteed. If you require any information, you can contact my project supervisors as follows:

Prof Sarah Bansilal

Principal Supervisor

Department of Mathematics Education

University of KwaZulu-Natal (UKZN)

Durban, South Africa

[redacted]

Bansilals@ukzn.ac.za

Dr. Khanare Fumane

Co-Supervisor

Department of Educational Psychology

University of KwaZulu-Natal (UKZN)

Durban, South Africa

+[redacted]

Khanare@ukzn.ac.za

If you have any question about your rights as a research subject, you may contact the University KwaZulu-Natal Research Office through:

Sabelo Nkulueko Mthembu

HSSREC Research Office,

Edgewood Campus. UKZN

E-mail: MthembuS4@ukzn.ac.za

Sincerely,

Patrick Nwasiwemua OJEME

Researcher

+[redacted] or 215000108@stu.ukzn.ac.za

Appendix 4

School of Education

Private Bag X03

Ashwood, 3605

18 August 201

Dear Parent or Guardian,

INFORMED CONSENT LETTER

I am Patrick Nwasiwemua Ojeme, a doctoral student of Prof Sarah Bansilal and Dr. Khanare Fumane in the school of education at University of Kwazulu-Natal (UKZN) in Durban in South Africa. I request permission for your child to participate in a research study to be used for my doctoral dissertation. I am conducting a research project on how learning style preferences could impact the mathematics achievement of graduating senior secondary school learners in Delta North Senatorial District in Delta State.

We hope to use the findings of the study to help learners in realizing their dominant learning abilities and best learning styles particularly in learning mathematics

The study consists of the following activities:

1. We will ask your permission for your child to take part in 2 to 4 tasks over the course of a total of about 2 months. Each task will last about 30 minutes to 1 hour.
2. These tasks may include: (1) responding to questionnaire on learning style to find out the best way in which your child prefers to learn, answering questions on mathematics

achievement to determine the effect of your child's learning style on his/her mathematics achievement, and (3) individual interview about how your child feels about the impact of learning style preferences on mathematics achievement which will audio, on things your child has learned in the program.

3. Sometimes the researchers will observe your child while he or she takes part in activities at the center.
4. Some activities may be audiotaped and video recorded. The audio tape and video recorder will be operated by one of the research assistants.

The project will be explained in terms that your child can understand, and your child will participate only if he or she is willing to do so.

Only Prof Sarah, Dr. Khanare and I will have access to information from your child. At the conclusion of the study, children's responses will be reported as group results only. At the conclusion of the study a summary of group results will be made available to all interested parents. Please indicate at the end of this consent form whether you wish to have these results. If so, please provide your mailing address. If you do not wish to provide your mailing address, you may obtain the results from the Internet at www.ukzn.ac.za. Results should be available in approximately 12 months.

Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect your child's classroom activities. Even if you give your permission for your child to participate, your child is free to refuse to participate. If your child agrees to participate, he or she is free to end participation at any time. You and your child are not waiving any legal claims, rights, or remedies because of your child's participation in this research study.

If you are willing to allow your child to participate in the activity-based task and audio and video method sessions, please indicate (by ticking as applicable) whether or not you are willing to allow the interview with your child to be recorded by the following equipment:

	willing	Not willing

Audio equipment		
Video equipment		

Should you have any questions or desire further information, please feel free to contact my me and my supervisors

Patrick Nwasiwemua OJEME

Researcher

School of Education Psychology

University of KwaZulu-Natal (UKZN)

Durban, South Africa

+[redacted]

215000108@stu.ukzn.za

Prof Sarah Bansilal

Principal Supervisor

Department of Mathematics Education

University of KwaZulu-Natal (UKZN)

Durban, South Africa

[redacted]

Bansilals@ukzn.ac.za

Dr. Khanare Fumane

Co-Supervisor

Department of Educational Psychology

University of Kwazulu-Natal (UKZN)

Durban, South Africa

[redacted]

Khanare@ukzn.ac.za

If you have any question about your rights as a research subject, you may contact the University KwaZulu-Natal Research Office through:

Sabelo Nkulueko Mthembu,

HSSREC Research Office,

Edgewood Campus. UKZN

E-mail: MthembuS4@Uukzn.ac.za

Keep this letter after completing and returning the signature page to me.

