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AN INVESTIGATION OF SECONDARY SCHOOL MATHEMATICS TEACHERS' KNOWLEDGE AND UTILIZATION OF THEIR STUDENTS' LEARNING STYLES

BY

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A thesis submitted to the School of Education in complete fulfilment of the academic requirements for the degree of Doctor of Philosophy in Mathematics Education in the

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PREFACE

The work in this thesis was done in the School of Education, Faculty of Humanities, University of KwaZulu-Natal, from July 2016 to December 2019 under the supervision of Professor Maharaj Aneshkumar.

This study represents my original work and has not been submitted in any form for any degree to any tertiary institution. Work taken from other scholars is properly acknowledged.

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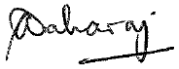

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DECLARATION

I, MANGWENDE EDMORE, declare that:

I. The research reported in this thesis, except where otherwise indicated, is my original work.

II. This thesis has not been submitted for any degree or examination at any other university.

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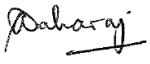
APPROVAL OF THESIS BY SUPERVISOR

This is to certify that the contents of this thesis are the original research work of Mr Mangwende Edmore.

As the candidate's supervisor, I have approved this thesis for submission.

Supervisor:

Signed: 

Name: **Professor Aneshkumar Maharaj**

Date: 4/12/2019

LIST OF PUBLICATIONS ARISING FROM THIS THESIS

The following papers, which arose from this thesis, were published in a peer reviewed journal. The journal is accredited by the Department of Higher Education and Training (DoHET):

1. Mangwende, E., & Maharaj, A. (2018). Secondary school mathematics teachers' use of students' learning styles when teaching functions: A case of Zimbabwean schools. *EURASIA Journal of Mathematics, Science and Technology, 14*(7), 3225-3233. https://doi.org/10.29333/ejmste/91679

2. Mangwende, E., & Maharaj, A. (2020). Barriers to mathematics teachers' use of their knowledge of students' learning styles in mathematics teaching: A case of secondary schools in Zimbabwe. *EURASIA Journal of Mathematics, Science and Technology, 16(1), 1305-1320*. https://doi.org/10.29333/ejmste/109198

Publication 1 reported on my work covered in chapter 6 of this thesis while publication 2 reported on the work covered in chapter 7.

LIST OF PAPERS UNDER PEER REVIEW

The following paper is under peer review:

1. Mathematics teachers' views on teaching students according to their learning styles: A case study of secondary school teachers in Zimbabwe. (See appendix 24)

The name of the journal to which this paper was submitted is EURASIA Journal of Mathematics, Science and Technology (ejmste).The paper reported on the work covered in chapter 5 of this thesis.

ACKNOWLEDGEMENTS

I express sincere gratitude to all those who made this study a success. The secondary school mathematics teachers who participated in the study were quite important to me. I wish to thank the teachers for their patience and cooperation. They chose to leave their precious work for the success of this study. I wish them blessings from the Almighty. Those who gave me permission to carry out this study in the areas under their control were very important to me too. This group includes the Permanent Secretary in the Ministry of Primary and Secondary Education (MOPSE) in Zimbabwe, the Provincial Education Director of Manicaland Province in Zimbabwe, the heads of the following secondary schools: Vengere High School, St Joseph's High School, Tsanzaguru High School, Manonga Secondary School, Tsindi Secondary School, Chamakumbu Secondary School, Mt Camel High School, Chitsva Secondary School, Rukweza High School and Chiundu High School.

My supervisor, Professor Aneshkumar Maharaj, did a great job in guiding me throughout the study period. He has been so patient to go through my work and has always given constructive advice. Had it not been for him, this study would not have been a success.

Lastly, I would want to express my gratitude to all those who encouraged me to carry out my studies despite economic and social hardships in my home country. I hope the Almighty shall give them strength to venture into their own endeavours.

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LIST OF ABBREVIATIONS AND ACRONYMS

AC	Abstract conceptualisation
AE	Active experimentation
CE	Concrete experimentation
ECD	Early childhood development
ICT	Information and communication technology
ILS	Index of learning styles
KLSI 4.0	Kolb's learning styles inventory 4.0
LSI	learning styles inventory
MOPSE	Ministry of Primary and Secondary Education
Pers.comm.	personal communication

ABSTRACT

This study explores secondary school mathematics teachers' knowledge of students' learning styles and how they used the knowledge when they were teaching mathematics. The study went further to explore barriers which the mathematics teachers faced when they were teaching their students according to the students' learning styles. The study was a qualitative exploratory interpretive case study of thirty-four secondary school mathematics teachers from ten secondary schools. It was carried out in the Makoni District of Manicaland Province in Zimbabwe. The schools were selected using stratified random sampling. Stratified random sampling was used as a way of making sure that schools from different responsible authorities were represented in the study. Mathematics teachers were purposefully selected since the researcher sought data on the mathematics teachers' knowledge of students' learning styles and how they used the knowledge in mathematics teaching. All the mathematics teachers at the selected schools took part in the study. The study was done in three phases. A phase addressed one research question. The results of the study revealed that the mathematics teachers had basic knowledge of students' learning styles. The teachers thought that teaching students according to their learning styles had more benefits than problems. The mathematics teachers varied their teaching strategies when they were teaching mathematics. They sometimes tried to meet the demands of their students' learning styles. However, some of the students' learning styles were not catered for by the teachers. The teachers did not use standard tools to assess the learning styles of their students. A number of barriers impinged on the mathematics teachers as they individualised their teaching strategies in order to meet the demands of their students' learning styles. The barriers were classified into the following categories: teacher related barriers, student related barriers, curriculum related barriers and socio-economic barriers. The researcher recommended that the mathematics teachers be in-serviced so that they could overcome the barriers that impinged on their use of students' learning styles when teaching mathematics. Besides attending to in-service courses, the teachers could form clubs, panels and associations so that they could share ideas on how best they could assist their students to learn. It was also important for the teachers to avoid competing with each other and collaborate for the benefit of all their students despite the different learning styles that the students had. The researcher also recommended that the teachers consider the learning styles of all their students when they teach mathematics. Their lesson plans and delivery of lessons had to be determined by the learning styles of their students. The researcher also found it important for the teachers themselves to know their own learning styles so that their teaching strategies were not

controlled by their learning styles but by the learning styles of their students. The researcher also recommended further studies on the same topic but to be carried out in a different setting. The researcher expressed interest, in future, to carry out a study to find the proportions of learners with particular learning styles in a normal class. Recommendations were also made on the need to carry out studies to establish the relationship between differences in learning styles and the performance of the students. There was also need to find out how factors like gender and age affect learning styles.

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CHAPTER 1

INTRODUCTION TO THE STUDY

1.1Introduction

This chapter serves as an introduction and an overview of the entire thesis. The chapter starts with a background of this study. In the background of the study, the researcher highlights the importance of considering students' learning styles when teaching mathematics. The researcher goes further to enlighten the reader on the different views held by different scholars, as found in reviewed literature, on the effectiveness of teaching mathematics students' according to their learning styles. The purpose of carrying out this study is also given in this chapter. Research questions as well as aims and objectives of the study are also stated. The chapter proceeds to give an explanation on the research methods and techniques which were used by the researcher to carry out this study. Limitations and delimitations of the study are also explained in detail in this chapter. The last part of the chapter gives an overview of the chapters that constitute the thesis. The thesis is made up of eight chapters.

1.2 Background of the study

Mathematics is one of the most important learning areas in secondary schools in Zimbabwe. According to the Ministry of Primary and Secondary Education (MOPSE) (2015), mathematics is one of the seven learning areas that are compulsory at secondary school level. However, despite its importance, the reviewed literature revealed some worrying reports on poor performance by mathematics students in Zimbabwe and in the entire southern region of Africa. Chirume (2016) carried out a study in the Shurugwi and Gweru districts of Midlands Province in Zimbabwe. In his report on the findings of his study, he reported that students in the two districts did not perform well in their mathematics examinations. Elsewhere in the region, Kafata and Mbetwa (2015) observed that the performance of mathematics students in Zambia was poor. Kafata and Mbetwa carried out their study in Kitwe District in Zambia. In South Africa, Gower (2019) reported that the failure rate in mathematics in South Africa had remained stubbornly high for a number of years.

The fact that mathematics students continued to fail mathematics, calls for measures to be taken by all stakeholders so that the performance of the students in mathematics in the region improves. There is need for intensive research on the possible remedies to the high failure

rate in mathematics. One way of doing it is by examining the teaching methods which the mathematics teachers are currently utilising as they teach mathematics. In my opinion, there is a possibility that mathematics teachers are misfiring by using teaching methods which do not suit the learning styles of their students. Studies have shown that students grasp concepts differently and they prefer to learn in different ways (Mkonto, 2015). Numerous studies have also shown that mismatches between teachers' teaching strategies and their students' learning styles have negative effect on the performance of the students (Abuzaid, Naimie,Shagoholi & Siraj, 2010; Abu-Asba,Azman &Mustaffa, 2014; Bosman & Schulze, 2018; Manochehri & Young, 2006). Some of the scholars even went further to state that mismatch between teachers' teaching strategies and students' learning styles cause boredom in students. The boredom results in students developing negative attitude towards mathematics, and in more serious cases, towards the entire curriculum (Felder and Silverman, 1988). According to Felder and Silverman boredom causes failure through self discouragement while continuous failure causes boredom through loss of self-esteem.

In order to avoid mismatches between teaching strategies and students' learning styles, mathematics teachers should be aware of their own learning styles as well as the learning styles of their students. The knowledge of learning styles enables them to make sure that they create learning environments in which all their students enjoy and participate freely and comfortably. In so doing, the teachers remove boredom in students and the students feel motivated to learn. However, studies carried out in the past revealed that most mathematics teachers did not have knowledge of their students' learning styles (Peacock, 2001; Reid, 1987, Zeeb, 2014). As a result, the teachers disregard their students' learning styles and teach them in the ways the teachers themselves felt comfortable. Peacock carried out a study in Hong Kong and found that mathematics teachers in his area of study did not consider the learning styles of their students when they were teaching mathematics. Zeeb confirmed the results by Peacock by obtaining similar results in a study he carried out in a different setting. Nziramasanga, Malaba, Kachingwe and Gerbecks (1999) also observed, in a study carried out in Zimbabwe, that mathematics teachers did not consider their students' learning styles when they were teaching mathematics. Instead they used traditional teaching methods which included lectures and other teacher-centred methods.

Although numerous scholars thought teaching students according to their learning styles improves the performance of the students, some few scholars believe otherwise. Those scholars criticised the strategy for various reasons (Cherry, 2019; Finley, 2015). Cherry

argued that the theory on learning styles is more complicated than what the learning styles theorists suggest. He suggested that more studies be done on the differences between brain function and learning styles so that the theory becomes more convincing. Different views held by scholars, found in literature, on the effectiveness of the strategy of teaching students according to their learning styles have given rise to an interesting debate. One of the purposes of this study is to participate in the scholarly debate by exploring what mathematics teachers think about the strategy of teaching mathematics according to students' learning styles.

In addition to making some contributions to the existing debate on the effectiveness of the method of teaching students according to their learning styles, this study intended to find out what mathematics teachers in Zimbabwe knew about students' learning styles. According to the literature reviewed, similar studies were done by other researchers elsewhere. However, the literature failed to produce researches on mathematics teachers' knowledge of learning styles done in Zimbabwe in the past.

After exploring mathematics teachers' knowledge and utilisation of students' learning styles, this study went further to investigate on barriers that impeded on mathematics teachers when they were utilising their knowledge of students' learning styles. The researcher observed from the reviewed literature that studies on barriers to mathematics teaching in general were done by other researchers in the past but no similar study was done in Zimbabwe. This gap made this study relevant as it was done in a new setting. This study was unique in the sense that it was carried out on the teaching of mathematics as a particular learning area. Previous studies generalised their findings to various learning areas. The results of this study are more useful to mathematics teachers and other stakeholders that deal with mathematics teaching than to any other learning areas.

1.3 Purpose of the study

The purpose of this study was to explore secondary school mathematics teachers' knowledge of students' learning styles and how they used the knowledge when they were teaching mathematics. The study was also meant to get the mathematics teachers views on the strategy of teaching mathematics according to students' learning styles. It went further to explore barriers which got in the way of the mathematics teachers as they were using their knowledge of students' learning styles in teaching mathematics.

1.4 Statement of the problem

Numerous studies done in the region in the past confirmed an existence of a high failure rate in mathematics by students and low enrolments into courses or studies which take mathematics as a pre-requisite learning area (Chirume, 2016; Gower, 2019; Kafata & Mbetwa, 2015). For instance, Gower (2019) found that there was a high failure rate in mathematics at secondary school level in South Africa. A similar study done in Zambia, Kitwe District, by Kafata and Mbetwa (2015) also found a high failure rate in mathematics in Zambia. In Zimbabwe, Chirume (2016) carried out a study which also revealed a high failure rate in mathematics by students in Shurungwi and Gweru districts. Although the studies done by the scholars did not give possible reasons for the high failure rate, Bosman and Schulze (2018) stated that prolonged mismatch between teachers' teaching styles and students' learning styles contributed to poor academic achievement and negativity towards the subject. In my opinion, one way of improving the performance of the students was for the mathematics teachers to ensure that they avoid mismatches between their teaching styles and the learning styles of their students. However, mismatches could only be avoided if the teachers possessed knowledge of students' learning styles and used the knowledge for the benefit of their students. The current study was done in order to establish if mathematics teachers had knowledge of students' learning styles. It also sought to find out how the knowledge was utilised by the teachers in the teaching of mathematics, and if the knowledge was being utilised by the mathematics teachers, what were the barriers that the teachers were facing. The results of which would be of much importance in making sure that mathematics teaching can be improved.

1.5 Research questions

This study sought answers to the following three research questions:

1) How do the secondary school mathematics teachers view the strategy of teaching students according to their learning styles?
2) How do the secondary school mathematics teachers use their knowledge of their students' learning styles in teaching mathematics?
3) How do barriers impact on mathematics teachers' effective use of their knowledge of their students' learning styles when teaching mathematics?

1.6 Aims of the study

The research questions given in the preceding section led to the formulation of the following three major aims of this thesis.

A. To investigate on secondary school mathematics teachers' views on teaching students according to the students' learning styles.
B. To investigate on how mathematics teachers utilised their knowledge of students' learning styles when teaching mathematics.
C. To investigate on how barriers impinged on mathematics teachers' use of their knowledge of students' learning styles in teaching mathematics.

1.7 Objectives of this study

In order to accomplish the aims stated above, the following objectives were formulated from the main research aims.

i. To find out what the mathematics teachers knew about students' learning styles.
ii. To find how the mathematics teachers' knowledge of students' learning styles was reflected in the teachers' classrooms.
iii. To find the mathematics teachers' views on the strategy of teaching mathematics according to students' learning styles.
iv. To obtain the strategies that the mathematics teachers used when they were teaching mathematics.
v. To find the teaching aids that the mathematics teachers used when they were teaching mathematics.
vi. To find how the mathematics teachers assessed their students when they teach mathematics.
vii. To find the teacher related barriers and how they impinged on the mathematics teachers' use of their knowledge of students' learning styles.
viii. To find the student related barriers and how they impeded on the mathematics teachers' use of their knowledge of students' learning styles.
ix. To obtain the curriculum related barriers and how they affected the mathematics teachers' use of their knowledge of students' learning styles.
x. To find barriers, related to socio-economic statuses of schools and how they impacted on the mathematics teachers' use of their knowledge of students' learning styles when teaching mathematics.

1.8 Importance of the study

As stated before, mathematics is one of the most important learning areas that a student cannot afford to fail. It is a pre-requisite to a number of courses that students do after secondary school. Unfortunately, more than half of the students who sit for ordinary and advanced level mathematics examinations in Zimbabwe fail. This was confirmed by Chirume (2016) who reported in his paper that more than half of the students who sit for mathematics examinations in Zimbabwe fail. The quest to improve performance of mathematics students in secondary school was the driving factor to this study. This study was carried out with the aim of providing useful information in the teaching of mathematics. In the researcher's point of view, the results of this study benefit mathematics students, mathematics teachers, mathematics textbook writers and curriculum planners. The findings assist mathematics teachers to improve on how they plan, deliver and evaluate their lessons. Equipped with the information found in this thesis, the teachers should make sure that their teaching instructions are student-centred. The major part of this thesis points to the fact that apart from subject content knowledge, a mathematics teacher should possess knowledge of his or her students' learning styles. According to the discussions in the thesis, the knowledge of students' learning styles ensures that the teacher's teaching strategy matches the students' learning styles. The study also alerts the mathematics teachers on the possible barriers that are likely to be faced when teaching students in their preferred ways. Once the teachers foresee the barriers, remedies can be prepared in advance. Mathematics students also benefit from the results of this study. The students are always on the receiving end of the learning process. As a result, they are the beneficiaries of an improved teaching-learning process. Mathematics textbook writers and other stakeholders who prepare learning materials for mathematics students also benefit from the findings of this study. Information on the teachers' views on the strategy of teaching mathematics according to students' learning styles enlightens them. They prepare learning materials with the teachers' views in mind so that the content in the learning materials matches the teachers' needs and expectations. Curriculum planners also benefit from the results of this thesis. They are equipped with knowledge on what teachers think about the policies in place and they can use the knowledge to develop better policies.

1.9 Context of the study

This study was done at ten secondary schools in Makoni District of Manicaland Province in Zimbabwe. The Zimbabwean education system has three levels, which are: infant level, junior level and secondary school level. The infant level comprises early childhood

development levels A and B (ECD A and B) as well as grades one and two. The infant level takes four years for a learner to complete. After going through the infant level, a learner proceeds to the junior level. The junior level starts from grade three and it ends at grade seven. A learner takes five years to go through this level. Both the infant and the junior levels are in the primary school sector of the Zimbabwean system of education; hence a learner takes nine years to complete primary school level. It is then after completing primary school level, when a learner goes for secondary school education. A learner takes six years to complete secondary school level before going for tertiary education. Secondary school starts from form one and it ends at form six. At secondary school level students learn a minimum of ten subjects and a maximum of twelve subjects. Seven subjects are compulsory. Mathematics is one of the compulsory subjects that are done by students at secondary school level. This shows the importance of mathematics in the secondary school curriculum in Zimbabwe. As a result, studies are required in order to ensure that the performance of students in mathematics improves.

1.10 Research methodology

This study followed a qualitative paradigm. The researcher collected qualitative data from secondary school mathematics teachers, hence qualitative data collection and analysis methods were appropriate. Principles of content analysis as stipulated by Bengtsson (2016) were followed during data analysis in this study. The principles stipulate that the researcher analyses the actual words uttered by the participants. The meanings of the words are also analysed. Statements spoken by the participants were used to support the findings. However when using the actual words, the issues of confidentiality and anonymity were observed by use of pseudonyms. A data analysis tool called ATLAS.ti. was used in arranging and coding the data collected. This study was done in three phases. Each of the three phases sought answers to one of the three research questions that guided this study. The first phase explored mathematics teachers' knowledge of students' learning styles and their views on the strategy of teaching students according to the students' learning styles. The second phase explored how the mathematics teachers used their knowledge of students' learning styles when teaching mathematics. The third phase then explored barriers that the mathematics teachers were facing when they used their knowledge of students' learning styles in teaching mathematics.

1.11 Research design

An exploratory interpretive case study design was used for this study. It was a case study of secondary school mathematics teachers. A small number of participants were used in the study hence a case study was the most appropriate design to use for the study. This was supported by Welman and Kruger (2001) who reiterated that case studies are used when small numbers of participants are dealt with. The case study was exploratory in nature in the sense that it was meant to investigate what mathematics teachers knew about students' learning styles and how they used the knowledge when teaching mathematics. The interpretive part meant that the researcher sought to get a deeper understanding of the teachers' knowledge, views and utilisation of their knowledge of students' learning styles. The case study was interpretive in the sense that the researcher had to interpret the actual words spoken by the mathematics teachers in order to get the meanings of the teachers' words.