STATEMENT OF CONSENT

I……………………………………………………………………………… (Full name of participant's parents) hereby confirm that I have read the above information regarding this research study on the impact of learning style preferences and instructional strategies on learning outcome involving written test, audio and video recording. I do grant permission for my child to participate in the study. I understand that my child is at liberty to withdraw from the project at any time, should he/she so desire.

SIGNATURE OF PARTICIPANT **DATE**

……………………………………… **…………………………………**

Appendix 5

UNIVERSITY OF KWAZULU-NATAL

School of Education

Private Bag X03

Ashwood, 3605

18 August 206

Dear Teacher,

INFORMED CONSENT FORM FOR TEACHER

Student's Learning Style Preferences, Teacher's Instructional Strategies and Gender on Mathematics Achievement of Graduating Senior Secondary School Learners in Delta North Senatorial District in Delta State in Nigeria.

Patrick Ojeme, Doctoral Student

University of KwaZulu-Natal, School of Education.

You and your class are invited to participate in a research study concerning the relationship between learners' learning styles and teachers' instructional strategies and the learners' academic achievement. Your class is chosen as potential participants because you are a mathematics teacher at ____. Your school administrative official, __________________________ has approved your participation. Please read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Patrick Ojeme under the direction of University of KwaZulu-Natal School of Education professor, Sarah Bansilal and Dr. Khanare Fumane.

Background Information

The purpose of this study is to examine student learning style preferences and teachers' instructional practices in an effort to explore the extent to which these could impact mathematics achievement. In addition, characteristics such as gender will be considered as variables that may affect the potential relationships between the level of learning style and teaching strategies and student achievement.

Procedures:

If you agree to participate in this study, I would ask you to do the following things:

• Complete a short (45-item) question-and-answer inventory concerning your learning style preferences. The inventory should take about 15 – 20 minutes to complete.

• Arrange a 30-minute period of time in October for me to administer a student version of the inventory in your classroom and 1hr, 30-minutes in December for me to administer mathematics achievement test. I would request that you be present in the classroom while they complete the inventory and mathematics achievement test.

• Record (audio and video) all of the instructional activities you utilize in the classroom during a two-week period of time. This would be similar to reporting lesson plans and is not intended to encourage or elicit any type of modification or deviation from your typical routine. If you are willing to participate in the audio and video method sessions, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	willing	Not willing
Audio equipment		
Video equipment		

Risks and Benefits of being in the Study

The study has minimal risks that are no greater than the participants would encounter in everyday life. All data collected about you and your learners will be kept confidential and no names or identifying information will be included in the research reports. The potential benefits of your participation include the following:

• Assisting yourself and other teachers in understanding the various learning styles favoured by themselves and their learners and recognizing the important relationship between the instructional strategies they utilize and the success their learners may experience.

• Providing motivation and direction for an increased thrust in exploring the concept of learning styles and instructional strategies in training experiences for mathematics teachers as well as professional development programs for current teachers.

Confidentiality:

The records of this study will be kept private. In any sort of report, I might publish, I will not include any information that will make it possible to identify individual participants or classes. All participants will be assigned an alpha-numeric code that will be used to compile and organize all subsequent data. Data analysis will be conducted on the basis of the entire sample and with subgroups of gender. Research records will be stored securely in password-protected files, and only the researcher will have access to the records. Data will be entered into the researcher's personal computer for organization and analysis, and a back-up copy will be kept on a USB flash drive at the researcher's home. Any paper copies of data will be destroyed once entered into the computer and stored digitally.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision concerning whether or not you participate will not affect your current or future relations with University of KwaZulu-Natal. If you decide to participate, you are free to not answer any question or to withdraw at any time without affecting those relationships.

Contacts and Questions:

Patrick Nwasiwemua OJEME

Researcher

School of Education Psychology

University of KwaZulu-Natal (UKZN)

Durban, South Africa

+[redacted]

ojemep@gmail.com &215000108@stu.ukzn.za

Prof Sarah Bansilal

Principal Supervisor

Department of Mathematics Education

University of KwaZulu-Natal (UKZN)

Durban, South Africa

[redacted]

Bansilals@ukzn.ac.za

Dr. Khanare Fumane

Co-Supervisor

Department of Educational Psychology

University of Kwazulu-Natal (UKZN)

Durban, South Africa

[redacted]

Khanare@ukzn.ac.za

If you have any question about your rights as a research subject, you may contact the University KwaZulu-Natal Research Office through:

Sabelo Nkulueko Mthembu,

HSSREC Research Office,

Edgewood Campus. UKZN

E-mail: MthembuS4@Uukzn.ac.za

Keep this letter after completing and returning the signature page to me.

You will be given a copy of this information to keep for your records.

STATEMENT OF CONSENT

I…………………………………………………………………………… (Full name of teacher) hereby confirm that I have read the above information regarding this research study on the impact of learning style preferences and instructional strategies on learning outcome involving audio and video recording. I have asked questions and have received answers. I consent to participate in the above study. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT **DATE**

……………………………………… ………………………………….

APPENDIX 6

UNIVERSITY OF KWAZULU-NATAL

School of Education

Private Bag X03

Ashwood, 3605

18 August 206

Dear Participant,

INFORMED ASSENT LETTER

You are being invited to participate in a research study on learning style preferences on mathematics achievement. In particular, I am interested in how learning style preferences may help improve mathematics achievement of learners in both internal and external examinations.

This research will require about 2-4 hours of your time though in 3 phases. In the first phase, you will be asked to describe the way you learn by answering the learning style questionnaire. In the second phase, you will solve some mathematics tasks to find out the impact of your preferred learning style on your mathematics achievement. In the third phase, you will be interviewed about your experiences with mathematics and how you think you learn mathematics. The interviews will be conducted wherever you prefer (within your school), and will be tape-recorded.

There are no anticipated risks or discomforts related to this research. The person interviewing you, however, can give you the name and telephone number of his supervisors, if you wish this information.

You may also find the study to be very enjoyable and rewarding, as it could help enhance your mathematics achievement in the next West African Senior School Certificate examinations (WASSCE) and National Examination Council (NECO) which you are preparing to go in for.

By participating in this research, you may also benefit others by helping people to better understand what it is like to identify their preferred ways of learning particularly in mathematics.

Several steps will be taken to protect your anonymity and identity. While the interviews will be tape recorded, the tapes will be destroyed once they have been typed up. The typed interviews will NOT contain any mention of your name, and any identifying information from the interview will be removed. The typed interviews will also be kept in a locked cabinet at the University of Kwazulu-Natal, and only researcher and the two supervisors (sworn to confidentiality) will have access to the interviews. All information will be destroyed after 5 years' time.

Your participation in this research is completely voluntary. However, you may withdraw from the study at any time for any reason. If you do this, all information from you will be destroyed. The results from this study will be presented in writing in journals read by school counsellors, teachers and educational professionals, to help them better understand the impact of learning style preferences on learning outcome particularly on mathematics.

The results may also be presented in person to groups of school counsellors or educational professionals. At no time, however, will your name be used or any identifying information revealed. If you are willing to participate in the activity-based task and audio and video method sessions, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	willing	Not willing
Audio equipment		
Video equipment		

If you wish to receive a copy of the results from this study, you may contact the researcher at the telephone number given below.

If you require any information about this study, or would like to speak to the researcher, please contact:

Patrick Nwasiwemua Ojeme

+27790301623)

email: ojemep@gmail.com.

You may also contact my Supervisors, Professor Sarah Bansilal and Dr. Khanare Fumane in one of the following ways:

- Prof. Sarah Bansilal on +27832795916 or Bansilals@ukzn.ac.za
- Dr. Khanare Fumane on +27834321772 or khanare@ukzn.ac.za

You may also contact the Research Office through:

- Tyzer Khumalo at HSSREC Research Office, Edgewood Campus. UKZN on E-mail: khumalot9@ukzn.ac.za

Thank you for your contribution to this research.

I………………………………………………………………………… (Full names of participant) hereby confirm that I have read the above information regarding this research study on the impact of learning style preferences and instructional strategies on learning outcome, and assent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT **DATE**

……………………………………… ………………………………

Appendix 7

Declaration

I Patrick Nwasiwemua OJEME hereby confirm that I understand the contents of this document and the nature of the research project and I consent to participate in the study. I am at liberty to withdraw from the study at any time should I desire.