1.12 Research techniques

Face to face semi-structured interviews, lesson observations and document analysis were the techniques which were used to collect data from the secondary school mathematics teachers. The researcher interviewed the mathematics teachers during their working hours and at their work stations. The researcher also observed lessons taught by the mathematics teachers. During the lesson observations, the researcher did not interfere with the process in the classrooms. He was a complete observer. The following documents also provided relevant data for this study: teachers' lesson plans, students' exercise books and class timetables.

1.13 Unique contributions made by the study

Although a myriad of studies on teachers' knowledge of learning styles were done before, this current study was unique in the following ways:

(i) The current study was done in a Zimbabwean context and on the teaching of mathematics in particular. The researcher found in the reviewed literature that previous studies were done on the use of students' learning styles in general and not specifically on the teaching of mathematics. The studies found in the literature were not subject specific. The reviewed literature had no evidence of the existence of studies on the use of teachers' knowledge of students' learning styles in mathematics teaching.

(ii) This study was made unique by the fact that it went a bit further from simply highlighting what mathematics teachers knew about students' learning styles. It investigated how the mathematics teachers utilised the knowledge when teaching their mathematics students. Having observed that the mathematics teachers had basic knowledge of students' learning styles but they were not effectively utilising their knowledge, the researcher went further to investigate on the factors that affected the teachers as they tried to utilise their knowledge on their students' learning styles.

(iii) The study serves as a guide to mathematics teachers on how and why they should teach their students in the students' preferred ways. It goes further to give the implications of the findings at each of the three phases of the study as a way of assisting the mathematics teachers to improve on their teaching strategies. The implications of the findings, as reported in this report, are also helpful to curriculum planners. In general, the study signifies the importance of considering students' learning styles when planning school curricula for students.

1.14 Limitations of the study

Although the researcher took relevant measures to ensure that the quality of the study was guaranteed, the study had some limitations. The following were the limitations of the study that were identified by the researcher.

(i) This study was a case study of thirty-four secondary school mathematics teachers from ten schools in Makoni District of Manicaland Province in Zimbabwe. By the general nature of case studies, generalisation of the findings of this study to other areas of study may not be applicable. The results obtained in this study may differ from the results that may be obtained from other areas depending on the setting of the study. However, the researcher made efforts to make sure that the aspects of quality research were maintained.

(ii) This study was done during the time when the economic condition of the country was not favourable for both the teachers and their students. Some of the findings, especially those on barriers affecting the teachers' effective use of their knowledge of learning styles, may have been affected by the hyper inflation that the country was experiencing during the time when the study was carried out. There is high possibility that if the study is repeated when the economic conditions improve, different results can be obtained. In future, the researcher intends to carry out a similar study in order to establish the effects of the economy on the research findings.

1.15 Delimitation of the study

The study was confined to ten secondary schools in the Makoni District of Manicaland Province in Zimbabwe. Zimbabwe is a country in Southern Africa. The country has twelve provinces. Manicaland Province is in the east of the country. It is the gateway to neighbouring Mozambique. Makoni District is one of the seven districts in Manicaland Province. The district has eighty-nine secondary schools. Out of this number, ten were chosen for the purpose of this study.

Secondary school mathematics teachers participated in the study. The study was delimited to the teaching of mathematics at secondary school level as determined by the education system in Zimbabwe. However the education system in Zimbabwe could be different from the education system in other countries. The data used in the study was obtained directly from the secondary school mathematics teachers; hence the findings are only related to the teaching of mathematics at secondary school level. The findings may not be applicable to other learning areas.

1.16 Definitions of key terms

This section gives some definitions of the key terms that were used in this thesis. The purpose of giving the definitions is to contextualise the meanings of the terms. The following terms were used in this thesis.

1.16.1 Secondary school

According to the Ministry of Primary and Secondary Education (MOPSE) (2015), a secondary school is a school that offers education to learners in their tenth to the fifteenth year in school (forms 1 to 6).

1.16.2 Mathematics

According to Fletcher (2006), mathematics refers to a broad domain which has a number of topics which include algebra, geometry, arithmetic, calculus and trigonometry. Askew, Rhodes, Brown, William and Johnson (1997) regarded mathematics as an area that deals with numerical information in a variety of contexts. The contexts include communicating and interpreting mathematical ideas. The two definitions of mathematics agree with the contextual meaning of mathematics in this study. In this study, mathematics involves processing, manipulating, communicating and making sense of numerical information.

1.16.3 Mathematics student

In this study, a student is a person enrolled at a secondary school for the purpose of learning. A student learns by attending lessons taught by a teacher. A mathematics student is a student who learns and attends mathematics lessons.

1.16.4 Mathematics teacher

A mathematics teacher is an adult person who is employed to facilitate the learning process of mathematics students in a formal class. The mathematics teacher plans, delivers and evaluates the learning process. He or she identifies and assists his or her students who require extra help from him or her.

1.16.5 Barrier

A barrier in this study refers to a factor or event that impeded on the mathematics teachers' effective use of their knowledge of students' learning styles in teaching mathematics. The barriers could impede by slowing down the teaching process or by making the utilisation of students' learning styles completely difficult for the mathematics teachers.

1.16.6 Utilisation

Utilisation referred to how the mathematics teachers used their knowledge of students' learning styles when they were teaching mathematics.

1.16.7 Learning styles

The definition of learning styles according to Hultzman (2018) was adopted in this study. Hultzman stipulated that learning styles are different ways in which students interpret, organise and represent new information. In simple terms, learning styles refer to students' preferred ways of learning.

1.16.8 Teaching styles

According to Bohren (2019), teaching styles refer to the teachers' general principles and management strategies for classroom instruction. As used in this report, teaching styles referred to the mathematics teachers' ways of preparing, delivering and evaluating teaching instructions.

1.16.9 Perception

Perception in this study had two meanings depending on the context in which the word was used. In the context of learning styles under learning style models, it referred to how the

learner finds out about the things around him or her. In the other contexts, it referred to how a person viewed or thought about mathematics as learning area.

1.17 Organisation of the thesis

The thesis comprises eight chapters. A summary of each chapter is given in this sub-section.

1.17.1 Chapter 1

This chapter introduced the reader to the thesis. It started with an introduction to the study in which the researcher gave an explanation of the background of the problem under study. The chapter gave an outline of the three research questions that guided this study. The research questions were split into sub-questions. The sub-questions were also outlined in this chapter. The chapter gave an explanation on the purpose and importance of this study to the teaching mathematics. This included an explanation on the gaps in the existing knowledge that were filled in by the findings of this study. A brief description of the research methods, techniques and design used in this study was given in this chapter. Most importantly, this chapter outlines the geographical and conceptual delimitations of the study. The research setting of the study was described. The limitations of this study were also given in this chapter.

1.17.2 Chapter 2

The second chapter of the thesis gave an outline of the framework on which this study was framed. It started with an overview of the theories on mathematics learning. It went further to give a brief history of the learning styles theory. Three learning style models were outlined. The outline included information on the learning styles theorists, their classification of learners and their descriptions of the classes of learners.

1.17.3 Chapter 3

This chapter reviewed literature related to the use of students' learning styles in the teaching of mathematics. It started by examining literature on mathematics teachers' knowledge of students' learning styles. Work by different scholars was examined under this sub-section. The chapter went further to examine what other scholars reported on the need for mathematics teachers and their students to be aware of their own learning styles. The importance of this knowledge to both teachers and students was discussed. The chapter also described instruments which are used to assess learning styles. In this chapter, the researcher reviewed literature on how mathematics teachers teach mathematics according to students' learning styles. Suggestions shared by different scholars were stated and discussed. The

chapter also examined literature on barriers that affected the teaching and learning of mathematics. The last part of the chapter had some critiques from other scholars on the strategy of teaching mathematics according to students' learning styles.

1.17.4 Chapter 4

Chapter 4 of the thesis gave a detailed explanation of the methodology used in carrying out this study. It had some description of the research method and design used in this study. The researcher explained in this chapter that this study used qualitative methods to collect and analyse data. It was also explained that the study was a case study of mathematics teachers who were teaching in the secondary school. The reasons for using a case study were given. The researcher also gave a description of the research instruments used to collect data from the participants. The participants were also described. The sampling methods which were used to select the participants were explained in this chapter. The researcher also gave an explanation of the ethical issues that were considered during this study. The ethical issues considered in this study included informed consent, confidentiality and anonymity. The researcher went further to give an assurance on the quality of the study. The quality was maintained through a number of measures taken by the researcher. The measures were highlighted. The last part of the chapter reported on the data analysis methods which were followed by the researcher.

1.17.5 Chapter 5

This chapter reported on the findings of the first phase of the study. It reported on the findings on the mathematics teachers' knowledge of students' learning styles. The teachers' understanding of learning styles was given. This was followed by a presentation of the teachers' views on the factors which determined students' learning styles. The researcher also reported on the mathematics teachers' views on the importance of their knowledge of learning styles in their work. The chapter then outlined the teachers' views on the strategy of teaching students according to the students' learning styles.

1.17.6 Chapter 6

Chapter 6 of this thesis presented findings from the second phase of the study. The presentation was done on the findings on how the mathematics teachers used their knowledge of students' learning styles in teaching mathematics. The presentation began with a discussion on the strategies that the teachers used when teaching mathematics. This was

followed by an outline of the teaching aids that the teachers used. The last part of the chapter presented the strategies used by the teachers to assess their students' learning process.

1.17.7 Chapter 7

This chapter reported on the findings on barriers that hampered the mathematics teachers' use of their knowledge of students' learning styles when they were teaching mathematics. The chapter gave a report of the findings of the third phase of the study. It started by a report on the barriers which were related to the teachers' personal attributes and teaching skills. It went on to give an outline of barriers that were related to the students. Curriculum related barriers were also identified and were reported. The last part of the chapter reported on barriers that were related to the socio-economic status of the schools.

1.17.8 Chapter 8

Chapter 8 is the last chapter in this thesis. The chapter gave a summary of some conclusions which were made by the researcher based on the findings of the study. The last part of the chapter presented recommendations which were made by the researcher. The recommendations were made in an effort to improve mathematics teaching. Recommendations for further researches were also given in this chapter.

1.18 Chapter summary

This chapter introduced the reader to the thesis. It started with the background of the study. In the background of the study, the researcher reported on the rationale for carrying out the study. The background of the study also enlightened the reader on the debate on the effectiveness of the method of using students' learning styles when teaching mathematics. The chapter proceeded to explain the purpose of this study. The researcher went further to outline the research questions that guided the study. Aims and objectives of the study were also stated. The researcher explained the education system in Zimbabwe in brief. The explanation was meant to make the reader understand the context of the study. A brief description of the research methodology was also given in this chapter. This was followed by an outline of the limitations and delimitations of the study. The chapter ended with an overview of the chapters which constitute the thesis.

CHAPTER 2

THEORETICAL FRAMEWORK

2.1 Introduction

The purpose of this chapter is to give an overview of the theoretical framework of this study. The chapter starts with an outline of the theories in mathematics teaching. It goes on to give the framework that guided this study. Different definitions of learning styles as found in literature are given. The definitions are followed by a brief history of the learning styles theory. The brief history enlightens the reader on how the learning styles theory developed. It also serves to acknowledge the sources of the ideas that are utilised today under the concept of learning styles. This chapter also gives an outline of studies on learning differences. The studies that are outlined in this chapter gave birth to models on learning styles. The following models are discussed: Kolb's experiential learning styles model, Honey and Mumford's learning styles model and Perini, Silver and Strong's learning styles model. The three models were chosen for discussion in this study on the basis of their relevance to the teaching and learning of mathematics. The chapter ends with a summary of the main details in the chapter.

2.2 Theories in the teaching of mathematics

This section provides an overview of the theories that assist mathematics teachers to effectively teach mathematics. Generally, theories help teachers to plan instruction, communicate the instruction, assess students' performance, evaluate the teaching process and keep professional ethics (Machaba, 2013). In simple terms, a theory on teaching endeavours to give an explanation to teachers of how human beings acquire new knowledge and in so doing it assists them to understand the complex process of learning. Illeris (2004) defined learning as a process that involves emotional, cognitive and environmental influences and experiences for gaining, enhancing or making changes in a person's values, skills, knowledge, behaviour and views. According to Hill (2002), theories of teaching and learning have two main functions. They provide teachers with the vocabulary to use in giving instruction and a conceptual framework to interpret the examples of learning that the teachers observe. The theories also suggest possible solutions to practical problems faced by the teachers and their learners. However, these theories may not provide the teachers with the exact solutions to the problems but they could direct the teachers towards the possible solutions.

Theories that are used in teaching mathematics can be categorised into three categories, namely behaviourism, cognitive and constructivism (Machaba, 2013).

2.2.1 Behaviourism learning theory

According to Kelly (2012), behaviourists deal with observable aspects of the learning process. They believe that individuals change their behaviour due to a relationship between stimuli and responses. Bush (2006) stated that according to behaviourists, not all learning outcomes are worthy studying. Only those that can be observed and measured are worthy scientific inquiry. That is the reason why teachers who follow the behavioural learning theory frame their lesson objectives in behavioural and measurable terms. Bacanli (2012) explained that behaviourists view human brain as a black box. One cannot see the contents of the box. However, to a behaviourist it is not important to know what is inside the box. What matters is what gets into the box and what comes out of it. Therefore, behaviourists are not keen to study the human brains, but they are interested in studying the information that the human brains receive and the reaction of the individual after receiving the information.

According to behaviourists, learning begins when a learner responds to a cue or a stimulus and learning is judged by a change in behaviour (Kelly, 2012). The change in behaviour is predictable and controllable (Weegar & Pacis, 2012). That means a teacher can easily predict a students' reaction to an instruction. The teacher can also control how the students respond to an instruction. Kelly stated that, according to behaviourism, the learning process can be reinforced so that the desired outcome can be maintained. For instance, getting a good grade can serve to reinforce good studying behaviour by a student. Kelly went on to state that when teachers reward or punish students, they apply the principles of behaviourism. Rewarding students for good performance reinforces hard work done by students. Punishing students for doing wrong things serves to make sure that the students desist from repeating the same action.

Weegar and Pacis (2012) reported that, according to behaviourism, the learning environment can affect the learning process. Some environments lead to poor performance by student whilst some encourage students to work hard. According to Weegar and Pacis, all students have potential to perform well provided the learning environment is conducive to effective learning.

However, as stated by Kelly (2012), behavioural instruction does not train students to be creative thinkers or to be competent problem solvers. It teaches students to follow rules,

formulae and algorithms without making any changes and without bothering to prove them. According to Kelly, examples of behaviourism teaching strategies include drilling or rote teaching, repetitive practice and provision of incentives or verbal comments like ‘good work’. As stated by Kelly, behaviourism theory was founded by Skinner and Watson.

2.2.2 Cognitive learning theory

According to Machaba (2013), cognitive theories endeavour to explain brain based learning. Unlike behaviourists, cognitivists believe that individuals process new information or new experiences rather than simply responding to cues. They believe that behaviour change can be noticed on individuals after a learning process, but the change in behaviour is a result of processes that take place inside the individual’s brains. When the learner receives new knowledge, the learner relates it to the knowledge already existing in the learner’s brains. The new knowledge is processed and included in the existing knowledge structure in the learner’s brains. According to Kelly, the founder of the cognitive learning theory is Jean Piaget.

According to cognitive theory, learning is defined as change in what the learner knows and keeps in his or her memory and not just a change in behaviour. The cognitive theory explains how the human brain works. It recognises that mental processes are affected by both intrinsic and extrinsic factors. Learning difficulties are a result of ineffective mental processes (Sincero, 2019),

Sincero (2019) reported that cognitive learning theory can be divided into two more specific theories which are social cognitive theory and cognitive behavioural theory. Social cognitive theory deals with three variables or factors that are interrelated. The variables are behavioural factors, environmental factors and the personal factors. Environmental factors are extrinsic factors while personal factors are intrinsic. Sincero explained that a combination of the three factors affects the way a learner thinks and behaves. Interaction between personal factors and environmental factors modifies the beliefs, ideas and cognitive competences of a person. Interaction between personal factors and behavioural factors affects the way a person behaves. When environmental factors and behavioural factors interact, the way a person behaves is also affected. The interaction can also result in change in the environment. Therefore in the cognitive theory perspective, for effective learning to take place, positive personal characteristics, appropriate behaviour and a conducive environment are necessary and mandatory.

According to Sincero (2019), from the social cognitive theory's viewpoint some basic cognitive aspects are noticeable in people. The aspects include observational learning, reproduction, self-efficacy, emotional coping, self-regulatory capability. Observational learning means learning from others by simply observing how they operate. Reproduction involves putting a learner in an environment that encourages the learner to repeat certain behaviour. Such an environment should provide all the required materials to enable the learner to retain new knowledge or skill for a long time. Self-efficacy involves putting a new skill or new knowledge into practice so that it can be retained for a long time. Emotional coping refers to development of coping mechanisms that enable the learner to learn effectively in environments that are not favourable. Self-regulatory capability refers to a person's ability to control his or her behaviour even in situations that maybe difficult for the person to control himself or herself, for instance, in situations that are tempting.

Cognitive social theory involves the use of cognition to make predictions or to determine the behaviour of an individual (Sincero, 2019). Cognition simply means knowledge. According to the cognitive social theory, individuals develop self concepts about their behaviour. Self concepts refer to what individuals think about themselves. An individual can think positively or negatively about himself or herself. The self concepts control the behaviour of the individual. They can be controlled by the environment in which the individual lives. Cognitive triad is used in cognitive social theory to explain human behaviour. Cognitive triad comprises thoughts about oneself, the world and one's future. The thoughts can be negative, for instance thought like 'I am a fool'. Such thoughts control the behaviour of a person, as explained by cognitive social theory.

Cognitive theory is applicable in many situations in teaching and learning. Examples of situations where ideas from cognitive theory are applied in mathematics teaching include situations in which teachers use the following strategies in teaching: problem solving, discussions, analogies and examples from real life situations.

2.2.3 Constructivism learning theory

Constructivists use ideas developed by theorists like Piaget, Vygostky and Bruner. According to Machaba (2013), constructivism theories take learning as a process in which the learners actively build new knowledge and concepts. It is based on the belief that individuals build their own perspectives of the world through their own experiences and internal processes. According to constructivists, learning is unique and it differs from individual to individual

depending on how the individual interprets the world. According to McLeod (2019), individuals make their own meanings and interpretations of the world. The meanings and the interpretations are a result of an interaction between the individual's prior and new knowledge and experiences. As explained by McLeod, teachers and their students share authority and knowledge. Although the teacher acts as a facilitator in the process in which the students learn, the teacher also learns from the students. McLeod also suggested that a teacher who teaches according to the constructivism theory should make use of small groups which consists of students who are heterogeneous. The reason for using small groups is to make sure that each member of the group gets an opportunity to participate actively in group activities. Heterogeneous groups ensure that students with different abilities and who interprets the world differently mix and share their perspectives of the world.

To a constructivist, learning outcomes are not predictable. Therefore a teacher who follows a constructivist approach to learning cannot tell the outcome of his or her teaching process before delivering the lesson. When teaching mathematics, constructivism theory can be applied in the following situations among others: brainstorming, problem solving, guided discovery learning and collaborative learning.

Constructivists define learning as how the individual learner interprets and creates own meaning of the new experiences that the individual learner receives. The learning process starts with the learner making some hypotheses. The learners are actively involved in the learning process, in which they construct knowledge depending on their prior and new knowledge and experiences. The role of the teacher is to facilitate learning and to negotiate meaning with the learners and not to dictate an interpretation to the students (Driscoll, 2015). The teacher gives help to the students whenever it is needed, especially in the early stages of learning a concept.

According to McLeod (2019), constructivism theory has the following five principles:

- Knowledge cannot be passively absorbed

This forms the central idea in constructivism theory. The theorists believe that knowledge cannot be transferred from one person to the other. Self discoveries are important in order to gain an understanding of concepts.

- Learning is a process

Learners need to be actively involved in the learning process. The learner can be actively involved in the learning process by carrying out experiments, making inquiries and through problem solving. An expert, for example a teacher, should only serve to guide the learner.

- Knowledge is socially constructed

According to constructivists, a learner acquires knowledge through interaction. The learner interacts with peers and experts in the area under study. Constructivists believe that the environment in which the learner lives affects the meanings that the learner attaches to the world (Vygostky, 1978).