………………………………..

Signature: **Patrick Ojeme**

Date: 8/18/2016

Appendix 8

Instructions for Completing Instructional Strategy Record Sheet

Please keep the following in mind as you complete the Instructional Strategy Record Sheet for this term:

- Choose two consecutive weeks when instruction will be typical of this term.
- Information for each week must be recorded on separate sheets.
- You may make photocopies of the record sheets if you need additional

space.

Complete the identification portion of the record sheet including:

- Dates
- Name of Teacher and School

Record all instructional activities used for each content area during each day

of both selected weeks.

- ➢ Identify all activities, keeping in mind the involvement of both:
    - Teacher
    - Learners

Briefly describe the "what" and "how" of each activity.

- ➢ Thinking in the following terms may be helpful:
- Format
- Methods
- Interaction
- Approach

Do not include content-specific topics or objectives.

Please note the example and non-example each for one day of instruction on the attached Sample Instructional Strategy Record Sheet

Thank you again for your willingness to participate in this study.

Your involvement is important and appreciated

Appendix 9

Sample Instructional Strategy Record Sheet

<table>
<tr><td colspan="4">Term:___________________

Teacher__________________________

School____</td><td colspan="2">Week
Dates_____________

to

_______________</td></tr>
<tr><td>Content Area</td><td>Monday</td><td>Tuesday</td><td>Wednesday</td><td>Thursday</td><td>Friday</td></tr>
<tr><td>Mathematics</td><td></td><td><u>Examples</u>

* <u>Teacher</u> presents a new topic and works examples on the board

* Teacher writes problems on the board; has individual learners come and solve problems on the board</td><td></td><td>Non-Examples:
Textbook lesson</td><td></td></tr>
</table>

		* Teacher assigns textbook problems; learners work individually at their desks			

Appendix 10

Section A

Demographic Data

Please tick (√) or fill in the gap --------- as applicable

(i) Gender: Male [ ] Female [ ]

(ii) Age of student [14] [15] [16] [17] [18] [19] [ ]

(iii) Name of student____

(iv) Name of School____

(v) Location of School____

(vi) Class: SSS [ ]

SECTION B

LEARNING-STYLE INVENTORY

The Learning-Style Inventory describes the way you learn and how you deal with ideas and day-to-day situations in your life. Below are 12 sentences with a choice of endings. Rank the endings for each sentence according to how well you think each one fits with how you would go about learning mathematics. Try to recall some recent situations where you had to learn something new, perhaps in your job or at school. Then, using the spaces provided, rank a "4" for the sentence ending that describes how you learn *best*, and down to a "1" for the sentence ending that seems least like the way you learn. Be sure to rank all the endings for each sentence unit. Please do not make draws.

Example of completed sentence set:

1. When I learn: __2_ I am happy. ___1_ I am fast. ___3_ I am logical. ___4__ I am careful.

Remember: 4 = most like you 3 = second most like you 2 = third most like you 1 = least like you

S/N	QUESTIONS	A		B		C		D	
1.	When I learn:		I like to come to an understanding with my feelings		I like to think about Ideas		like to be doing things.		I like to watch and listen.
2.	I learn best when:		I listen and watch Carefully		I rely on reasonable thinking.		I trust my ideas and feelings.		I work hard to get things done.
3.	When I am learning:		I tend to reason things out.		I am responsible about my ideas		I am quiet and reserved.		I have strong feelings and answers.
4.	I learn by:		Feeling.		Doing.		Watching.		Thinking.
5.	When I learn:		I am open to new understandings.		I look at all sides of topics.		I like to analyze my ideas, break them down into different parts		I like to try my ideas out.
6.	When I am learning:		I am an observing person.		I am an active person.		I am a concentrating person.		I am a logical person.