- Knowledge is personal

Learners can be taught by the same teacher using the same teaching strategies and under the same environment, but the learners understand the concepts learnt differently.

- Learning takes place in the mind of the learner

Individuals develop their own mental models of the world around them. The process takes place in the individual's mind.

The theories of learning discussed in this section provide a framework for various studies on teaching and learning. They form the basis or the foundation of the theory on learning styles. The learning styles theory borrows ideas from the three categories of the theories of learning discussed in this section.

2.3 Theoretical framework

A theoretical framework provides a lens on which a researcher positions his or her study (Henning, Van Resbeg & Smit, 2005). The researcher makes some assumptions on the study using ideas from the theoretical framework. The framework connects the study to the world. It facilitates a dialogue between the researcher and the available literature. It also forms a basis from which a research is anchored.

This study is anchored on the learning styles theory. The learning styles theory forms the foundation of this study. The study seeks to understand how secondary school mathematics teachers view the application of the theory on learning styles in the teaching of mathematics. It also seeks to explore how the teachers utilise the theory in teaching mathematics. It goes further to get an understanding of the barriers that the teachers face as they implement the

ideas from the theory in teaching mathematics. The origin of the theory of learning styles and the ideas from the theorists that contributed to this theory are discussed in the sub sections below.

2.3.1 Definition of learning styles

Review of literature shows that learning styles are defined by different scholars in different ways. The following are some of the ways in which learning styles are defined in literature. Patel and Singh (2014) defined learning styles as the ways a learner processes, internalises and remembers new academic information. To Markova in Al-balhan (2007), a learner's learning style is the most comfortable way the learner can learn. This definition by Markova makes it clear that each learner has a choice of ways that appear most comfortable to him or her to acquire new knowledge. For instance, as explained by Markova, some learners learn comfortably through interacting with peers while others feel comfortable when they learn as individuals.

Felder (2010) defined learning styles in relation to the learner's learning environment. Felder says that a learner's learning style is a way in which the learner perceives, interacts with and responds to the learning environment. This definition by Felder suggests that learning styles are a result of an interaction between the learner and the learning environment. In other words, Felder claims that learning styles are determined by the environment in which the learner learns. However, studies done by other scholars revealed that learning styles are also determined by other factors like culture, personality type, educational specialisation, career choice, current job role and task to be performed (Kolb & Kolb, 2013; Kolb, 1984). Kolb and Kolb found that culture and educational specialisation shape the learner's learning styles by instilling positive attitude towards specific sets of learning skills and by teaching the student how to learn. One's choice of career and job role expose one to a specific learning environment and one becomes a member of a reference group of peers who share a common set of values, beliefs and rules. The professional mentality and behaviour expected of the job shapes one's learning style. According to Kolb and Kolb learning styles expected of a mathematician are different from those expected of a politician. Kolb and Kolb believed that each mathematics task a learner faces requires a set of corresponding skills. In order to perform effectively, the learner is forced to match the demands of the task with his or her personal skills.

Haar, Hall, Schoepp and Smith (2002) referred to learning styles as individual differences in perceiving, processing and communicating information. This definition brings in the fact that learners are unique individuals. Learning styles differ from learner to learner. This point was supported by a number of scholars (Cassidy, 2004; Felder, 2010). Of these scholars, Cassidy raised some very interesting points. He says that even children learn differently from their biological parents. However, as stated by Cassidy, some individual learners have different learning styles. Their learning styles are determined by the tasks to be learnt. They can flexibly change from one learning style to the other in order to suit the teacher's instruction and the task ahead of them.

Another school of thought put forward the view that learning styles are an integration of the learner's cognitive processes and the learner's behaviour (Barke, 2009; Chandler, 2019). According to Barke and Chandler, learning styles are a result of the interaction between the learner's cognitive thinking and the learner's observable behaviour. In other words, those scholars think that the learner's cognitive thinking plays a role in determining the learning style of the learner. In explaining this point, Chandler purported that a learning style is an output of a process in which the learner's cognitive thinking, behaviour and attitudes are combined.

A close analysis of the definitions of learning styles found in literature reveals that in simple terms, learning styles are unique ways a learner prefers to master learning, solve problems, think and react to instruction. Learning styles explain how a learner perceives learnt concepts and how he or she makes scholarly decisions. They also explain how the learner interacts with the learning environment. The learning environment comprises, among others, the learner's peers, the teacher and the society. Various theories on learning styles present different views on how learning styles can be defined and how they can be categorised. However common concepts about the theories are that individuals differ in how they learn and that learners can be classified according to their styles of learning. Consideration of students' learning styles has become increasingly important for the learners, teachers and parents to understand optimal conditions that foster effective learning. As discussed in the literature reviewed in this study, particular teaching strategies, teaching tools and environment suit certain learning preferences. Students perform better when the conditions are consistent with their learning preferences.

2.3.2 The origin of the learning styles theory

The learning styles theory is a relatively common theory in the teaching and learning of mathematics, today. It is of paramount importance for scholars to know how the theory developed. In this section, a brief history of the learning styles theory is given.

According to Chandler (2019), the study of learning styles started in the twentieth century with the development of an intelligence test by Binet Afred in 1904. Alfred developed an intelligence test in order to identify students who needed extra care in learning. He had particular interest in individual learning differences. According to Wishner (2019), Afred Binet studied children (including his own two daughters), mental patients and professional artists in order to come up with the intelligence test. His study was guided by the belief that an individual's score on the intelligence test can vary depending on a number of factors. One of the factors is motivation. According to Binet in Wishner, when a learner is motivated to learn, there is a possibility that the learner's intelligence improves. In his remarks, Binet gave room for further studies on individual differences as he admitted that his work had some limitations (Cherry, 2019).

The development of an intelligence test by Alfred Binet and the fact that he had admitted that his work had some limitations challenged other scholars to pursue vigorous studies on individual differences in learning. One of the scholars who followed Alfred Binet's footsteps was Maria Montessori. According to Chandler (2019), Maria Montessori initiated the Montessori Method of Education in 1907. Montessori Method of Education entails that the teacher makes use of materials that enhance the learning styles of his or her learners. She adopted a model which was later referred to as the 'follow-the-child' model. This means the child determines what the teacher teaches. The teacher's instruction is tailored to suit the child's interests, abilities and learning styles. It has to be child-centred. The child is provided with a variety of learning materials and the child chooses the materials to use in learning under the guidance of the teacher. The teacher's role is only to facilitate learning and to ensure safety to the child. With this method, the teacher acknowledges the individual learning styles of the learners. He or she is also mandated to assist the learners to develop on other learning styles that may not be dominant in them. According to Chandler (2019), Montessori believed that learners show mastery of subject content through their actions and not by responding to multiple choice questions. For that reason, the ideas that were shared by Montessori were action related. With passage of time, the Montessori Method of Education was adopted by several schools around the world, which deal with young learners.

According to Chandler (2019), after discoveries by Montessori, studies on learning styles were put to a halt for about fifty years and then they continued in the 1950s. During the period when studies on learning styles had stopped, emphasis was put on studies on academic performance of the learners. In 1956, Benjamin Bloom emerged with his taxonomy. It was referred to as Bloom's taxonomy. The taxonomy contributed immensely in explaining differences in learning styles. Bloom classified students' learning styles into six levels of cognitive thinking. As explained by Chandler, the levels were quite distinct and the following were the levels suggested by Bloom: knowledge, comprehension, application, analysis, synthesis and evaluation. The levels are hierarchical and they can be represented in a pyramid form, with a wider base and a narrow top. From the bottom of the pyramid, the first three levels are more basic than the other three. According to Bloom (1956), a learner progresses from the lower level towards the apex. A learner who masters an upper level is deemed to have mastered the lower levels because according to Bloom, mastery progresses from the bottom of the pyramid to the top. Bloom believed that when teachers teach, their emphasis should be on mastery of subjects and not on transfer of knowledge. He discouraged teachers from using rote methods of teaching. Rote methods of teaching serve to transfer knowledge from teachers to students, sometimes without proper mastery of the subject. The ideas that were brought in by Bloom are applicable to different learning areas (Anderson, Krathwohl & Bloom, 2001). His taxonomy provides a useful template or checklist for teachers when they prepare lessons. As teachers prepare lessons or training programmes, they should make sure that all aspects of the taxonomy are covered by the lessons or the training programmes. According to Anderson et al., the levels of the taxonomy can be attained by students in three domains. The three domains are affective, cognitive and psychomotor. The affective domain comprises the students' attitudes and beliefs. The cognitive domain covers the students' knowledge and intellect. The psychomotor domain deals with the students' abilities to use their physical and bodily skills. Anderson et al. suggested that teachers should aim to develop their students in the three domains.

In 1972, Carl Jung developed a theory of personality types (Perini, Silver and Strong, 1997). The theory states that individual learners have differences in perception, interaction and decision making. Jung identified four pairs of contrasting dimensions of learning styles that are found in learners. The dimensions are: extraversion versus introversion, sensation versus intuition, thinking versus feeling and judging versus perceiving. Table 2.1 shows the

dimensions of the learning styles (as suggested by Carl Jung) and the characteristics of the learners that fall under each of the dimensions.

Table 2.1: Carl Jung's dimensions of learning styles and the characteristics of the learners in each learning style dimension

Learning style dimension	Characteristics of the learners
Extravert learners	• Learn through direct experience • Enjoy group-work • Always willing to participate and give opinions • Jump into implementation of ideas • Do not consider of the pros and cons of their actions
Introvert learners	• Enjoy solving problems on their own • Generate ideas from internal forces like brain storming • Use personal reflections • Think before taking a decision • Listen, observe and reflect
Sensate learners	• Focus on the present • Are practical and they use reasoning • Use experience and common sense when solving problems • Enjoy observing the practical world
Intuitive learners	• Work in small sessions instead of finishing the work at once • Enjoy new challenges and experiences • Use theories and abstract ideas in solving problems
Thinking learners	• Enjoy discovering patterns and logic behind actions • Do not use emotions in making decisions • Use logic and reasoning in making decisions
Feeling learners	• Enjoy getting people's feelings • Make decisions on their present feelings • Generate excitement and enthusiasm in group settings
Judging learners	• Make firm decisions • Are organised and structured

	• Follow rules as they are without criticising
Perceiving learners	• Make impulsive decisions • Can change decisions when they get new information • Flexible in decision making • Have problems in making decisions

Jung's theory of personality types states that any learning process requires perception and judgement (Mctighe & Silver, 2019). Perception refers to how the learner finds out about the things around him or her. Judgment refers to how the learner processes, evaluates, makes decisions or judges what he or she perceives. According to Jung in Mctighe and Silver, perception occurs through sensing or intuiting, while judgment occurs through thinking or feeling. The preference for sensing or intuiting is independent of the learner's preference for thinking or feeling. This means a learner can perceive new knowledge by sensing and then judge the knowledge by either thinking or feeling. The same happens to a learner who perceives new information by intuiting. Figure 2.1 illustrates the learning process as suggested by Carl Jung.

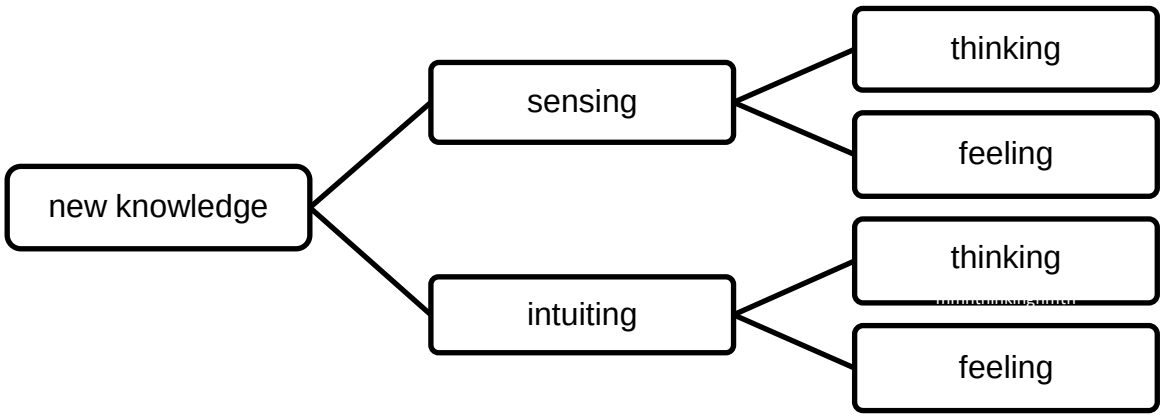


Figure 2.1: Illustration of the learning process as suggested by Carl Jung

Jung's work inspired numerous researchers who then developed interest in understanding specific differences in human learning. Several studies on learning differences were carried

out and different learning style models were developed. Some of the followers of Carl Jung who developed learning style models were David Kolb, Mathew Perini, Harvey Silver, Richard Strong, Alan Mumford and Peter Honey. The learning style models developed by these theorists formed the backbone of this study. The next session analyses the learning style models that were developed by these scholars.

2.3.3 Learning style models

This section gives an overview of the learning style models by the following scholars: David Kolb, Allan Mumford, Peter Honey, Mathew Perini, Harvey Silver and Richard Strong. The models developed by those scholars were supported by research done by the scholars themselves. The models are vital in the teaching and learning of mathematics.

2.3.3.1 David Kolb's experiential learning style model

Kolb's learning style model has its roots in Carl Jung's theory of personality types (Kolb, 1984). According to Kolb, some of the ideas used in developing the model were borrowed from constructivism theory. Constructivism theory emphasises on the use of child-centred methods in teaching. Constructivists believe that the learner should be active in discovering own knowledge. The teacher should only be a facilitator in the learning process. John Dewey, Kurt Lewin, Jean Piaget, Lev Vygotsky, William James, Carl Jung, Paulo Freire, Carl Rogers and Mary Parker Follett were some of the constructivists whose ideas were borrowed by Kolb (Kolb & Kolb, 2013).

Kolb and Kolb (2005) described learning as a process of developing knowledge by transforming experiences; hence they refer to Kolb's learning styles model as an experiential learning style model. The model is based on a four-stage learning cycle. Figure 2.2 shows the four-stage learning cycle.

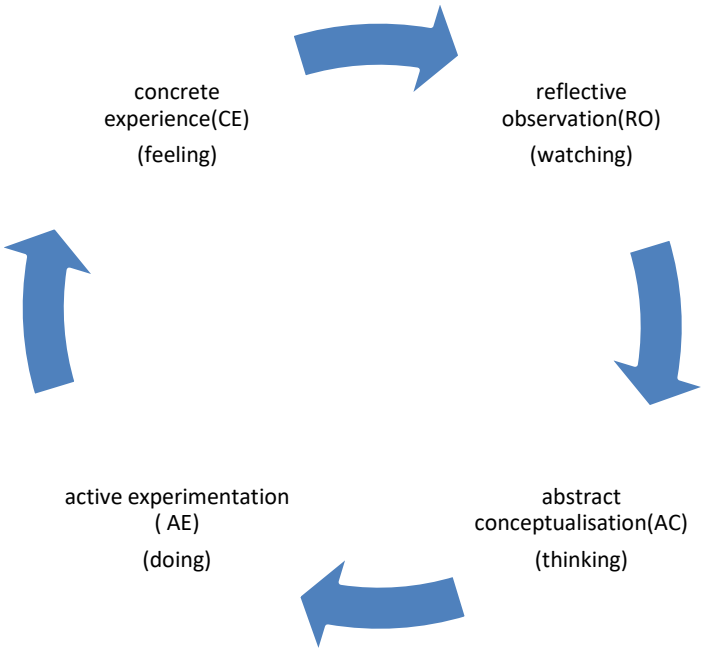


Figure 2.2: Kolb's four stage learning cycle

Kolb and Kolb (2011) articulated that a learner's learning style describes the learner's preferred approach to the learning cycle. The learner's learning style indicates which stages on the learning cycle the learner prefers and which ones the learner avoids or underutilises. The learning cycle gives the stages at which knowledge is grasped and transformed by a learner. Grasping refers to the process of taking in new information. Transforming information is a process by which a learner interprets and acts on the new information (Kolb & Kolb, 2013). According to Kolb and Kolb, a learner has one dominant grasping preference and one dominant transforming preference. Like Carl Jung, Kolb believed that the learner's way of grasping information is independent of the way the learner transforms the information. A learner grasps new knowledge in one of the following two ways: by concrete experiences or by abstract conceptualisation. The knowledge is then transformed or processed in one of the following two ways: by reflective observation or by active experimentation. Figure 2.3 illustrates the ways in which a learner can grasp and transform information as suggested by Kolb (1984).

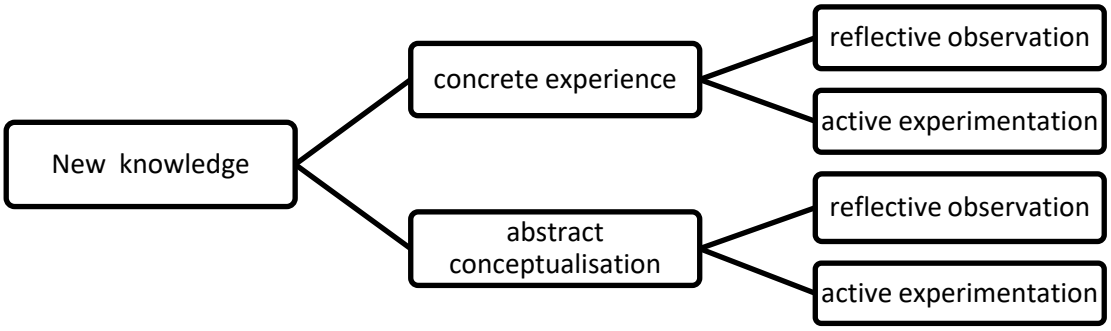


Figure 2.3: Illustration on how learners grasp and transform new knowledge

The concrete experience stage marks the stimulus. At this stage, the learner receives new experience or new meaning from a previously experienced situation. At the reflective observation stage, the learner tries to understand the new meaning or the new experience. The learner reviews his or her previous experience. A comparison is made between new and old experiences. Discussions with peers are important at this stage. The abstract conceptualisation stage is when the learner receives new ideas or develops new abstract thoughts from new experiences. Generalisations are made basing on abstract thoughts. The learner tries to apply the ideas or the abstract thoughts to real life situations. This stage is the active experimentation stage. For effective learning to take place, a learner should pass through all the four stages of the learning cycle. However as the student passes through the stages, he or she will be dominant at some stages and dormant at the other stages. The stages at which the learner is dominant determine his or her learning style.

According to Kolb and Kolb (2005), learning starts from either the concrete experience stage or the abstract conceptualisation stage of the learning cycle depending on the stage of the learning cycle the learner is dominant. As explained above, these are the two ways in which a learner grasps new information. Kolb (1984) used the learners' dominant ways of grasping and transforming new knowledge to classify the learners into four classes. The classes are convergers, divergers, assimilators and accommodators. Table 2.2 gives the classes of learners and the description of the learners in each class as suggested by Kolb.

Table 2.2: Kolb's classes of learners and the description of learners in each class (Kolb, 1984)

Class of learners	Description of the learners in the class
Convergers	• Their dominant stages are abstract conceptualisation(AC) and active experimentation(AE) • Prefer thinking and doing • Learn through deduction and practice • Enjoy solving problems that have only one solution • Skilled in applying practical ideas • Do not like dealing with social or interpersonal issues • View a teacher as a standard setter, facilitator and a role model of how things are done • Are not emotional • Use sensory experiences when making inferences
Divergers	• Their dominant stages are concrete experience(CE) and reflective observation(RO) • Prefer feeling and watching • Learn through discussions, experiences and reflections • Are emotional and creative • Use imaginations • Interested in solving problems affecting people • Enjoy observing and collecting a wide range of information • Good at brain storming • Are good artists • View a teacher as a facilitator and motivator
Assimilators	• Their dominant stages are abstract conceptualisation(AC) and reflective observation(RO) • Prefer thinking and watching • Use inductive thinking • Learn by thinking ,synthesising and developing concepts • Analyse and critique information • Can understand theoretical models easily

	• Can deal with abstract concepts • Create theoretical models • Enjoy application of theories • Enjoy data collection • Are good planners and researchers • View a teacher as a subject expert who communicates information
Accommodators	• Their dominant stages are concrete experience(CE) and active experimentation(AE) • Prefer feeling and doing • Learn by doing • Are risk takers • Depend on gut feelings in place of logic • Learn through hands-on • Enjoy doing experiments • Use trial and error method in solving problems • Depend on others for information • View a teacher as a person who coaches and encourages self-discovery

According to Kolb (1984), experiential learning has six characteristic features. The following are the features of experiential learning as given by Kolb:

- Learning as a process

According to Kolb, learning cannot be described in terms of its outcome. It can rather be described as a process with a starting point, but without an end point. However the process has some observable outcomes.

- Learning as a continuous process

The process of learning depends on the learners' experiences. However, the learner continues to look for more new knowledge. Therefore the process does not terminate.

- Learning as a conflict resolution process

Kolb believed that learning is full of tension hence it can be described as a process that is meant to resolve conflicts that emerge between the learner and the environment whenever the learner is exposed to new experiences.

- Learning as a way of adapting to the world

As the learner resolves conflicts that emerge between the learner and the environment, the learner adapts to the world.

- Learning as a transaction process

Kolb viewed learning as a process involving transactions between the learner and the learning environment. In the process of learning, either the learner or the environment changes to suit the condition of the other.

- Learning as a process of creating knowledge

Kolb emphasised the point that by learning, the learner creates new knowledge.

Recent and further developments on Kolb's experiential learning style model have resulted in the modification of Kolb's experiential learning cycle (Kolb & Kolb, 2013). The modified learning cycle has nine stages. Figure 2.4 shows an illustration of the modified experiential learning cycle.

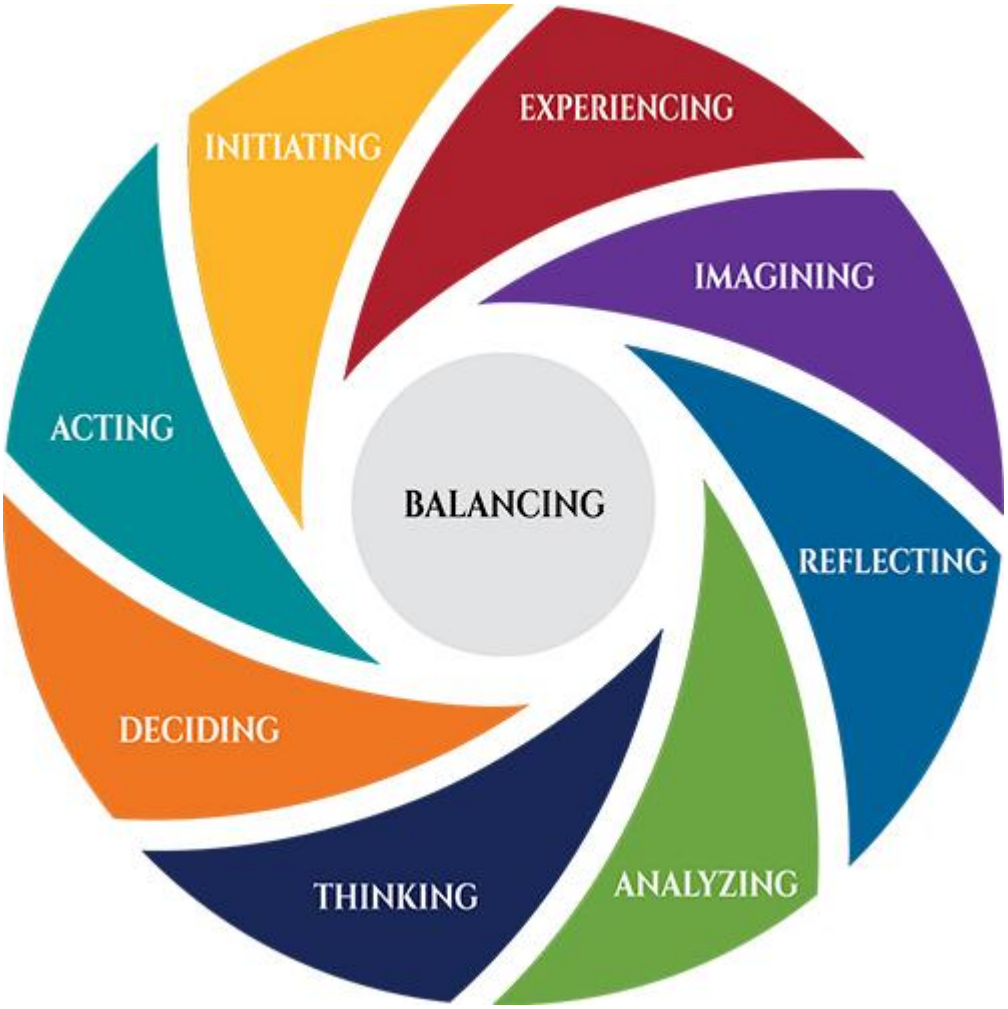


Figure 2.4: Kolb's modified experiential learning cycle (Kolb & Kolb, 2013)

The development of the modified learning cycle resulted in the formation of nine learning style classes into which learners are classified under the experiential learning style model. The classes are as follows:

1. *The initiating learning style*: the learners have an ability to initiate actions which they apply when they face new experiences or situations. Their modes of grasping and transforming new knowledge are concrete experience (CE) and active experimentation (AE) respectively.
2. *The experimenting learning style*: they possess an ability to find meaning to new knowledge by getting deeply involved in new experiences. They use concrete experiences (CE) and a balance between active experimentation (AE) and reflective observation (RO).

3. *The imagining learning style*: they imagine possibilities as they observe and reflect on experiences. They are strong in using imaginations. These learners use concrete experiences (CE) and reflective observation (RO).
4. *The analysing learning style*: they integrate and systematise ideas through reflection. They use reflective observation (RO) and a balance between concrete experiences (CE) and abstract conceptualisation (AC).
5. *The reflecting learning style*: they connect ideas and experiences through reflection. They use reflective observation (RO) and a balance between concrete experience (CE) and abstract conceptualisation (AC).
6. *The thinking learning style*: they possess an ability to use abstract and logical reasoning. They apply abstract conceptualisation (AC) and maintain a balance between active experimentation (AE) and reflective observation (RO).
7. *The deciding learning style*: they have an ability to use theories and models in problem solving. They make use of abstract conceptualisation (AC) and active experimentation (AE).
8. *The acting learning style*: they are goal oriented. They enjoy working towards achieving specific goals. They are always motivated to go for goal directed tasks. They make use of active experimentation (AE) and a balance between concrete experience (CE) and abstract experimentation (AE).
9. *The balancing learning style*: they possess an ability to adapt. They choose between acting and reflecting by weighing pros and cons. They also choose between experimenting and thinking after weighing pros and cons. They maintain a balance of concrete experience (CE), abstract conceptualisation (AC), active experimentation (AE) and reflective observation (RO).

Kolb (1984) believed that a learner gets into a learning situation with already developed learning styles. Therefore it is important for a teacher to identify the learners' learning styles in the beginning of a learning session. According to Kolb, teaching strategies or learning environments which are dissimilar to the learners' preferred styles of learning are likely to face rejection or resistance from the learners.

2.3.3.2 Honey and Mumford model

Two years after David Kolb had developed his experiential learning styles model, Peter Honey and Alan Mumford came up with their learning styles model. According to Rumson (2017), Honey and Mumford were inspired by David Kolb. In fact the two scholars were

disciples of David Kolb and because of that reason, their learning styles model was similar to the one suggested by Kolb. However, they suggested different classes of learners. According to Mobbs (2010), Honey and Mumford classified learners into the following four classes: activists, pragmatists, theorists and reflectors. Table 2.3 gives the classes of learners and the description of the learners in each class as suggested by Honey and Mumford in Mobbs.

Table 2.3: Honey and Mumford's classes of learners and the description of learners in each class (Mobbs, 2010)

Class of learners	Description of the learners in the class
Activists	▪ learn by doing ▪ always want to experiment ▪ open to group discussions
Pragmatists	▪ always want to know how concepts learnt work in real life ▪ dislike abstract concepts ▪ do not enjoy games ▪ try out ideas and theories
Theorists	▪ always want to understand theories behind actions ▪ need role models ▪ seek to develop new information into logical theories
Reflectors	▪ observe before taking action ▪ are not risk takers ▪ take time to get to a conclusion

Rodwell (2005) noticed some similarities in Kolb's model of learning styles and the learning styles model by Honey and Mumford. According to Rodwell, the classifications of the learners according to the two models can be compared as shown in Table 2.4

Table2.4: Comparison of Kolb's learning style model with Honey and Mumford's learning style model.

Kolb's learning styles model	Honey and Mumford's learning styles model
Accommodators	Activists
Divergers	Reflectors
Convergers	Pragmatists
Assimilators	Theorists

2.3.3.3 Perini, Silver and Strong model

Another learning styles model was developed by Mathew Perini, Harvey Silver and Richard Strong (Perini, Silver & Strong, 2000). According to McTighe and Silver (2019), the model was directly drawn from Carl Jung's theory of personality types. Perini et al. utilised the fact that learners perceive new knowledge in two ways, by sensing or intuiting, and then process the knowledge in two ways, by thinking or feeling. The scholars applied their research on learning styles specifically to the learning of mathematics. They classified mathematics learners into four classes which are '*mastery maths learners'*, '*interpersonal maths learners'*, '*understanding maths learners'* and '*self- expressive maths learners*'(Perini, Silver & Strong, 2000).

Mastery maths learners enjoy learning mathematics through application of formulae, rules, procedures and algorithms. They face difficulties when solving non routine problems. To them a good teacher is one who coaches them to solve mathematical problems. *Mastery maths learners* prefer a teacher who demonstrates to them. They like well-organized classrooms in which expectations are clearly explained and the expectations are strongly related to practical outcomes such as good grades, things they can make or do, and practical connections to jobs and careers (McTighe & Silver, 2019). According to McTighe and Silver, these learners get motivated when they complete given tasks well and better than their colleagues or when they get higher grades than their peers. In other words, these learners like competition.

Interpersonal maths learners learn better when they work with others in groups. They enjoy solving problems with real life applications. Their motivation comes from the quality of their relationships with the teacher, with the other students, and with their parents and friends.

These students judge new knowledge through feelings. Their need for association provokes in them a strong need for conversation with people around them.

Understanding maths learners always seek to prove and explain why and how concepts learnt work practically. They look for mathematical patterns or trends in the problems they solve. They get excited if they get logic behind doing something. They always strive to find logic behind given formula rather than applying the formula. *Understanding maths learners* do not simply accept what the teacher teaches without getting the logic behind it. They always want to get the reason why they have to do it the way they do. They need proof for almost everything they do. At times they are so concerned with intellectual content and reasoning to an extent that they undervalue the need for routine work.

Self-expressive maths learners look for different alternatives to solve mathematical problems. They possess skills necessary for solving non-routine problems. When solving mathematical problems they sometimes use imaginations. Their motivation comes from their ability to be creative, to communicate ideas, to express themselves and to create imaginations (McTighe & Silver, 2019).

The classes of maths learners and their description are summarised in Table 2.5.

Table 2.5: Perini, Silver and Strong's classes of learners and description of the learners in each class (adopted from Mangwende & Maharaj, 2018).

Class of learners	Description
Mastery maths learners	• Their perception mode is sensing and they judge by thinking • Learn in a step by step manner • Enjoy solving problems by following algorithms, theorems and formulae • Dislike reading and lectures • Have difficulties in solving non-routine problems • Prefer teachers who coach them • Prefer demonstrations followed by immediate practice • Judge learning by clarity and practicality of the concepts learnt • Require immediate feedback after an exercise • Possess skills to use numbers in computing, describing and

	documenting reports • Can be good accountants, bookkeepers or statisticians
Interpersonal maths learners	• Their mode of perception is sensing and they judge through feeling • Learn through dialogue and collaboration • Like exercises that asks for their thoughts, feelings, and personal opinions • Are interested in how mathematics concepts help in real life • Have difficulties in solving problems as individuals • Do not like solving problems that do not have real life application • Want teachers who appreciate their successes and struggles • Judge mathematics learning by its potential to help people • Possess skills to apply mathematics in personal and daily life • Their relationship with the teacher and the peers drive them to do well • Can be good home makers
Understanding maths learners	• Their mode of perception is intuition and they judge new knowledge through thinking • Seek to understand why mathematics concepts work • Like problems that allow them to prove and explain reasons for taking certain decisions • Like provocative lectures that stimulate their brains to act. • Criticise other people's ideas • Dislike drill and practice method of teaching • Seek patterns in mathematical concepts • Have difficulties in working with others in solving problems • Judge learning by use of evidence and logic • Possess skills to use mathematical concepts in establishing proofs and constructing scientific arguments • Can be good scientists, quantitative problem solvers or logicians

Self-expressive maths learners	• Their mode of perception is intuition and they process new knowledge through feeling • Use imaginations to solve mathematics tasks • They sometimes use hunch and guessing in solving mathematics problems • Enjoy solving non-routine problems • Need long time to work through their thoughts • Like content that require them to add personal, creative hook or to create a project that stimulates their imaginations • Generate possible solutions by exploring alternatives • Judge learning by originality of the concepts learnt • Possess abilities to use logic and develop models • Can be good designers, engineers or qualitative problem solvers

2.4 Chapter summary

This chapter gave an overview of the theoretical framework that guided this study. It started by an introduction to the chapter. It proceeded to an overview of the theory of learning styles. The overview started with some definitions of learning styles found in the reviewed literature. It went on to examine some theories in mathematics teaching. This was followed by a brief outline of the origin of the studies on human differences in learning. Learning style models by Kolb, Honey and Mumford as well as by Perini, Silver and Strong were then discussed.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

The chapter provides a discussion on what other researchers reported about teaching mathematics according to students' learning styles. It started with a review of the literature on the importance of mathematics teachers' knowledge of their students' learning styles in mathematics teaching. The main emphasis is on the effects of mismatches between mathematics teachers' teaching styles and their students' learning styles as well as on how the mismatches can be avoided. The chapter also gives a review of the suggestions given by other scholars on how mathematics can be taught according to students' learning styles. The suggestions are given under the learning styles models suggested by Kolb, Honey, Mumford, Perini, Silver and Strong. The chapter is then concluded by a discussion on barriers to mathematics teaching as found in various reports by different scholars in the reviewed literature.

3.2 Mathematics teachers' knowledge of students' learning styles

Numerous studies have shown that it is important for teachers, especially mathematics teachers, to know their students' learning styles (Ellington & Benders, 2012; Lohri-Porsey, 2003; Solvie & Sungur, 2012). Ellington and Benders stated that knowledge of students' learning styles is an important ingredient in the teaching of mathematics that teachers cannot do without. They reiterated that knowledge of students' learning styles assists teachers to research on how to conduct lessons that are enjoyable to all their students. Lohri-Porsey (2003) emphasised on the importance of knowing students' learning styles by stating that teachers' understanding of their students' learning styles provides them with effective strategies to use and it assists them in preparing the necessary learning tools. Lohri-Porsey went on to state that a teacher who knows the learning styles of his or her students is able to give tips to the students on how they can improve their learning. According to Lohri-Porsey, students need to understand how they learn so that they can fully utilise their potential.

Powell and Kusuma-Powell (2011) provided further support for the importance of teachers' knowledge of students' learning styles by reiterating that the knowledge enables the teachers to know the challenges and opportunities that are associated with each learning style. Powell and Kusuma-Powell argued that if the challenges are foreseen, possible remedies can be

sought in advance. The teachers will not wait until they face a problem in order for them to look for solutions.

Solvie and Sungur (2012) asserted that knowledge of students' learning styles enables teachers to plan, integrate teaching tools and assess students in ways that match the identified learning styles. Those scholars concurred with Solvie and Kloek (2007) who had a similar assertion. According to Solvie and Sungur, the alignment of students' learning styles and the teaching tools provides access to learning for all students by providing comfortable learning to all the students. In other words, Solvie and Sungur argued that the knowledge enables the teachers to provide multiple ways of learning so that each and every student in the class finds something to enjoy during the learning process. Dasari (2006) reinforced the need to align teaching strategies and teaching tools with students' learning styles by stating that students retain information longer if they are taught in their preferred learning style.

According to Gilakjani (2012), possessing knowledge of students' learning styles assists the teachers to avoid mismatch between students' learning styles and the teachers' teaching styles. Studies have shown that prolonged mismatch between students' learning styles and their teacher's teaching style has negative effect in learning (Abuzaid,Naimie,Shagoholi & Siraj, 2010;Abu-Asba,Azman &Mustaffa,2014;Bosman & Schulze,2018;Manochehri & Young, 2006). Bosman and Schulze stressed that prolonged mismatch between the teachers' teaching style and the students' learning styles contributes to poor academic achievement and negativity towards the subject. Abuzaid et al. supported this assertion when they said congruence between teaching and learning styles has a positive impact on learning achievement. According to Abu-Asba et al., matching teaching and learning styles improves the learners' attitude and behaviour during the lesson.

In other studies, research has shown that matching students' learning styles and teacher's teaching styles motivates the student, builds student self-awareness and enhances student satisfaction (Csapo & Hajen, 2006; Tulbure 2011). According to Csapo and Hajen, students get motivated when they learn in ways in which they feel most comfortable. Continued failure caused by mismatch between students' learning styles and the strategies used by the teacher only serves to demotivate the students. Tulbure added on by saying that success enhances self-awareness. It helps the students to discover their potential and it makes them feel satisfied. When students experience success, they become eager to learn more.

Although it is important for mathematics teachers to know their students' learning styles, reviewed literature revealed that research has found that some mathematics teachers in different parts of the world lack knowledge of their students' learning styles (Haar, Hall, Schoep & Smith, 2002). In a study carried out in secondary schools in West Shoa Zone of Ethiopia, teachers were found to be practising autocratic styles of teaching (Geche, 2009). The teaching styles used by these teachers did not match their students' learning styles. According to Geche, most of the students in the area preferred brief outlines given by the teachers followed by concrete presentations by the students themselves. However their teachers used teacher-centred strategies which left the students passive. The mismatch that was found between the students' preferred learning styles and the teachers' teaching strategies was presumed to be a contributing factor to the high failure rate in the schools in the West Shoa Zone of Ethiopia.

In a study done in Yemen, Abu-Asba, Azman and Mustaffa (2014) investigated the relationship between the learning styles of the students in Yemen and their teachers' teaching styles. The study revealed that, due to lack of knowledge of students' learning styles, most of the teachers in Yemen used 'chalk-and-talk' approach which suited the learning styles of only a few students. According to Abu-Asba et al., the majority of the students required hands-on experience supported by related literature. The mismatch resulted in most of the students being tired and inattentive in class.

3.3 Do mathematics students need to know their own learning styles?

The reviewed literature revealed that some scholars emphasised that students need to be familiar with their own learning styles (Kolb & Kolb, 2013; Honey & Mumford, 1982). Honey and Mumford (1982) avowed that each learner should understand his or her learning style. According to Honey and Mumford, knowing one's learning style has great advantages. They argue that if a learner understands his or her learning style, the learner can look out for opportunities that maximise his or her own learning. The knowledge serves the learner from approaching learning from a 'hit and miss' approach. Instead, the learner gets more 'hits' and fewer 'misses'. Learning becomes easier, effective, enjoyable and comfortable for the learners.

Kolb and Kolb (2013) reiterated in their report that knowledge of one's own learning style, enables one to develop oneself in the other learning styles other than one's own preferred learning styles. By so doing, one widens one's band-width of experiences and become an all-

rounder. Once that happens, one can learn from formal, informal, planned and spontaneous experiences without difficulties. Kolb and Kolb said that knowledge of one's learning style increases one's capacity to control one's meta-cognitive learning processes to an extent that one is able to monitor and select learning approaches that work best in different situations.

Rumson (2017) suggested that an understanding of one's learning style allows one to practise self-scrutiny for self-improvement. By this Rumson meant that for a learner to know his or her own weaknesses and strengths, the learner should be aware of his or her own learning styles. Equipped with the knowledge, the learner can find ways of improving on the weaknesses and ways of maintaining the strengths. In supporting this line of argument, Kolb and Kolb (2013) stated that an understanding of one's unique capabilities, weaknesses and learning preferences as well as the match between these and the demands of the task to be learnt help to increase learning effectiveness.