7.	I learn best from:		observation.		Personal interactions		Self-interest and preferences		a chance to try out my effort and practice.
8.	When I learn:		I like to see results from my work.		I like ideas and Facts or realities		I take my time before communicating ideas.		I feel personally involved in my learning.
9.	I learn best when:		I rely on my observation or explanation		I rely on my understanding or confidence.		I can try things out for myself.		I rely on my ideas.
10	When I am learning:		I do not like to talk about my opinions or thoughts		I am a respectful person.		I am a responsible person.		I am a reasonable or practical person.
11	When I learn:		I get engaged and focused		I like to observe.		I value or consider my knowledge.		I like to be active in class.
12	I learn best when:		analyze ideas		I am interested and open-minded.		I am careful		I am practical

Appendix 11
Mathematics Achievement Test (MAT)

Multiple Choice Questions (MCQ)

1. Adding 42 to a given positive number gives the same result as squaring the number. Find the number.

   A. 14

   B. 13

   C. 7

   D. 6

2. Simplify: $5\sqrt{12} - 4\sqrt{75} + 3\sqrt{48}$

   A. $3\sqrt{3}$

   B. $2\sqrt{3}$

   C. $-2\sqrt{3}$

   D. $-3\sqrt{3}$

3. Find the 7th term of the sequence: 2, 5, 10, 17, 26, …

A. 37

B. 48

C. 50

D. 63

4. If m=4, n=9 and r=16, evaluate $\frac{m}{n} - 1\frac{7}{9} + \frac{n}{r}$

   A. 1516

   B. $1\frac{1}{16}$

   C. $\frac{5}{16}$

D. –37/48

5. Solve the equation $7x^2 - 3x - 10 = 0$

A. -1, 10/7

B. 1; -10/7

C. -1. -10/7

D. 1, 10/7

6. Find the equation whose roots are ¾ and -4

A. $4x^2 - 13x + 12 = 0$

B. $4x^2 - 13x - 12 = 0$

C. $4x^2 + 13x - 12 = 0$

D. $4x^2 + 13x + 12 = 0$

7. Ada draws the graphs of $y = x^2 - x - 2$ and $y = 2x - 1$ on the same axes. Which of these equations is she solving?

A. $x^2 - x - 3 = 0$

B. $x^2 - 3x - 1 = 0$

C. $x^2 - 3x - 3 = 0$

D. $x^2 + 3x - 1 = 0$

8. Find the equation of the line that passes through (2, 3) and is perpendicular to the line $3x - 2y + 4 = 0$.

A. $2y - 3x = 0$

B. $3y - 2x + 5 = 0$

C. $3y + 2x + 5 = 0$

D. $2y - 3x - 5 = 0$

9. Given that the lines $3x + 4y + 6 = 0$ and $4x - by + 3 = 0$ are perpendicular, find the value of b.

A. 4

B. 3

C. $\frac{1}{3}$

D. $\frac{1}{4}$

10 A book seller gives 5% discount to a customer who pays cash. What is the marked price of a book for which the customer pays N475.00?

A. *N*300.00

B. *N*400.00

C. *N*500.00

D. *N*600.00

11. A money lender collects \$200 simple interest on a capital after 2 years at 5%. Calculate the capital invested.

A. \$1,000.00

B. \$2,000.00

C. \$3,000.00

D. \$4,000.00

12. A trader bought an engine for \$15,000.00 outside Nigeria. If the exchange rate is \$0.075 to *N*1.00, how much did the engine cost in naira?

A. *N*250,000.00

B. *N*200,000.00

C. *N*150,000.00

D. N100,000.00

13. The volume of a cone of height 3cm is $\sqrt{38}$ cm^3. Find the radius of the base. [Take π= 22/7]

A. 3.0cm

B. 3.5 cm

C. 4.0 cm

D. 4.5 cm

14. The dimensions of a rectangular tank are 2m by 7m by 11m. If its volume is equal to that of a cylindrical tank of height 4cm, calculate the base radius of the cylindrical tank. [Take π=22/7]

A. 14m

B. 7m

C. $\sqrt{3}$ m

D. 3.5m

15. The volume of a cube with side of 7m is

A. 49 cm3

B. 28 cm3

C. 343 cm3

D. 14 cm3

16. If a cone with slant height l is formed from the sector of a circle with radius R. Check what is r from R?

A. $2l = R$

B. $R = 2r$

C. $R = l$

D. $\pi l = \pi R^2$

17.