Kolb and Kolb (2011) articulated that knowledge of one's learning style provides a framework for understanding other learners with learning preferences that are different from one's. By this statement, Kolb and Kolb meant that the knowledge of one's own learning styles assists a learner to tolerate ideas from other learners. This ability enables the learner to work well with peers during the learning process. The learner gets to understand why and how he or she is different from his or her peers. It also helps the learner to understand the need to help others and the need to look for help from others.

In my view as the researcher, in order for students to understand their learning styles, their teachers need to be well equipped with knowledge of the learning styles theory. I believe teachers are the facilitators in the learning process. For them to carry out their role as facilitators, they must possess better knowledge of the subject matter and of the best ways to learn than their students.

3.4 Instruments used to assess learning styles

Various assessment tools were developed by different scholars for the purpose of assessing students' learning styles (Kolb & Kolb 2013). Ferrara (2010) stated that learning style inventory for students were created so that both teachers and students can have a better understanding of prevalent learning styles in the classroom. According to Kolb and Kolb, the first experiential learning style inventory (LSI) was developed in 1971 by Kolb. This was the first version of a series of six learning style inventories that were later developed. The later versions were developed as a way of trying to improve on the reliability and validity of the

first assessment tool. According to the literature reviewed, the latest version under the experiential learning style model is the Kolb Learning Style Inventory 4.0 (KLSI 4.0). This inventory assesses an individual's learning style based on the recently developed nine experiential learning style model by Kolb. The inventory places a learner into any one of the nine learning style classes under the experiential learning styles model.

Another learning styles assessment tool was developed by Honey and Mumford (1992). The shortcomings that were associated with Kolb's learning styles inventory prompted Honey and Mumford to develop the learning styles questionnaire. The tool is a self-administered learning styles questionnaire (LSQ). The questionnaire is based on experiential learning styles. However, Honey and Mumford used different names for the classes of learners (activist, reflector, theorist and pragmatist) in explaining the learning styles. The questionnaire has eighty questions to which a learner is supposed to respond to by means of putting a tick on the responses that appear true to him or her. It has no time limit. The items on the questionnaire are concerned with information processing and decision making. After completing the questionnaire, the learner is then referred to a given scale on the questionnaire in order to find the class in which he or she falls. The learner places herself or himself in a particular learning styles class according to a criterion given on the questionnaire.

Felder and Soloman (1999), with the assistance of North Carolina University, invented another learning styles assessment tool which they referred to as the 'index of learning styles' (ILS). The index of learning styles by Felder and Soloman has forty-four questions. Each of the questions has two choices. The assessment tool is available on line and it can be completed on line. It is completed by means of encircling the option that suits the person being assessed. At the end of the assessment tool, a key is provided which assists in interpreting the final score.

Commenting on the need for self -assessment of one's learning style, Ferrara (2010) said that learning styles for both the teachers and the students impact instructional strategy hence there is need for the teachers to also assess their own learning styles too. If not monitored well, the teacher's learning style can dominate the classroom instruction and the instruction may not meet the needs of the students' learning styles resulting in disengagement and lack of motivation on the part of the students (Perini, Silver and Strong, 2007). According to Ellington and Benders (2012) teachers should assess each student at specific points in time throughout the learning process. This is because according to Ellington and Benders,

students' learning styles change as the students meet new experiences in life. Regular and continuous assessment helps the teachers to prepare for possibly new learning styles.

3.5 How can mathematics teachers teach according to their students' learning styles?

In my opinion, for mathematics problems, there are usually alternative paths towards their solution. Not all problems in mathematics have neat and exact solutions. As a result, students of different learning styles can approach a required solution from different angles. However, they need the teachers' assistance for them to get to the solution. Various scholars gave different opinions on how mathematics teachers can assist students of varying learning styles to improve on their learning.

According to McLeod (2007), teachers should design instructions that offer students best opportunities to learn in their preferred manner. Mkonto (2015) supported by reiterating that teachers should develop balanced strategies. A balanced strategy according to Mkonto is one that accommodates the various learning styles displayed in the classroom. However, Mkonto thought that there is need for teachers to sometimes create intentional mismatches between teaching strategies and students' learning styles so that students are forced to practise using their less preferred learning styles.

Sarasin (1999) outlined four steps that a mathematics teacher should follow in order to effectively assist students of different learning styles. According to Sarasin, the mathematics teacher should begin by assessing his or her own learning style. The teacher then assesses his or her students' learning styles. He or she checks if his or her learning style matches the learning styles of his or her students. The third stage is when the teacher analyses and evaluates his or her teaching style. This stage is done in order for the teacher to match his or her teaching style with the students' learning styles. In the fourth and final stage, the teacher plans an instruction that accommodates the students' learning styles.

Evans and Sadler-Smith (2006) suggested some strategies which can be used by mathematics teachers when they teach their students. The two scholars suggested that when teachers teach according to students' learning styles they should be sensitive to the students and employ learner-centred strategies. Teaching strategies should offer choice and flexibility to the students. According to Evans and Sadler-Smith, there are benefits for both matching and mismatching teaching strategies with students' learning styles. Therefore teachers should use a variety of teaching styles. Those scholars thought that when teaching students according to their learning styles, the students should be made aware of their learning styles and be

encouraged to learn in their less preferred learning styles. Evans and Sadler-Smith also suggested that teachers create suitable learning environments in which the aims of the learning programme are clearly stated and guidelines for the assessment requirements are given to students in advance. The scholars further advised that the teachers should avoid labelling their students as it may have negative effects on the students' self-esteem. According to the two scholars, the effects of culture on the development of learning styles should not be overlooked. Hence teachers were advised by the two scholars to properly guide their students so that culture does not affect the students negatively. Students should be allowed to discuss in groups. Evans and Sadler-Smith thought groups encourage diversity in learning. As a result, they encouraged teachers to take advantage of group work so that students learn from their peers. They also emphasised on the need for mathematics teachers to develop the students' meta-cognitive skills.

Kolb (1984) suggested learning activities that can be used by mathematics teachers to assist students according to their learning styles. The activities were given under the classes of learners suggested under Kolb's experiential learning styles model. Table 3.1 shows the classes of learners and the suggested learning activities.

Table 3.1: Kolb's classes of learners and suggested learning activities

Class of learners	Suggested learning activities
Convergers	• Performing technical tasks • Experimenting • Simulations • Laboratory assignments
Divergers	• Group discussions • Collecting information • Brainstorming • Field trips
Assimilators	• Reading notes and textbooks • Attending lectures • Analysing theoretical models • Doing independent research • Watching demonstrations

Accommodators	• Exploring new experiences • Using trial and error • Hands-on • Experimenting

According to Kolb and Kolb (2013), each class of learners expect a mathematics teacher to behave in a particular way. In order to make sure that all the four learning styles displayed by the students in a mathematics class are catered for, the mathematics teacher should take four different roles. The four roles that the mathematics teacher should take are the following: coach, facilitator, subject expert, standard setter and evaluator.

- Mathematics teacher as a coach

According to Kolb and Kolb (2013), *accommodators* view a teacher as a coach. This implies that the teacher should work collaboratively with the students. He or she teaches each student on a one-on-one basis so that the students' weaknesses and strengths are found. The teacher should always encourage self-discovery. Students should be motivated so that they ride on their strengths. Students should take advantage of their strengths for them to acquire new experiences. The teacher as a coach looks for remedies which overcome students' weaknesses. As the teacher works with his or her students, he or she is expected to give immediate feedback to the students on their performance. By so doing, the students are encouraged to keep on trying and exerting effort in their learning.

- Mathematics teachers as a facilitator

Divergers view their mathematics teacher as a facilitator (Kolb, 1984). Kolb and Kolb (2013) stated that when a teacher takes the role of a facilitator, he or she should promote inside-out learning in students. By this statement, Kolb and Kolb meant that the teacher should make sure that the students comprehend the new knowledge taught and they should be able to show understanding by change in behaviour. When a teacher facilitates learning, student-centred teaching strategies are used. Such teaching strategies include the inquiry method which entails that the teacher gives students a problem to solve and the students carry out researches to find possible solutions. In order for the teacher to effectively facilitate learning, the teacher should create conducive personal relationship with the students. The teacher should always promote dialogue with the students. Students must be free to interact

with the teacher. A teacher-facilitator motivates students to keep on working hard despite hardships faced in the process.

- Mathematics teacher as a subject expert

According to Kolb (1984), *assimilators* view their mathematics teachers as experts in the field of mathematics. In their role as subject experts, mathematics teachers must possess abilities to systematically analyse statements in mathematics. The teachers are also expected to organise the subject matter in such a way that the students can easily grasp. This involves planning instructions so that topics to be covered are arranged in sequential order. Arranging concepts in sequential order ensures that the students learn simple concepts first and then progress to concepts that are more challenging. As explained by Kolb and Kolb (2013), a teacher who is viewed by students as a subject expert should be convincing, respectable, dependable and trustworthy. He or she must be a deep thinker. Kolb and Kolb suggested that when the expert teacher teaches learners that fall under a group of learners referred to as *assimilators,* he or she can make use lectures and texts.

- Mathematics teachers as a standard setter or evaluator

Convergers view their mathematics teachers as standard setters (Kolb, 1984). The teachers as standard setters are expected to be objective. They should teach for a purpose and they seek to achieve particular goals. The students expect them to be result oriented all the time. Mathematics teachers take this role when they set tests or examinations for their students. They set performance objectives for their students. The teachers set the evaluation criteria and they evaluate their students' performance using the set criteria. As put forward by Kolb and Kolb (2013), when *convergers* learn mathematics they work in order to convince their teachers that they can do well.

Honey and Mumford (1992) also suggested learning activities that can be used by, mathematics teachers as they teach students of different learning styles. Table 3.2 gives the classes of learners and the suggested learning activities.

Table 3.2: Honey and Mumford's classes of learners and suggested learning activities

Class of learners	Suggested activities preferred
Activists	▪ problem solving ▪ group discussion ▪ puzzles ▪ competitions ▪ role-play
Pragmatists	▪ Applying learnt concepts to real life situations ▪ problem solving ▪ discussions
Theorists	▪ following role models ▪ gathering statistics ▪ using quotes ▪ seeking background information ▪ applying theories
Reflectors	▪ paired discussions ▪ completing self-analysis questionnaires ▪ observing activities ▪ getting feedback from others ▪ coaching others ▪ interviewing others

According to Honey and Mumford (1992), pragmatists prefer learning through hands-on. Their preferred learning techniques are experimenting and continuous practice. They expect their teacher to show them what to do before they get an opportunity to practise on their own. Activists and theorists look for challenging situations. They enjoy facing challenges that are associated with problem solving. Theorists always look for background information behind theories, formulae and algorithms. They prefer exploring complex situations. Activists always desire to be the best performers. They like competition. Therefore teachers should

allow them to compete in solving problems in mathematics. Reflectors on the other hand, should be given time to assimilate new knowledge and reflect upon it.

Honey and Mumford (1992) stated that teaching students according to their learning styles takes two dimensions. The two dimensions are: concrete versus abstract and safety versus challenge.

- Concrete versus abstract

As put forward by Honey and Mumford (1992), the first dimension of the strategy of teaching students according to their learning styles has concrete on one end and abstract on the other end. The preference for concrete involves dealing with real life experiences whist the preference for abstract involves dealing with manipulation of symbols. Pragmatists and activists have preference for concrete whilst theorists and reflectors have preference for abstract. That means pragmatists and activists prefer dealing with real life experiences. They prefer dealing with concrete ideas. Theorists and reflectors on the other hand can easily deal with symbols and texts.

- Safety versus challenge

Honey and Mumford stated that the other dimension has safety on one side and challenges on the other. Activists and theorists seek challenges when they learn while on the other hand pragmatists and reflectors look for safety. Pragmatists need enough time to practise and reflectors need time to reflect on new knowledge. Safety can be provided by the teacher through providing the students with ample time to practise and to reflect. This can be achieved if the teacher delivers lessons in a step by step manner without rushing to finish. Challenge can be given to students through provision of more demanding tasks. Students should be allowed to experiment, hypothesise or try alternative methods. They should be given an opportunity to control their learning environment. They should be provided with chances to reverse their decisions when they feel the decisions are not appropriate.

Figure 3.1 illustrates the dimensions that the strategy of teaching students according to their learning styles can take.

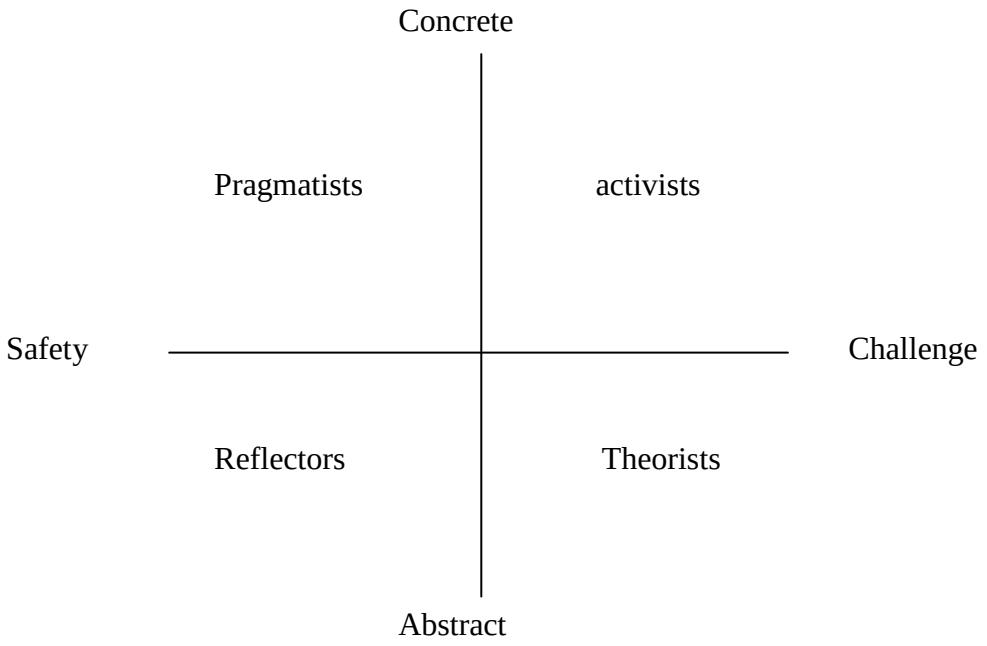


Figure 3.1: Illustration for Honey and Mumford's two dimensional teaching strategy

The interpretation for figure 3.1 is as follows: Pragmatists are concrete-safety learners. They prefer to learn from real life situations and they need time to practise. Activists are concrete-challenges learners. They learn from real life experiences and they need to be provided with more challenging or demanding tasks. Theorists are abstract-challenges learners. Theorists can learn through symbols and they need more demanding tasks. Reflectors are abstract-safety learners. They prefer learning through manipulation of symbols and they need time to reflect on their new experiences.

Due to the diverse nature of students' learning styles, Perini, Silver, and Strong (2000) advised mathematics teachers to use a variety of teaching strategies. They recommend that students be permitted to work in their preferred learning styles but to be advised to use the strategy as a way of developing confidence to use the other three learning styles so that they become balanced. According to Perini et al., students should be assisted in recognising their learning styles through the use of four dimensions of mathematics learning. Perini et al. argued that it is important for mathematics teachers to align teaching and assessment strategies with students' learning styles as they go through the four dimensions of mathematics learning. The four dimensions are computation, explanation, application and problem solving. The descriptions of the four dimensions are as follows:

- Computation

Computation involves making some calculations. These calculations are done following specific rules, formula or algorithms.

- Explanation

Explanations involve expressing oneself to others. In order words it means communicating one's mathematical ideas or one's way of thinking. It also involves describing mathematical processes.

- Application

Application is when a learner applies mathematical concepts in real life situations, for example, when one uses the concept of addition to find the total number of cattle in a village.

- Problem solving

This dimension involves using mathematical concepts in coming up with solutions to real life problems, for example calculating the time and amount of fuel required to travel from point A to point B.

In order to assist mathematics teachers, Perini, Silver and Strong (2000) suggested some learning activities that can be done by mathematics students in the four classes suggested by their model. They made use of their classification of learners in order to come up with the activities for each class. The activities matched the description of the learners in each class. Table 3.3 shows the classes of learners and the suggested learning activities.

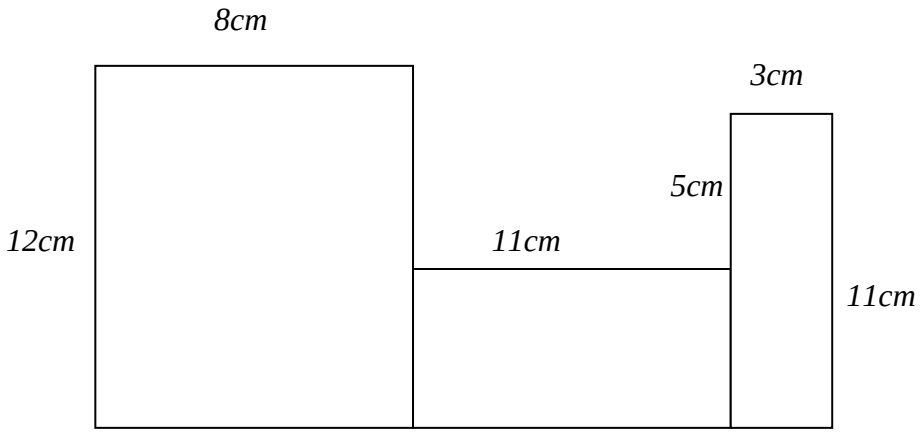
Table 3.3: Perini, Silver and Strong's classes of learners and suggested learning activities

Class of learners	Suggested learning activities
Mastery maths learners	• Application of algorithms, formulae and theorems • Computing • Producing mathematical reports
Interpersonal maths learners	• Group discussions • Applying mathematical concepts in solving real life problems
Understanding maths learners	• Proving why concepts work in real life • Individual work • Identifying mathematical patterns • Constructing scientific arguments

Self-expressive maths learners	• Solving non-routine problems • Solving project-like problems • Developing mathematical models • Designing

Bender and Waller (2011) advocated differentiated teaching to ensure that all learners benefit from the learning process. Differentiated teaching as defined by Tomlinson (2001) entails tailoring instruction so as to meet the individual needs of the learners. Laura (2017) added by stating that differentiated teaching means the teacher observes and understands differences and similarities among their students and uses the information to plan instruction. Weselby (2017) summarised differentiated teaching as designing a lesson based on students' learning styles. According to Weselby, differentiated teaching involves continuous formative assessment and adjustment of lesson content until it meets students' needs. Tomlinson (2001) suggested that differentiated teaching can be done in three areas of teaching which are content (what the learner learns), process (how the content is mastered by the learner) and product (how the learning process is assessed and evaluated). When differentiating the content, the teacher can vary his or her instruction so that it includes questions that demand the use of different skills. The following is an example of a balanced instruction found in the reviewed literature. This instruction was given to a junior secondary class. The class of learners catered for are given in brackets. These were based on the model by Perini et al. (2000).

(i) *Use the formula for area of a rectangle to compute the area of the irregular shape given below*.(Mastery maths learners)



(ii) *Create your own area problem by connecting four rectangles. The rectangles can be of any measurements. Arrange them in any way you want and find the area of the irregular shape formed*.(Self- expressive maths learners)

(iii)*Picture your own home. Think about each room in your house. Draw a floor plan of the house indicating the dimensions of each room. Suppose you want to carpet each room, how much carpet would you need*.(understanding maths learners and interpersonal maths learners) (Perini, Silver &Strong, 2007)

Umugiraneza and Bansilal (2017) purported that the most common strategies that are used in mathematics learning are direct instruction, cooperative learning and problem based instruction. However, Moore (2012) proposed alternative mathematics learning strategies which include manipulation of objects, real life application of mathematics concepts, and integration of information and communication technology (ICT) devices and use of games. Of these strategies, Moore emphasised on the use of games in mathematics learning by saying that games help in developing mathematical thinking.

White (2012) noted that the use of manipulative objects like drawing instruments and computers create more concrete representations of mathematical concepts in learners than any other method. The Ministry of Primary and Secondary Education (MOPSE) Mathematics Syllabus in Zimbabwe for Forms 1-4 (2015) suggested the following teaching strategies to be used in teaching mathematics concepts: discussions, expositions, demonstrations, simulations, educational tours and presentations by experts. As reported by Mangwende and Maharaj (2018), the MOPSE syllabus suggests that mathematics teachers use relevant texts, information and communication technology tools, the environment, Braille materials, talking tools and software. Yousuf and Behlol (2015) supported the use of information and communication technology (ICT) systems when teaching mathematics by reporting that the application of ICT as a teaching strategy was found to be effective as compared to traditional strategies. ICT as defined by Mohanty (2011) refers to all technological tools and resources used to communicate, create, disseminate, store and manage information. It includes computers, the internet, broadcasting technologies (radio and television), cell phones and calculators. Mohanty proclaimed that ICT has many benefits to students. One of the benefits is that it gives students an opportunity to collaborate on assignments with people inside and outside school through flexibility of anywhere, anytime access. Tinker (2017) also supported

by reporting that different computer software packages were used with positive results in schools in Mathematics teaching. Tinker reported that the most widely used packages in teaching mathematics concepts like functions were ClarisWorks, Microsoft works, Alice and Stella.

Ozgen and Bindak(2012) carried out a study in order to find the opinion of students with different learning styles on the use of ICT in mathematics learning. Qualitative and quantitative methods were used in collecting the data. The study revealed that students with diverging and accommodating learning styles had positive opinions towards the use of computers in mathematics learning compared to those with assimilating and converging learning styles.

However, a study carried out in Ghana revealed that mathematics teachers were not effectively integrating ICT in their mathematics instruction (Agyei & Voogt, 2010). According to Agyei and Voogt, despite the benefits of ICT in assisting students of varying learning styles, mathematics teachers in Ghana lacked knowledge about how ICT can be integrated in mathematics teaching. As given by Agyei and Voogt, this impacted negatively on the teaching of students of different learning styles.

Apart from teaching methods that are student-centred and sensitive to students' learning styles, assessment of the learning process is also a very important practice in mathematics teaching. Boaler (2016) proposed continuous assessment of students' learning styles with the aim of improving their understanding of mathematics concepts. Boaler reiterated that mistakes made by students should present a powerful learning opportunity which teachers should take advantage of by providing immediate feedback on students' actions and how the actions can be improved.

3.6 Barriers to the use of students' learning styles in mathematics teaching

The literature reviewed exposed lack of research on barriers to mathematics teaching related to the use of teachers' knowledge of students' learning styles. However, the reviewed literature revealed that mathematics teaching in general had numerous barriers. This section gives an overview of the literature on the barriers that affected the effective teaching of mathematics. Kaniz (2015) defined barriers as factors that inhibit or prevent people from participating in activities. In this study, barriers refer to rules, policies or any other things or

events that hindered or prevented mathematics teachers from using their knowledge of students' learning styles to the best advantage of their students.

Kaniz (2015) carried out a study in Bangladesh which uncovered that mathematics teachers were facing a number of barriers. These barriers made it difficult for the teachers to use their knowledge of students' learning styles in teaching mathematics. As reported in Mangwende and Maharaj (2019), the barriers found by Kaniz were classified under three categories. The categories were societal, pedagogical and systematic barriers. Soc*ietal barriers* included negative perceptions about mathematics as a learning area that were held by members of the society (including the students and the teachers). One of the perceptions was that of viewing mathematics as a subject in which boys perform better than girls. *Pedagogical barriers* were those that were related to teachers' teaching strategies. Among these was the use of severe punishment for failing to solve mathematical problems. According to the study by Kaniz, the use of punishment resulted in students developing negative attitude towards mathematics learning. *Systematic barriers* included lack of suitable resources like textbooks and other mathematical instruments.

In another study, Crystal (2012) reported on barriers that affected the teaching of mathematics and science in Michigan. The results of the study indicated that the most prevalent barriers were lack of motivation on the part of the students and lack of parental support to education.

In a study carried out in Mabasa South District in Kenya, Oisebe (2012) found that lack of in-service courses for teachers and low expectation of mathematics performance on students by their teachers were common barriers to mathematics teaching. The mathematics teachers in Kenya did not expect some of their students to excel in mathematics. The teachers' attitude contributed to low performance by the students as they got little support from the teachers.

Marban and Mulenga (2019) observed that mathematics teachers' attitude towards use of information and communication technology (ICT) was a barrier to mathematics teaching. Marban and Mulenga studied the relationship between pre-service teachers' teaching styles and the teachers' attitude towards use of ICT. The results of the study revealed that the teachers had a negative attitude towards use of ICT. The attitude impacted negatively on mathematics teaching. Studies have shown that integration of mathematics teaching and use of ICT creates a learner friendly environment that facilitates differentiated teaching (Allan &Tomlinson, 2000).

Doskocil (2016) reported on two barriers that mathematics teachers face as they differentiate teaching in order to suit students' needs. The first barrier is failure by the teachers to balance the learning style needs of their students. According to Doskocil, different learners bring into the class different learning styles which the mathematics teacher is supposed to balance and satisfy. This gives pressure to the mathematics teacher. A variety of strategies are supposed to be employed. The second barrier according to Doskocil is a need to meet the demands of the school. Whilst the teacher needs time to attend to the demands of each and every student in the class, the teacher is supposed to be involved in other school activities like club activities and assemblies. Duff (2002) shared the same opinion as she says that the challenge faced by mathematics teachers of 11 - 16 year olds in the U.K. was that they needed to make their work relevant and fun for all their students whilst keeping up the demands of the national curriculum and schemes of work.

Lyuch and Star (2013) observed that lack of time was the greatest barrier to mathematics teachers' use of differentiated strategies that were meant to assist students of different learning styles. In a study carried out with experienced middle and secondary school mathematics teachers, Lyuch and Star found that 45% of the mathematics teachers were facing challenges in getting enough time to reach for all their students. Some of the teachers indicated that they ended up speeding so that they cover the syllabi within the required time.

Apart from lack of time, Lyuch and Star (2013) also found that resource constraints, teacher knowledge constraints and lack of motivation were some of the barriers that affected the mathematics teachers' use of multiple strategies. In as much as the teachers wanted to differentiate their strategies so that they cater for all their students, shortage of resources affected them. According to Lyuch and Star, the teachers were not motivated to work and they lacked knowledge of their students' learning habits.

3.7 Critiques on the use of the learning styles theory in mathematics teaching

Although several studies have shown that teaching students according to their learning styles improves the teaching and learning of mathematics, the theory faces criticism from other schools of thought. Cherry (2019) stated that the theory of learning styles fails to acknowledge the impact of culture in the learning process. The culture of the society in which the learner lives has some influence on the way a learner learns. However despite the role culture plays in learning, the theory does not seem to give a detailed explanation on how it impacts the learning process. Supporting this point, Anderson in Finley (2015) suggests that

there was need to take account of differences in cognitive and communication styles that are culturally-based.

Cherry (2019) claimed that the learning process is more complicated than what the learning style theorists suggest. Cherry thought that the process is affected by a number of factors which includes the students' brain function. The theory of learning styles is silent about how brain function affects a learner's learning style. According to Cherry, some of the learning style models, for instance Kolb's experiential learning, are based on weak empirical evidence hence they lack enough research evidence to support the theory. Cherry advocated for more research on the relationship between how a student's brain functions and the student's learning style.

Pashler in Finley (2015) demanded that any credible validation of learning-styles-based instruction should be accompanied by robust documentation of experimental findings. Pashler suggested that vigorous experiments be done in which students are put in groups so that the relationship between learning styles and teaching strategies can be established.

Although the reviewed literature shows that there were several studies done on students' learning styles, no study has been done in the Zimbabwean context despite the high failure rate at ordinary level in mathematics in the country. The literature also shows lack of research on barriers that mathematics teachers face as they use their knowledge of learning styles in mathematics teaching. This study provides the much needed information on mathematics teachers' knowledge of students' learning styles. The results of this study shall provide a basis for further studies on learning and teaching styles in mathematics. The reviewed literature also failed to produce a single study on the views of mathematics teachers on the effectiveness of the approach of using students' learning styles in teaching mathematics. This study fills the gap in the literature on the use of students' learning styles in mathematics teaching.

3.8 Chapter summary

The aim of this chapter was to review literature related to the use of the learning styles theory in the teaching of mathematics. The second part of the chapter examined suggestions given by other researchers on how mathematics can be taught according to students' learning styles. The suggestions were examined under the models discussed in the chapter 2. It was noted from the reviewed literature that most of the scholars suggested that teachers vary their teaching strategies so that their instructions meet the varying demands of the students'

learning styles. The third part of the chapter discussed the importance of the mathematics teachers' knowledge of their students' learning styles in mathematics teaching. The literature reviewed indicated that numerous scholars were of the view that mathematics teachers must possess knowledge of their students' learning styles. According to the reviewed literature, lack of knowledge of students' learning styles leads to existence of mismatch between the teachers' teaching styles and the students' learning styles. The effects of the mismatch were discussed in this section. Some of the scholars even suggested that the students themselves be aware of their own learning styles. The last part of the chapter examined barriers in mathematics teaching. The researcher found however, that there was lack of studies on barriers that were directly related to the use of the learning styles theory in mathematics learning. The chapter was concluded by an outline of the critiques on the learning styles theory as found in the reviewed literature.

CHAPTER 4

RESEARCH METHODOLOGY AND DESIGN

4.1 Introduction

The theoretical framework and literature review in the foregoing chapters served to illuminate the learning styles theory and what other researchers say about the use of students' learning style in the teaching of mathematics. This chapter outlines the research methodology and design used in this study. It goes further to give an explanation of the data collection techniques used, namely observation, face to face interviews, and document analysis. The research setting, sampling methods used in selecting participants, description of the participants, ethical requirements and the rationale for using the techniques are also explained in this chapter. The chapter goes on to give a detailed description of data collection techniques and data analysis methods employed in this study. It also includes the measures taken by the researcher to ensure validity and reliability of the findings.

4.2 Research Methodology

This study was done in three phases. Each phase was guided by a specific research question. The three research questions were as follows:

1. How do the secondary school mathematics teachers view the strategy of teaching mathematics according to students' learning styles?
2. How do the secondary school mathematics teachers use their knowledge of their students' learning styles in teaching mathematics?
3. How do barriers impact on mathematics teachers' effective use of their knowledge of their students' learning styles when teaching mathematics?

Before carrying out the main study, a pilot study was done at one secondary school in the Makoni District of Manicaland Province in Zimbabwe. The school was not used in the main study. The purpose of the pilot study was to test the suitability of the research instruments. The pilot study also helped the researcher to budget the time required for data collection. It gave the researcher a chance to test how the participants would react to his request for them to participate in the study. The outcome of the pilot study was that some questions on the interview guide needed to be rephrased. The questions were ambiguous. These questions were corrected accordingly. The other research instruments namely, document analysis

checklist and observation checklist were not corrected. There were no discrepancies found on them. The researcher found that an interview session would take approximately thirty minutes.

This study was done using qualitative methods. The reasons for choosing qualitative methods are explained in the next section.

4.2.1 Qualitative research method

As stated in the preceding section, this study followed a qualitative paradigm. A qualitative research is an analysis of people's individual or collective actions, beliefs, thoughts, views and perceptions. It is designed to understand particular social phenomena from the participants' point of view (McMillan & Schumacher, 2010). Yin (2009) added that qualitative studies are preferred research strategies when what, how and why questions are asked. Creswell (2010) purported that the aim of qualitative research studies is to engage in research that probes for a deeper understanding of a phenomenon rather than to search for causal relationships.

In this study, the researcher sought to find what secondary school mathematics teachers knew about students' learning styles and how they used their knowledge in teaching mathematics. The researcher wanted to understand the teachers' actions in terms of how they used their knowledge of students learning styles in teaching mathematics. The purpose of this study was in line with what Yin (2009) and McMillan and Schumacher (2010) stated about qualitative research.

Qualitative research method was appropriate for this study since the study was not dealing with any statistical hypotheses and procedures. This was supported by Strauss and Corbin (1998) who asserted that when no statistical procedures or other means of quantifications are used in categorizing and interpreting relevant information that has been gathered then qualitative method is used. This was supported further by Bryman (2010) when he argued that qualitative research involves the use of words rather than numbers when carrying out data analysis. For this study, the data collected was in the form of words said by the mathematics teachers; hence no numbers were used in the analysis of the data collected. The analysis was done on the words shared by the participating teachers. This made qualitative methods more suitable than any other research methods.

The use of qualitative research methods allowed the researcher to carry out the study in a naturalistic way without setting conditions that were different from the ones that prevailed on daily basis. The data was collected while the mathematics teachers were doing their day to day business. A number of scholars supported this method of data collection (Creswell, 2014; Denzin & Lincoln, 2011; Marshall & Rossman, 2011). These scholars pointed out that qualitative method allows the researcher to holistically study a phenomenon within a natural setting in an attempt to make sense of the phenomenon. Ritchie and Lewis (2003) agreed by stressing that qualitative research is a naturalistic and interpretative approach that attempts to understand the meaning that people attach to certain actions and decisions. Golafshani(2003) concurred by saying qualitative research uses a naturalistic approach that seeks to understand a phenomenon in a context specific setting and the researcher does not attempt to manipulate the phenomenon of interest.

The current study dealt with a phenomenon that was context specific in the sense that it sought to get data from mathematics teachers from a secondary school setting and the data obtained was specifically meant for secondary school mathematics teaching. The results of the study apply specifically to secondary school mathematics teaching. In collecting the data the researcher did not attempt to manipulate the data nor the settings from where the data was obtained.

The choice of qualitative research methods was also informed by the instruments used in the study. In this study, data were collected using observations, face to face interviews and document analysis. According to Marshall and Rossman (2011), the sources of qualitative data include observation, interviews, documents and cultural materials. Fouche and Delport (2002) concured with this assertion when they say that the data collection instruments that are used with qualitative data are interviews, focus group discussions, observations, field notes, tests and pictures. They also assert that more than one of the data collection methods mentioned can be used.

4.2.2 Research design

According to Mouton (2006) a research design is a plan of how a researcher intends to conduct a study. The plan outlines the procedure to be followed by the researcher. It involves identifying a problem, formulating research questions and drawing up ways of collecting and analysing data. David and Sutton (2004) pointed out that a research design provides a

framework for collecting and analysing data. They go on to say that it enables the researcher to examine the research problem.

This study was designed as an exploratory interpretive case study. According to Zaidah (2007) an exploratory case study seeks to investigate or explore a phenomenon of interest in a chosen field. For the current study, a case study enabled the researchers to get in-depth and detailed understanding of the mathematics teachers' knowledge of students' learning styles and how the teachers used the knowledge in mathematics teaching. The choice of a case study was supported by a number of scholars who argued that a case study allows for an in depth study of a phenomenon in a real life situation (Baker, 1999; Creswell, 2010; McMillan & Schumacher, 2010; Yin, 2009). The number of mathematics teachers who participated in this study also made a case study the most suitable design. This was in line with the assertion by Welman and Kruger (2001) that a case study deals with a small number of units (individuals, groups or institutions) which are studied intensively. Thirty-four mathematics teachers participated in this study.

4.3 Research setting and sample

This section gives an outline of the research settings and a description of the participants for this research. It also gives an explanation of the sampling methods that were used in selecting the participants.

4.3.1 Research Setting

Given (2008) defined a research setting as the physical, social and cultural site in which a researcher conducts a study. This study was conducted in secondary schools in Makoni District of Manicaland Province in Zimbabwe. Zimbabwe is a country in Southern Africa. It is divided into ten provinces. Manicaland Province is one of the provinces and it is in the eastern side of the country. Manicaland Province has seven districts of which Makoni District is one of them. Makoni Districts has eighty-nine (89) secondary schools. It is the largest district in Zimbabwe, in terms of number of schools. Secondary schools in Makoni District are owned by different responsible authorities. The responsible authorities are: local councils, individuals, churches and the Zimbabwe government. Four schools are owned by the Zimbabwe government, four by individuals, twelve by churches and sixty-nine are under local councils.

4.3.2 The participants

Secondary school mathematics teachers at selected secondary schools participated in the study. Table 4.1 shows the demographic information of the mathematics teachers who participated in this study.

Table 4.1: Participants' demographic information (n=34)

Sex	Teaching experience in full years			Highest professional qualifications		
	Less than 5	Between 5 and 10	More than 10	Diploma in Education	Bachelor's degree	Master's degree
Males	10	6	6	4	14	4
Females	2	1	9	4	8	0
Total	12	7	15	8	22	4

All the mathematics teachers who participated in this study had at least a diploma in education as their highest professional qualifications. All of them were qualified teachers who were trained to teach mathematics at secondary school level. Both male and female teachers participated in the study.

4.3.3 Sampling method

Creswell (2010) described sampling as a process used to select a portion of a given population for purposes of carrying out a study. The portion of the population that is selected for study purposes is called a sample (McMillan &Schumacher, 2010). The sample is studied in an effort to understand the population from which it is drawn. Researchers are interested in describing the sample, not primarily as an end in itself, but rather as a means of helping them to explain some facet of the population (De Vos, Strydom, Fouche & Delport, 2000; Bryman, 2012).

There are two main categories of sampling methods that can be used in research. These are probability sampling and non probability sampling. With probability sampling every member of the population has a chance of being selected while with non probability sampling some members of the population have better chances of being selected than others. (Machaba, 2013). According to Machaba, probability sampling methods include simple random sampling, stratified sampling and cluster sampling. Simple random sampling is the basic form of probability sampling in which all the members have an equal chance of being selected and

the members are selected at random. Stratified sampling involves dividing the population into clusters. Members are then chosen from each cluster in a proportional manner so that each cluster is represented. Cluster sampling involves treating clusters as sampling units. Simple random sampling is then used to select clusters at random. All the members in the selected clusters participate in the study.

On the other hand, non probability sampling methods include convenience sampling and purposive sampling among others (Bryman, 2012). Convenience sampling is a sampling method in which the researcher chooses a sample that is most convenient to him or her. Purposive sampling involves choosing members that bear the most wanted characteristics.

Both probability and non probability sampling methods can be used in qualitative research (Machaba, 2013). According to Creswell (2010), sampling in qualitative research is flexible and often continues until new themes no longer emerge from the data collection process. This is referred to as data saturation. Qualitative researches usually require smaller sample sizes as compared to quantitative researches (Machaba, 2013). However the researcher should make sampling decisions that lead to selection of the richest possible sources of data in order to rightfully answer the research questions.

For this study, different sampling methods were applied at different levels of selection. Makoni District in Manicaland Province was selected using convenience sampling. As stated earlier in this report, convenience sampling is a non probability sampling method that involves the sample being drawn from a portion of the population that is close at hand (Dudovskiy, 2012). The district was found to be convenient to the researcher. Its size as compared to other districts in the country was also considered. The use of convenience sampling at this level had some advantages. It made the research less expensive and the mathematics teachers were easy to get.

The secondary schools that were used in the study were selected using stratified random sampling method. Stratified random sampling refers to a probability sampling method in which the researcher divides the population into separate groups called strata and the subjects are then selected proportionally from the different strata (Foley, 2018). Black (1999) supported the use of stratified random sampling by saying that stratified random sampling ensures that groups are proportionally represented in the sample. The schools were first grouped according to their responsible authorities: Zimbabwe government, individuals, churches and local councils. The responsible authorities were treated as the strata. Ten

secondary schools were selected from the eight-nine schools in the district. Stratified sampling method at this stage had the following advantages:

(i) The researcher made sure that the sample is heterogeneous

(ii) The sample was representative of the population of the schools in the district since each category of schools was represented.

Table 4.2 shows the number of schools selected from each group of responsible authorities.