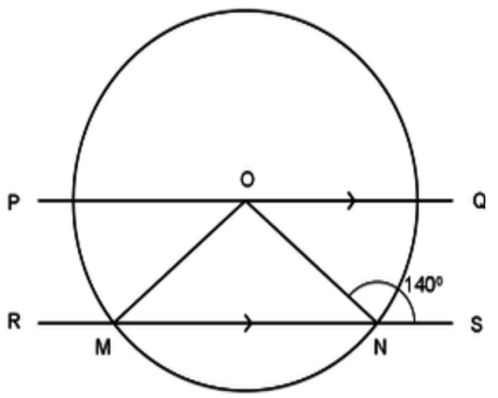
In the diagram below, O is the Centre of the of the circle. If PQ//RS and $< ONS = 140^0$, find $< POM$.

A. 40

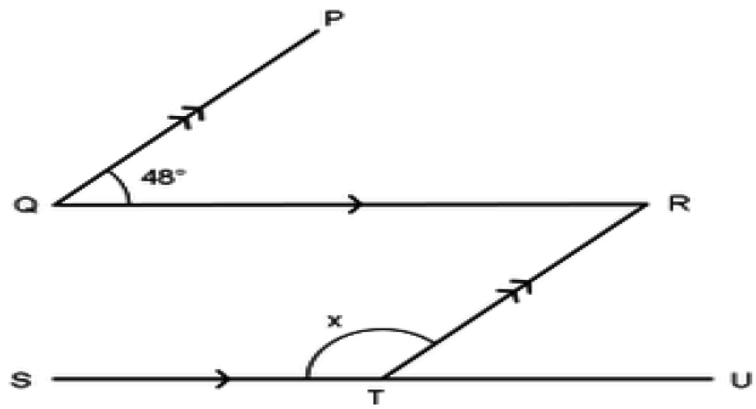
B. 50

C. 60

D. 80



18.



In the diagram above, PQ//RT, RQ//US, $< PQR = 48^0$ and $< RTS = x^0$. Find the value of x .

A. 134

B. 132

C. 96

D. 48

19. If $y = \frac{2}{2+1}$, then find $\int y dx$.

A. $\frac{x^2}{2} + x + c$

B. $2\ln(x+1) + c$

C. $\ln 2 + c$

D. $2x^2 + x + c$

20. Find $\frac{dy}{dx}$ given that $y = \frac{x^7}{x^3 + 1}$.

(a) $\frac{3x^9 - 7x^6(x^3+1)}{(x^3+1)^2}$

(b) $\frac{7x^6}{x^3+1}$

(c) $\frac{7x^6(x^3+1) - 3x^9}{(x^3+1)^2}$

(d) $\frac{7x^6(x^3+1) - 3x^9}{3x^2+1}$

THEORY QUESTIONS

1. A man invests N100 in the bank for 4 years at 30% compound interest per annum. Calculate the amount at the end of the period.

2. Find the equation of the line that is parallel to $2y + 5x - 6 = 0$ and is passing through the point $(4,3)$

3. (a) Copy and complete the table of values for $y = 2x^2 - 3x - 4$ for the interval $-3 \leq x \leq 4$.

X	-3	-2	-1	0	1	2	3	4
Y	23			-4				16

(b) Using a scale *2 cm* to represent 1 on the x-axis and 2 cm to represent 5 units on the y-axis, draw the graph of:

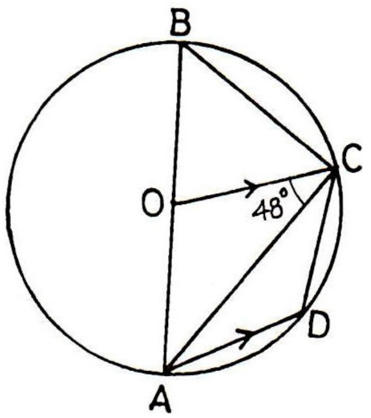
(i) $y = 2x^2 - 3x - 4$; (ii) $y = 3x - 4$.

(c) From your graph, solve the equations

(i) $2x^2 - 3x - 4 = 0$; (ii) $2x^2 - 6x = 0$.

4 (a) A cube of 4cm has same volume as a cone with base diameter 7cm. Calculate, correct to the nearest cm, the height of the cone. [Take π = 22/7].

(b).



In the diagram, o is the centre of the circle, /OC/ is parallel to /AP/, /AB/ is a straight line and <OCA = 48^0. Calculate <ABC.

5. If Ilorin is at (8.5°*N*, 4.6°*E*) and Freetown is at (8.5°*N*, 13.3°*E*). Calculate their;

(a) distance apart measured along the parallel of latitude

(b) distance from the equator

(c) Speed in km/h due to the rotation of the earth.

Appendix 12

A schedule for individual interviews with the graduating senior secondary school learners in Delta North Senatorial District of Delta State in Nigeria.

Interview Schedule

1. Can you explain to me how you engage in or learn mathematics in the classroom?
2. As a graduating senior secondary school student, can you explain to me the different learning styles used in learning mathematics in the classroom?
3. As a graduating senior secondary school student, which learning style do you prefer in learning mathematics?
4. Please, can you explain why you are using that particular learning style in learning or engaging in mathematics task?
5. From your observation, would you say that your learning style is good enough to help you achieve greatly in mathematics as a subject in the next coming WAEC/NECO examination?
6. Please, vividly explain the general responses of your teachers particularly mathematics teachers in class when using your best learning style in learning mathematics?
7. From your mathematics achievement, explain how your achievement is influenced by your preferred learning style?
8. From your achievement in mathematics, would you recommend your best learning style to your classmates?
9. What would you recommend with regard to the teaching and learning of mathematics at your level?
10. What challenges did you come across or have while responding to the learning style questionnaire and mathematics achievement test?

Appendix 13

A schedule for individual interviews with the mathematics teachers teaching graduating senior secondary school learners in Delta North Senatorial District of Delta State in Nigeria.

Interview Schedule

1. Can you explain to me how long you have been teaching mathematics?
2. As a mathematics teacher, can you explain the types of instructional strategies which are adopted in teaching mathematics?
3. As a mathematics teacher, which instructional strategy do you prefer?
4. Please, can you explain why you are using that particular instructional strategy?
5. From your own observation, would you say that learners respond positively to your teaching strategy?
6. Please, vividly explain the general responses of your learners particularly graduating learners in the class when using your best instructional strategy in teaching mathematics?
7. From the mathematics achievement of graduating senior secondary school learners, explain how their achievement is influenced by your instructional strategies?
8. From the achievement of your learners, would you recommend your best instructional strategy to other mathematics teachers?

Appendix 14

RESPONSES ON LEARNERS' PREFERED LEARNING STYLES IN LEARNING MATHEMATICS FROM INTERVIEW TRANSCRIPTS OF 16 PARTICIPANTS IN A RESEARCH STUDY TITLLED:

AN EXPLORATION OF LEARNING STYLES, INSTRUCTIONAL STYLE PREFERENCES AND MATHEMATICS ACHIEVEMENT OF SECONDARY SCHOOL LEARNERS IN A DISTRICT IN NIGERIA.

A	PREFERED LEARNING STYLE	Tell me your best or preferred learning style in learning mathematics, what your best method of learning mathematics in the class?
P1(16f)	I learn mathematics best	Engaging in solving mathematics problem or activities along with the teacher in a very quiet environment. I also try to ask questions as I'm writing and listening so I could gain a better understanding of the mathematics problem in class.
P2(17f)	I learn mathematics best	My best method for instance, is observing my mathematics teacher, concentrating on her examples and comments and practice solving mathematics problems or task. Practical method makes me to learn faster and works well for me in learning mathematics and it has always helped me to achieve in mathematics.
P3(16f)	I learn mathematics best	I learn mathematics best by trying to get along with the teacher before trying my effort through her examples and asking questions as well for a better understanding of the areas I want explanations.
P4 (18m)	I learn mathematics best	I learn mathematics best by concentrating on the explanations of my teacher and her several examples carefully before attempting to solve mathematics problems.
P5(18m)	I learn mathematics best	I learn mathematics best by watching and listening attentively to the instructions of my mathematics teacher. After observing and