Table 4.2: Number of schools selected from each group of responsible authorities in the district

	Responsible authorities				**Total**
	Zimbabwe government	Individual	Church	Local council	
Number selected	1	1	2	6	10
Total in district	4	4	12	69	89

Mathematics teachers at the sampled schools were chosen to participate in this study. All of them participated in the study at one stage or the other. These teachers were selected purposefully because the aim of the study was to explore mathematics teachers' knowledge of their students' learning styles and how they used the knowledge in mathematics teaching. For that reason, mathematics teachers were the richest source of the required data for this study. The use of purposive sampling method in selecting the mathematics teachers was supported by White (2005) who stated that in purposive sampling the researcher chooses the 'information rich' participants as they are possibly knowledgeable in the phenomenon under study. White goes further to say that the judgment in purposive sampling rests entirely with the researcher.

The sample comprised thirty-four mathematics teachers who were all trained to teach mathematics at secondary school level. As stated earlier, they were holders of at least a diploma in education. Their teaching experience ranged from two to thirty six years.

4.4 Ethical consideration

When carrying out a study, the researcher should ensure that his or her behaviour conforms to a set of principles that governs the conduct of researcher (Bless, Kagee & Smith, 1995). Creswell (2010) concurred by saying that the ethical issues should be carefully considered

before a research process is started. Creswell added that consent letters, permission to be interviewed and an undertaking to destroy all tapes (video or audio) should be part of the set of principles. Marshall and Rossman (2011) asserted that the privacy of individuals is important when carrying out a research. This is in conformity with the requirements of the ethical committee at the University of KwaZulu-Natal. As a result, an ethical clearance letter was obtained from the University of KwaZulu-Natal for the purpose of carrying out this study. When carrying out this study ethical issues were considered. The major ethical issues that were considered in this study were the following: permission to carry out the study, informed consent, appointments, confidentiality and scientific ethics.

- **Permission**

In Zimbabwe, permission to carry out the study was sought from the office of the Permanent Secretary of the Ministry of Primary and Secondary Education, the Provincial Education Director and from the Heads of the chosen schools. Letters were obtained from these gatekeepers to show that permission was granted.

- **Informed consent**

The mathematics teachers who participated in the study were informed of the purpose of the study. They were also informed of their rights in the study. The issue of discontinuance was highlighted to them. They were informed that they were free to withdraw from their participation at any time without any penalties. All the thirty-four mathematics teachers agreed to participate and were asked to fill in a consent form.

- **Appointments**

Venues, dates and time of interviews and lesson observations were agreed between the researcher and the mathematics teachers. This was done so as to avoid disturbing the normal daily work of the teachers.

- **Confidentiality**

The identity of the mathematics teachers who participated in this study was kept confidential. Pseudonyms were used in data analysis. This was done as a way of making sure that no participant could be linked to the data used in the research. The data obtained from the teachers was kept in a secured file. The participants were assured that no other person except the researcher and his supervisor will have access to the data.

- **Scientific ethics**

Scientific misconduct according to Mouton (2006) referred to unethical behaviours like plagiarism and falsification of data. The researcher made sure that all information obtained from other sources was acknowledged. This was done as a way of avoiding scientific misconduct.

4.5 Data collection techniques

This study used qualitative data collection techniques. According to Creswell (2010), with qualitative research the researcher is the main data collection device. The researcher should be at the centre of data collection (Creswell, 2010; Lincolin, & Guba, 1985; White, 2005). In this study, the researcher was fully immersed in the research process. The researcher identified and selected the secondary school mathematics teachers as the data sources. The researcher also collected data from the mathematics teachers. The data collection methods used were lesson observations, face to face interviews and document analysis.

4.5.1 Observation

Creswell (2010) described observation as a systematic process of recording behavioural patterns of the participants without necessarily informing or communicating with the participants. The researcher uses his or her senses (seeing, hearing, touching, smelling, and feeling) and intuition in gathering the data. According to Machaba (2013), observation as a method of data collection relies on what the researcher observes rather than on what the subjects give as responses to questions. De Vos (2002) took observation as a typical method in which the emphasis is on both one's own and others actions. Denzin and Lincoln (2000) added that when using observation method, the researcher observes both human activities and physical settings in which the activities take place.

Creswell in Machaba (2013) reported that there are four types of observers that can be involved in a study. The four types are: complete observer, observer as a participant, participant as an observer and complete participant.

- Complete observer

This type of an observer does not interfere with what he or she observes. The observer observes from a distance. He or she makes sure that he or she does not obstruct the participants.

- Observer as a participant

This observer gets into the situation but makes sure that he or she does not interfere with the dynamics of the situation or the setting.

- Participant as an observer

This observer is part of the research process. The observer is a participant in the research. He or she carries out some action research.

- Complete participant

This observer is completely in the process. He or she is a full participant to an extent that those being observed cannot notice that they are being observed.

In this study, the researcher assumed the role of a complete observer. The researcher observed lessons taught by the mathematics teachers. During the lesson observations, the researcher sat at the back of the classroom taking down some notes from the on the following: teaching aids used in the lesson, teaching methods employed, activities done by the students, nature of resources available in the classroom and observable teaching barriers. An observation guide or checklist was used to assist in taking down the required notes observation process. The researcher observed the following during the mathematics lessons: activities done by the students, teaching tools used by the teachers, teaching strategies employed by the teachers, classroom organisation, student to student interaction and teacher to student interaction.

4.5.2 Interviews

Gillham (2001) described an interview as a conversation between two people. Creswell (2010) viewed an interview as a two way conversation in which the interviewer asks the participants some questions about their ideas, beliefs, views, opinions and behaviours. According to Cohen, Manion and Morris (2011) an interview is used to gather information that have direct bearing on the participants. They stress that an interview provides the interviewer with what is 'inside' the person. The interviewer gets an opportunity to probe the participants for detailed information which enables him or her to understand the participants' views, ideas, opinions and ways of thinking (Bertram & Christiansen, 2014).

According to Wallen and Fraenkel (2013) there are three types of interviews. The three types are structured, semi structured and informal interviews. Structured interviews are interviews that require the interviewer to have a set of pre determined questions before the commencement of the interview process. All interviewees are asked the same questions and the questions are asked in the same order. In semi structured interviews, the interviewer uses predetermined questions but has an opportunity to ask follow up questions during the interview process. Thus the main difference between structured interviews and semi

structured interviews is that in semi structured interviews the interviewer can ask questions that are not part of the pre determined questions. Informal interviews involve the interviewer asking questions that are not predetermined. The questions are created during the interview process. The environment or the situation at hand leads to the formulation of the questions to be asked by the interviewer. Machaba (2013) also identified three types of interviews. Machaba identified the following types of interviews: open ended interviews, structured interviews and semi structured interviews. Machaba described open ended interviews as interviews in which the aim of the interviewer is to get the participants' ideas, views, beliefs and attitudes about an event or an object by having a series of interviews that do not make use of predetermined questions. Cohen, Manion and Morris (2011) and Creswell (2010) claimed that there are four types of interviews: structured, unstructured, non-directive and focused interviews. They defined structured interviews as those in which the interviewer uses predetermined questions. Unstructured interviews involve the uses of questions that are not pre determined. Non-directive interviews are interviews in which the questions to be asked are not prepared in advance. The interviewer simply asks what comes to his or her mind. The interviewer goes on to interrogate the interviewee on points of his or her interest. The questions depend on the prevailing situations. They sometimes emanate from what the interviewer observes at that particular point. Focused interviews are event specific. The interviewee is given time to respond to questions on a specific subject.

Interviews can be done through different media. An interviewer can carry out an interview through a phone call, over the radio or using face to face mode. Descombe (2014) stated that semi structured and structured interviews are mostly done face to face. According to Lincoln and Guba (2006) semi structured interviews are mostly used in carry out qualitative research studies. It is because semi structured interviews allow the interviewer to clarify concepts and problems to the participants. They also allow new aspects of the problem to emerge during the interview process. White (2005) identified the following advantages of using an interview as a data collection instrument:

a) Eradication of cheating

   The interviewer makes sure that the questions are directed to the rightful participant and the rightful participant answers the questions.

b) Flexibility

   The interviewer has the opportunity to clarify questions that may need clarity. The interviewer can ask follow up questions on vague and incomplete responses in order to

get rich data. The interviewees can also ask questions to the interviewer if they wish to do so.

c) Communication through gestures

The interviewer gets important information from the gestures and behaviour displayed by the interviewees. Gestures are a way of communicating. They assist the interviewer to assess the interviewees.

d) Controlling the interview process

The interviewer remains in control of the interview. The interviewer maintains the order of answering the questions and controls the time to be taken by each interview session. The interviewer makes sure that the focus of the interview is not diverted by the interviewees.

e) Spontaneity

Immediate answers may be more informative than answers about which a participant has had time to think. If participants are given time to think, they may avoid answers that give them bad image or they may think of responses which they think please the interviewer.

Faces to face semi structured interviews were used in this study. The researcher interviewed the mathematics teachers who participated in this study. English and Shona were the languages that were used in the interviews. Since the researcher had permission to carry out the study, the interviews were carried out during the teachers' working hours and at the teachers' workplaces. The teachers and the researcher agreed on the time for the interviews. This arrangement was done so that the interviews would not interfere with the normal day to day business of the teachers. An interview session lasted for about thirty minutes. The mathematics teachers were interviewed individually. This was because the researcher wanted to avoid a situation in which an interviewee's response was influenced by responses from another interviewee. As advised by Leedy and Ormond (2005), the researcher used probes in order for the participants to provide further information. During the interview sessions, the researcher recorded the proceedings on audio tapes. The researcher asked for permission from the participants to audio tape the discussions since it was not possible for him to capture the proceedings otherwise. A diary was used to record the researcher's own reflections. The gestures, reactions and behaviours that were displayed by the participants were recorded as field notes. After the completion of the interviews, the researcher asked all participants if they had questions to ask in case the researcher left out something important. The researcher

thanked all the participants for their time, their contribution, and for agreeing to take part in this research. After the interviews, the researcher played the tapes five times while transcribing the information verbatim.

Interview guides were employed in accordance with the principles outlined by Hollway and Jefferson (2001). Since the study was carried out in three phases, three interview guides were prepared, one for each phase. The first interview guide had seven questions. The first question asked the teachers to state their highest professional qualifications and the length of their teaching experience. This question was very important in the study as it served to enable the researcher to assess the expertise of the participants in the teaching of mathematics at secondary school level. Question two and three asked the participants to explain what they knew about students' learning styles and how they got the knowledge about these learning styles. The forth question wanted them to explain what they thought were the causes of the learning styles differences in their students. The fifth question required the teachers to explain, giving examples, how they implemented their knowledge of students' learning style when teaching mathematics. The sixth question sought the teachers' views on the use of students' learning styles in teaching mathematics. The last question was an open question which sought any other information that the teachers could share on the use of students' learning styles in mathematics teaching.

The second interview guide had four sections. This interview guide was targeted at getting the teachers' responses to questions related to their use of students' learning styles in the teaching of a chosen topic in mathematics; Functions. The first section had questions on the participants' qualifications and experience. The second section probed the mathematics teachers on the strategies they used in teaching functions. In the third section the interviewer asked about the teaching tools that the teachers used in the teaching of functions. Emphasis was on how these teaching tools were related to the learning styles of the students. The fourth section had questions on how the teachers' assessed their students. By probing the teachers on the ways they assessed their students' progress, the researcher wanted to check if the teachers' methods were targeted to assess the students according to their learning styles.

The third interview guide had both closed and open-ended questions. This interview guide was aimed at getting the teachers' responses on questions on barriers that impinged on their use of their knowledge of students' learning styles in the teaching of mathematics. It had five sections. The first section sought data on the participants' teaching experience and

professional qualifications. In the second section, the interviewers required the interviewees to state and explain barriers that were related to the teachers' personal attributes and pedagogical skills. The third, fourth and fifth sections required the teachers to state and briefly explain giving examples barriers that were related to the students, the curriculum and the socio-economic status of their schools respectively. In the sixth section, the mathematics teachers were asked to give any other barriers that could not be classified under the given categories.

Although using interviews in collecting data had great advantages in terms of flexibility and adaptability, the process was costly and time consuming. It involved the researcher travelling from one school to the other in order to carry out the interviews. At times the researcher had to visit a school more than ten times depending on the number of participants at the school. The time required for all the teachers to be interviewed was quite long. It required a lot of patience on the part of the participants and the researcher.

4.5.3 Document analysis

McMillan and Schumacher (2010) described documents as printed or written records of past plans and events. These documents are useful and valuable sources of evidence that can be used in qualitative research (Henning, Van Rensberg & Smit, 2004). In carrying out this study, the researcher made use of some documents that were obtained from the mathematics teachers. The documents were analysed and integrated with oral information that was collected through face to face interviews with the mathematics teachers. This was done as a form of triangulation of the data collected. A document analysis checklist was used as a guide in collecting the data from the documents.

The following documents were collected and analysed for the purpose of this study: teachers' lesson plans, students' exercise books and class time tables.

- Teachers' lesson plans

  The teachers' lesson plans provided information on the teachers' plans of instruction including plans on activities to be done by the students, teaching tools to be used in the lesson, the objective of the lesson and the concepts to be covered in the lessons. The teachers' lesson plans were the most useful documents in this study as they provided information on almost all the activities done by the teachers and their students. Images of some of the lesson plans were taken. However the teachers' permission was sought before taking the images.

- Students' exercise books

The students' exercise books were used in conjunction with the teachers' lesson plans. The exercise books provided evidence of the activities done by the students. They also gave supporting evidence to the oral information given by the teachers.

- Time tables

The class time tables were used by the researcher to check how mathematics lessons were time tabled on the school curricula. This information was integrated with the information given by the teachers during interviews.

4.6 Phases of data collection

The data was collected in three phases since the study was done in three stages. Each phase was designed to provide answers to a specific research question.

Phase 1

In this phase the researcher wanted to answer the following research question:

1. What do the secondary school mathematics teachers know about students' learning styles?

This research question was split into the following three sub questions:

(i) What do the mathematics teachers know about students' learning styles?

(ii) How is the teachers' knowledge of students' learning styles reflected in the classroom?

(iii) What are the mathematics teachers' views about teaching mathematics according to students' learning styles?

The data used in this phase was collected using semi structured face to face interviews and observation. An interview guide and an observation guide were prepared in advance. These were used to guide the researcher in collecting the data.

Phase 2

In this phase the researcher sought answers for the following research question:

2. How do the secondary school mathematics teachers use their knowledge of their students' learning styles in teaching mathematics?

The aim of this phase was to find how the different mathematics teachers used their knowledge of students' learning styles in teaching mathematics functions. A common topic was chosen so that the researcher could compare the different approaches used by the teachers to teach the topic according to the students' learning styles.

The research question was split into the following three sub questions:

(i) What are the teaching strategies used by mathematics teachers when teaching functions?
(ii) What are the teaching aids used by the teachers when teaching functions?
(iii) How do the teachers assess their students' progress in learning functions?

The data used in this phase were collected using semi structured face to face interviews and document analysis. The researcher collected data from the mathematics teachers' lesson plans, their students' exercise books and the class timetables.

Phase 3

The following research question guided the study in this phase:

3. What are the barriers that impinge on the secondary school mathematics teachers' use of their knowledge of students' learning styles when teaching mathematics?

The research question was split into the following sub questions:

(i) What are the teacher related barriers that affected the effective use of the mathematics teachers' knowledge of their students' learning styles in teaching mathematics?
(ii) What are the student related barriers that affected the mathematics teachers' use of their knowledge of students' learning styles in teaching mathematics?
(iii) What are the curriculum related barriers that impinged on the mathematics teachers' use of their knowledge of their students' learning styles in teaching mathematics?
(iv) What are the socio-economic barriers that impinged on the mathematics teachers' use of their knowledge of their students' learning styles in teaching mathematics?

The researcher collected data through semi structured face to face interviews and through lesson observations. The researcher observed fifteen lessons taught by the mathematics teachers.

4.7 Trustworthiness

Trustworthiness in qualitative research refers to the extent to which the research is credible, dependable, confirmable and transferable (Bertram & Christiansen, 2014; LeCompte, 2000). Bertram and Christiansen suggested the use of data triangulation in order to make the research findings trustworthy. Patton (2002) concurred by suggesting that the researcher should employ different data collection methods. In line with these suggestions, this research made use of different data collection methods that assisted in data triangulation thereby ensuring trustworthiness of the research findings. The data collection methods used were face to face interviews, observation and document analysis.

According to Lincoln and Guba (1985) and Stenbacka (2001), the trustworthiness of a research is ensured if the quality and rigor of the research is ensured. These scholars point out that rigor and quality of a qualitative research is guaranteed if the following are addressed: credibility, transferability, dependability and confirmability. This study ensured that these aspects were addressed. Table 4.3 shows how the features of quality of research were addressed.

Table 4.3: Criteria used in addressing the aspects of quality of this study

Quality features	Criterion used	Description of the criterion
Credibility	• Triangulation • Prolonged stay in the field	Different methods of data collection were employed. The data collection methods were observation, semi structured face to face interviews and document analysis. Some form of researcher triangulation was done. The data obtained through face to face interviews was analysed by two different people separately. Consensus was then reached before producing the final analysis of the data. The researcher stayed in the field long enough in order for him to collect credible data.
Transferability	• Triangulation • Detailed description of	The researcher gave a detailed description of the findings from the research which included the statements shared by the participants which

	phenomena	were quoted verbatim.
Dependability	• Peer briefing • Clear description of methods used	The data collected was shared and separately analysed by a colleague who is an expert in carrying out qualitative researches. Feedback obtained from the colleague helped in further enriching the research. Clear description of the methods used in data collection and data analysis were given.
Confirmability	• Participants Checking	After collecting data, the collected data was transcribed and themes were developed from the data. The researcher went back to the mathematics teachers for them to verify that the data had been captured correctly. Cases that had some inaccuracies were rectified in the process. Some of the statements shared by the teachers were used verbatim in data analysis. This reduced researcher bias.

4.8 Validity and reliability

Cohen et.al (2011) stated that the credibility of a research is assessed through validity and reliability of the research instruments. According to Creswell (2010), validity of an instrument is the instrument's ability to measure what it is intended to measure. Validity in this study was ensured through triangulation. Triangulation was done in two forms, which are instrument triangulation and researcher triangulation.

- **Instrument triangulation**

More than one instrument was used to collect data from the mathematics teachers. The data collected by one instrument was triangulated with data collected by another instrument. For instance data collected through face to face interviews were triangulated with data collected though document analysis.

- **Researcher triangulation**

The data collected through face to face interviews was tape recorded. A colleague, who is an expert in research, was asked to go through the recordings and produce themes. The researcher also produced themes from the same data. The work done by the colleague and that done by the researcher were compared. The researcher and the colleague agreed on the themes produced and then the final analysis of the data was done.

Reliability is defined by Creswell (2010) as the ability of an instrument to produce the same results when applied several times. In order to ensure reliability of the instruments used in this research, a pilot study was carried out before the main study. The instruments were revised accordingly after the pilot study. This was in line with the suggestion by Leon, Davis and Kraemer (2011) who suggested that a pilot study should be conducted before the main study so as to check on the reliability and validity of the research instruments. Apart from assisting the researcher in testing his research instruments, the pilot study helped the researcher to budget the time required for data collection. As the researcher collected data during the pilot study, he was able to gauge the time required to implement each of the three research instruments (interview guide, observation guide and document analysis guide). For instance, he could judge the approximate time required for an interview session. It was also through the pilot study that the researcher learned how the mathematics teachers were likely to respond to his request. This equipped the researcher with appropriate approaches which he had to use in order to gain the teachers' willingness to participate in the study.

4.9 Data analysis

According to Machaba (2013) and Creswell (2010) qualitative data analysis is an ongoing process by which a researcher analyses the participants' feelings, attitudes, values, views, knowledge, understanding, perceptions and experiences in order to find out how the participants make meaning of a specific phenomenon. The purpose of this study was to investigate and explore secondary school mathematics teachers' knowledge and utilisation of students' learning styles. An exploratory interpretive paradigm was adopted. The paradigm allowed the researcher to get a deep understanding of the mathematics teachers' views, experiences, perceptions, opinions and understanding of the use of students' learning styles in mathematics teaching.

Mertler and Charles (2008) purported that the purpose of data analysis is to reduce and synthesise data in order for it to make sense to the readers. Data analysis enables the

researcher to make inferences about the population of the secondary school mathematics teachers in the district of study. For this research, the interpretive aspect of the research design enabled the researcher to combine the findings with the values and standards of mathematics teaching and this made it possible for the researcher to make conclusions, judgment and recommendations on the research findings.