		listening to my teacher, I can be able to perform a new task using the formulas and examples.
P6(17m)	I learn mathematics best	My best or preferred style in learning mathematics in the class is active participation in classroom discussions on a particular mathematics task or problems. Though I also pay adequate attention to the maths teacher's instructions and examples. The reason is that it helps me to understand any mathematics question better.
P7(16f)	I learn mathematics best	I learn mathematics best by participating in group discussions to come up with new ideas in solving math problems and I also gain a deep understanding in mathematics through observation and explanation of my mathematics teacher and the ideas I receive from group work. I cannot take the instructions of my mathematics teacher for granted.
P8(16m)	I learn mathematics best	I learn mathematics best by watching and listening to my teacher and fellow classmates based on my understanding and experience. Group discussions also helps my mathematics understanding and I am okay in learning new idea with my classmates in mathematics in the class.
P9(16m)	I learn mathematics best	I learn mathematics best by watching or listening to my teacher and gathering information through his examples in solving mathematics problems or task.
P10(17f)	I learn mathematics best	My best way or style of learning mathematics is sharing my ideas and looking at the mathematics problem as a whole. I like to be active in class and participate in gathering information to a specific mathematics problems or questions.
P11(19m)	I learn mathematics best	My best way or style of learning mathematics in the class is by working on my own in search of solution to the mathematics questions or examples provided by the teacher on the chalk board. My best style or method of learning mathematics is to be

		given a chance to try my effort. I prefer to learn and practice solving mathematics always on my own.
P12(17m)	I learn mathematics best	I learn mathematics best by going through all the areas of the problem and the examples of the teacher before asking questions or discussing my ideas in the class. class discussions helps me a lot to know if my ideas or my feelings on the topic taught is right or wrong and when its wrong, I try to take corrections but must engage in discussions to find out if I'm wrong or not.
P13(17f)	I learn mathematics best	I learn mathematics best by putting more effort in observing both the examples of the teacher and that of my classmates before sharing my ideas and asking questions for a better understanding of the mathematics problem.
P14(17f)	I learn mathematics best	I learn mathematics best by always practicing solving mathematics problem using my own ideas. I always seek a chance to try my own effort with my ideas in problem solving without disturbing the teacher or asking him any question.
P15(16f)	I learn mathematics best	I learn mathematics best by watching and listening carefully to my mathematics teacher and gather enough information before I can use my idea to solve mathematics problems.
P16(18m)	I learn mathematics best	I learn mathematics best by solving mathematics problem alone and always in the class and meditating on my ideas in the process. It helps me so much in the process of understanding mathematics problems or questions.

Appendix 15

RESPONSES OF LEARNERS ON THE OPINIONS OF MATHEMATICS TEACHERS TOWARDS LEARNERS' PREFERED LEARNING STYLE

PARTICIPANTS	***How does your teachers particularly your mathematics teacher feel about your learning style on mathematics, is he/she happy with the way you prefer to learn mathematics in the class?***
P1(16f)	My teachers and particularly my mathematics teacher do not feel so bad about the way I learn mathematics but always supporting us on how we can understand mathematics very well.
P2 (17f)	My teachers and particularly my mathematics teacher do not feel so bad about the way learn mathematics.
P3(16f)	My teachers especially my mathematics aunty encourages us to put more effort in learning mathematics.
P4(18m)	Sometimes, my mathematics teacher feels distracted out of my excitement when I seek more practical examples of the mathematics problem.
P5(18m)	My teachers and particularly my mathematics teacher do not feel so bad about the way learn mathematics.
P6(17m)	I'm not sure if she is unhappy with the way I learn mathematics in the class.
P7(16f)	I am not sure if my teachers particularly my mathematics teacher feels bad about the way I'm learning mathematics in the class.
P8(16m)	My teachers and particularly my mathematics teacher is not unhappy with my behaviour or the way I'm leaning mathematics in the class.
P9(16m)	I am not sure if my teachers particularly my mathematics teacher is unhappy with the way I engage in learning mathematics in the class.
P10(17f)	Well, my teachers particularly my mathematics teacher have not told me that the way I'm learning mathematics in the class is not good.
P11(17m)	My teacher doesn't feel bad about the way I learn mathematics in the class.
P12(18m)	My teachers and particularly my mathematics teacher do not feel so bad about the way learn mathematics.

P13(17f)	Before now, my mathematics teachers was not happy with me concerning the way I was learning mathematics in the class.
P14(17f)	My teachers and particularly my mathematics teacher do not feel bad because I don't disturb in the class.
P15(16f)	I don't think my teachers particularly my mathematics teacher is not okay with the way I learn mathematics.
P16(18m)	My teachers and particularly my mathematics teacher have never told me that the way I'm learning mathematics is not good.