The researcher played the interview audio tapes several times. The data on the audio tapes were then transcribed. The field notes in the researchers' diary were examined. This was done so that the researcher got an initial sense of the data. This exercise was done after every three interview sessions in order to reduce the volume of raw data at hand. The data was handed over to a peer researcher who also carried out the same process. Data cleaning was done just after going through the data. Data cleaning refers to a process of removing irrelevant data and remaining with what the researcher deemed relevant.

A qualitative analysis tool called ATLAS.ti was used to arrange, assemble, code and manage the data. Patterns, similarities and differences were identified and these were used to develop themes that were then used in data analysis. The principles of content analysis as outlined by Bengtsson (2016) were followed. The principle entails that the actual words said by the participants and the meanings of the words be analysed. Verbatim statements made by the participants were used to support or illustrate the research findings. In order to ensure confidentiality, the participating schools were coded using letters of the alphabet from A to J. The mathematics teachers were coded using numbers. Pseudonyms were formulated using this coding system. For instance, Mr BT_2 meant a male teacher number two from school B.

4.10 Chapter summary

This chapter gave an outline of the methodology that was used in carrying out this study. The chapter began with an explanation of the research method adopted for the study. It was explained that the study adopted an exploratory interpretive case study design which followed a qualitative paradigm. The researcher pointed out that the study was done in the Makoni District of Manicaland Provine in Zimbabwe. A brief description of the research setting was given. The researcher mentioned that three different sampling methods were employed at three different levels. Convenience sampling was used to select the district, stratified random sampling was used to select the secondary schools and the mathematics teachers were selected using purposive sampling. A brief description of each sampling method and the

advantages of using each of the methods were given. The chapter went further to provide the demographic information of the participants and the ethical issues that were considered in carrying out the study. Observations, face to face interviews and document analysis were the data collection techniques that were used to collect data. These instruments were described in detail in this chapter. Issues of validity and reliability were not left out as they enhanced the quality of the study. The criteria used to ensure quality of the research was outlined. It was also pointed out in this chapter that the research was done in three phases. Each phase was addressed a specific research question. The chapter ended with an outline of the data analysis procedure that was used to analyse the data obtained from the mathematics teachers.

CHAPTER 5

FINDINGS AND ANALYSIS OF THE TEACHERS' KNOWLEDGE OF STUDENTS' LEARNING STYLES

5.1 Introduction

This chapter reports on the data obtained on the teachers' knowledge of students' learning styles. The chapter starts by stating the research question that guided this part of the study. The research question is split into three sub questions which are also stated in this write up. Secondary school mathematics teachers who participated in this phase of the study comprised nine female and eleven male teachers who were experienced and well qualified to teach mathematics at secondary school level. This chapter goes further to report on what the mathematics teachers understood about students' learning styles. That is followed by a report on how the teachers utilised their knowledge of learning styles in mathematics teaching. The researcher then provides a discussion of the research findings. In the discussion section, the findings from the mathematics teachers are compared with the findings from the reviewed literature. The chapter ends with some implications of the findings for the mathematics teachers.

5.2 Research question

This part of the study was guided by the following research question:

- How do secondary school mathematics teachers view the strategy of teaching mathematics according to students' learning styles?

In order to get answers to the research question above, the following sub questions were formulated.

- What do the mathematics teachers know about students' learning styles?
- How is the teachers' knowledge of students' learning styles reflected in the classroom?
- What are the mathematics teachers' views on teaching mathematics according to students' learning styles?

5.3 The participants

Participation in this study was by choice. As stated earlier, one of the ethical issues considered was 'informed consent' which meant that participants were not coerced to participate in this study. When this phase of the study was carried out, the mathematics teachers were asked to show their consent to participate in the study by filling in a consent form. Thirty mathematics teachers from the ten schools selected gave their consent. Those included both male and female teachers.

In order for the researcher to make sure that the participating teachers were the richest sources of the required data, the researcher collected data on the participants' professional qualifications and teaching experience. Table 5.1 shows the participants' demographic information.

Table 5.1: Demographic information of the teachers who participated in phase one of the study (n=30)

Sex	**Teaching experience in years**			**Highest professional qualification**		
	Less than 5	Between 5 and 10	More than 10	Diploma	Bachelor's degree	Master's Degree
Females	2	1	7	1	8	0
Males	10	1	9	4	14	3
Total	**12**	**2**	**16**	**5**	**22**	**3**

It was pleasing to note that all the teachers who participated in the study were well qualified to teach mathematics at secondary school level and their experience ranged from three to forty-one years. The study was then carried out based on the assumption that the data obtained from the teachers was based on their experience and expertise in the teaching of mathematics at secondary school level.

5.4 Data collection and analysis

The data used in this part of the research was collected through semi-structured face to face interviews and through lesson observations. Data collected through lesson observations was used to triangulate data obtained through face to face interviews. An interview guide and an observation guide were prepared in advance. The interview guide used in this phase is shown in appendix 17 and the lesson observation guide is shown in appendix 15.

In order to analyse the mathematics teachers' use of their knowledge of their students' learning styles, the researcher used the learning style model developed by Perini, Silver and Strong (2000). The model enabled the researcher to analyse if the activities done by the teachers during the lessons observed were suitable for the four classes of learners identified by Perini et al. The classes are *Mastery maths learners*, *understanding maths learners*, *interpersonal maths learners* and *self-expressive maths learners*. The researcher considered this model for the analysis of the data obtained because the model is directly linked to the teaching of mathematics unlike the other models discussed earlier in this thesis. The researcher also noted that the model was the most recent of all the models discussed.

5.5 Sub question 1: The mathematics teachers' knowledge of students' learning styles

This section reports on the findings on the mathematics teachers' knowledge of students' learning styles. It starts by a report on what the mathematics teachers understood by the term 'learning styles'. It goes on to report on what the teachers thought were the factors that determined their students' learning styles.

5.5.1 The teachers' understanding of students' learning styles

When asked to explain what they understood by students' learning styles, the mathematics teachers had different explanations. Table 5.2 gives a summary of the ways in which the mathematics teachers described learning styles.

Table 5.2: Summary of the ways in which the teachers described students' learning styles (n=30)

Description of learning styles	Frequency	Percentage
Differences in students' abilities to learn from teachers' instructions	11	36.67%
Students' abilities to learn from concrete or abstract ideas	3	10%
Students' abilities to learn as individuals or as part of a group	3	10%
Type of learning assistance and learning tools required by the students	5	16.67%
Students' preferred learning methods	8	26.67%

- Differences in students' abilities to learn from teachers' instructions

Eleven (36.67%) of the teachers thought learning styles refer to the students' varying abilities to follow their teachers' instruction. One of the teachers who shared this view had the following to say:

> *"I can rightly say that students' learning styles refer to the abilities of the students to learn or to follow the teacher's instruction. Some students can grasp new information so easily while some take time to grasp concepts. Some need the teacher to repeat the same instruction several times for them to understand."(Mr CT $_{4,}$ pers. comm.).*

- Students' abilities to learn from concrete or abstract ideas

In their explanation, three (10%) of the teachers mentioned that students' learning styles refer to their abilities to learn from either abstract or concrete ideas. According to the teachers, some students are able to understand concepts that are presented in abstract terms, while others need to use their senses for them to understand concepts. They are only able to learn from concrete examples. One of the teachers said:

> *"It refers to the student's preferred mode of learning. Some students can be taught from abstract while others cannot comprehend abstract concepts."(Ms BT$_{1,}$ pers. comm.).*

The researcher probed Ms BT_1 to explain what she meant by abstract concepts. She gave the following explanation:

> *"For example, suppose you are teaching students to convert centimetres to metres. When you teach from abstract you can explain to the students that one metre is equivalent to one hundred centimetres, and then you ask them to calculate the number of metres in two hundred centimetres, and so forth. However some students have problems with such methods of teaching. They need to get hold of the metre rule, count the number of centimetres in a metre by themselves and probably use the metre rule to measure given dimensions of an object in both metres and centimetres. It is only after such activities that they will then be able to understand the relationship between centimetres and metres."(Ms BT$_{1,}$ pers.comm.).*

- Students' abilities to learn as individuals or as part of a group

Some of the mathematics teachers interviewed thought that students' learning styles refer to their abilities to solve mathematical problems as individuals or in groups with peers. Three (10%) teachers shared this way of thinking. The following statement was said by one of the teachers during an interview session:

> *"Some mathematics students have problems in working with others. If you give them problems to solve, they choose to work by themselves. They feel satisfied if they get things right while their peers fail. On the other hand, some students look for help from others or from the teachers. They cannot work independently. They always want to socialise with peers or with their teacher. They are willing to help their peers too. Some are not sure of what they are able to do."(Mr CT_3, pers. comm.).*

- Students' preferred learning methods

Eight (26.67%) of the mathematics teachers described students' learning styles as students' preferred learning methods. According to these teachers, learning styles also refer to the methods which the students prefer their teachers to use when teaching them. The following were statements from some of the teachers:

> *"In my understanding students' learning styles refer to the ways or methods in which the students prefer to learn. It can be through demonstrations, games, role plays, illustrations or any other methods."(Mr AT_2, pers. Comm.).*

> *"Students have favourite ways in which they prefer us to teach them. Their learning styles are their ways of learning from teachers' instructions. Some of the students prefer a teacher who demonstrates to them. Some prefer learning by doing. No one method of teaching is the best for all the students."(Ms ET_2, pers. comm.).*

- Type of learning assistance and learning tools required by the students

Another group of teachers thought students' learning styles prescribe the type of assistance required by students for them to learn effectively. As expressed by those teachers, the assistance includes the learning aids or tools required by the students for them to understand concepts. One of those teachers had the following to say:

"Learning styles prescribe the assistance that students need in order to grasp concepts taught. These learning styles suggest to the teacher which teaching strategies he or she should adopt and which teaching aids best suit the students. Decisions on what to use, when to use it and how it is supposed to be used in the lesson is based on the students' learning styles."(Mrs JT_1, pers. comm.).

The teachers were asked if they had been taught or exposed to formal knowledge of students' learning styles. Ten of the teachers (33.33%) said that they learnt about learning styles when they trained as teachers. Eleven (36.67%) reported that they got information on learning styles from the internet and the other nine (30%) said that they learned about learning styles from their colleagues through peer interaction during in-service courses and during mathematics panel meetings. The following were some of the responses from the teachers:

"Studies on learning differences were part of the course content that we learnt at college. Although I trained as a teacher a long time ago, I still have some memories."(Mrs DT_1, pers. comm.).

"In our panel meeting last year, someone presented on how students differ in the ways they learn mathematics. It was quite informative and enlightening."(Ms DT_2 pers.comm.).

"Nobody has ever taught me about learning styles, but you know as you gain experience in working with students you end up picking up something. The assistance I get from the internet these days has given me useful knowledge on how to teach mathematics effectively."(Mr FT_1, pers.comm.).

The researcher probed the participants in order to find out if they had knowledge on any learning style models. Twenty-eight (93.33%) of them could not remember any learning style model. Only two of the teachers had some idea. Those two teachers had little knowledge on the experiential learning style model. They were able to recall that students can be classified into four classes according to the experiential learning style model. One of them could only remember the class of accommodators and the other one mentioned the *accommodators* and the *assimilators*. None of them gave a clear description of the learners in the classes they had mentioned. One of the teachers was quoted as follows:

" ……mmmm 'accommodators' and 'assimilators' are some of the classes of learners in which students can be classified, however I cannot remember the details of how the students differ according to these classes."(Mr $ET_{3,}$ pers. comm.).

5.5.2 The teachers' opinions on factors which determined their students' learning styles

The mathematics teachers were asked to give their opinion on the factors that they thought determined their students' learning styles. Table 5.3 gives a summary of the factors that the mathematics teachers thought influenced the learning styles of the students.

Table 5.3 Summary of the factors that determined the learning styles of the students (n=30)

Factors that determined the learning styles of the students	Frequency	Percentage
Differences in how the students used their dominant and dormant senses	5	16.67%
Students' social backgrounds	6	20%
Students' attitude towards the teacher or the subject	5	16.67%
The students' biological make up	14	46.67%

- Differences in how the students used their dominant and dormant senses

Five (16.67%) teachers thought that their students differ on how they used their senses. Those teachers thought their students had some senses which were more active than the others. They referred to these senses as the 'dominant' senses. The other senses which were not active were the 'dormant' senses. According to the teachers, the students' dominant senses determined their learning styles. In an attempt to clarify this point, one of the teachers said:

"Students differ in the ways they use their senses in mathematics learning. I believe they use their strongest sense. Strongest senses dominate the other senses. Some students learn better by seeing, while others learn better when they use their sense of hearing. The strongest sense overrides the other senses and it determines the student's preferred way of learning. You may find that some students always want to draw some sketch diagrams when they are given word problems to solve in mathematics. It's a way of creating something they

can see so that they use their sense of sight to enhance their thinking. Such students prefer something they can visualise."(Ms CT_2, pers.comm.).

- Students' social backgrounds

Some of the teachers who participated in the study believed that the ways in which the students were socialised had an impact on their styles of learning. This was a belief shared by six (20%) of the teachers. The following statements were shared by two of the mathematics teachers:

"*Some students enjoy working together with their peers in groups. If you give them group work they participate actively. On the other hand, some students prefer working as individuals. It depends on how the students grew up. Remember they come from different backgrounds."(Mr DT_1, pers.comm.).*

"A student who grew up in an urban setting definitely learns differently from a student who grew up in a rural setting. The settings together with the people who socialise the students impact on the students' learning styles."(Mr BT_3, pers.com.).

- Students' attitude towards the teacher or the subject

According to some of the mathematics teachers, the students' attitude towards their teachers or towards mathematics as a subject determined the students' preferred way of learning. The researcher probed the teachers who had this way of thinking to clarify how attitude determined the students' learning styles. The following was an explanation given by one of the teachers:

"Students who view their teacher as an expert in mathematics are likely to develop more patience in following the teacher's instruction. They become loyal to their teacher and listening to what the teacher says religiously than those who think their teacher has little knowledge of the subject. In trying not to disappoint their teacher, such students always try hard using different ways of learning until they manage to get things right. The relationship between the student and the teacher matters much in shaping the students' learning styles. On the other hand, a student who has a positive attitude in mathematics always try to work hard and this improves the students' abilities in applying different

ways of learning. In the end the student can use multiple learning styles."(Mr AT_2, pers.comm.).

- The students' biological make up

Many of the teachers (about 47%) reported that the biological make up of the students played a pivotal role in determining their learning styles. After probing the teachers, the researcher realised that by biological make up, the teachers referred to brain function, abilities and inabilities of the students. One of the teachers made the following sentiment:

"I think the students' abilities and disabilities as individuals affect the way the students learn. Some have impairments which make it difficult for them to learn in particular ways and easy to learn in other ways. For instance you cannot expect a student with visual impairment to use his or her sense of sight in learning. Brain also plays a very important part in determining the learning styles. Brain controls the functions of our body parts and in so doing it controls how we do things. As a result, we cannot separate brain function from learning styles."(Mrs IT_2, pers. comm.).

5.6 Sub question 2: How the mathematics teachers used their knowledge of students' learning styles in the teaching of mathematics

This section reports on how the teachers utilised their knowledge of students' learning styles when teaching mathematics. The data used in this section were obtained through face to face interviews and were triangulated with data obtained through lesson observations. The researcher observed ten lessons taught by the mathematics teachers. A lesson was observed at each of the selected schools. The teachers' consent to be observed was considered and respected.

5.6.1 Findings from face to face interviews

During the face to face interviews, the teachers were asked to explain how their knowledge of students' learning styles assisted them in teaching mathematics. Table 5.4 gives the summary of the findings from the face to face interviews on how the knowledge of students' learning styles assisted the mathematics teachers.

Table 5.4: How the knowledge of students' learning styles assisted the mathematics teachers (n=30)

How the knowledge assisted the teachers	frequency	percentage
Making decisions on the teaching strategies to use in teaching the students	25	83.33%
Determining the assessment criterion to use in assessing students	11	36.67%
Determining the teaching pace	15	50%
Choosing effective teaching aids to use during the lessons	24	80%

- Making decisions on the teaching strategies to use in teaching the students

In their responses to the question on how they used their knowledge of students' learning styles in teaching mathematics, twenty- five (83.33%) of the mathematics teachers reported that the knowledge enabled them to make rightful choices on the strategies they used in teaching mathematics. Two of the teachers had the following to say:

> *"Knowledge of students' learning styles enables me to plan for instructions that benefit all the students in my class."(Mr FT_1, pers. comm.).*

> *"When you know how your students learn, it makes it easy for you to plan for activities that keep all the students active. You need to know whether giving group work can be the right way of teaching your students or not. The activities that you give to your students should not make them passive or make them bored by the lesson. Hence the knowledge of students' learning styles is very important when planning an instruction."(Mr CT_1, pers. Comm.).*

- Choosing effective teaching aids to use during the lessons

The mathematics teachers felt that their knowledge of their students' learning styles helped them to choose teaching and learning aids they used during their lessons. One of the teachers said:

> *"The teaching aids I use in my lessons are determined by the learning styles of my students. When I choose learning aids I always do it with my students in*

mind. I choose teaching aids that attract the attention of my learners during the lesson."(Mrs HT_1, pers. comm.).

- Determining the assessment criterion to use in assessing students

The teachers felt that their knowledge of learning styles helped them to vary assessment activities so that all their students are fairly assessed. According to the teachers, test items and lesson activities should be varied enough to ensure that each and every student in the class gets something to enjoy. The following is a statement from one of the teachers:

"The learning styles of the students assist the teacher to vary the methods he or she uses in assessing the students' progress. Test questions are normally targeted to fairly assess students despite their learning styles."(Mr FT_1, pers.comm.).

- Determining the teaching pace

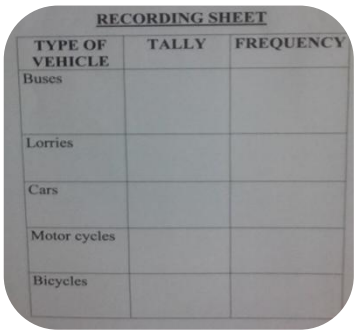
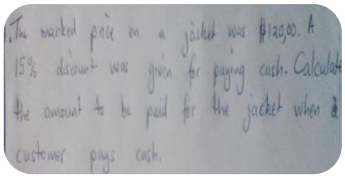
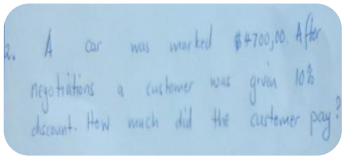
According to the teachers, the knowledge assisted them to determine the pace at which they moved with their work. Mr BT_3 explained this point by saying:

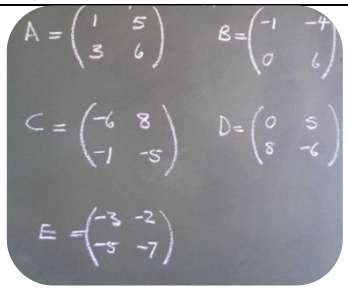
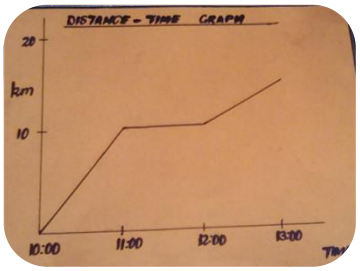
"Some of my students cannot fully understand concepts before I expose them to hands-on experience. They need time to prove the concepts and observe how they work practically. At times I give them some projects to do. I have to consider the time required in order for me to cater for all of them. As a result the time I need to complete a given concept largely depends on the learning preferences of my students."(Mr BT_3, pers. Comm.).

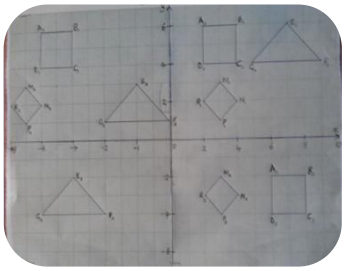
5.6.2 Findings from lesson observations

The researcher observed ten lessons taught by some of the participating mathematics teachers as a way of triangulating the data obtained through face to face interviews. Table 5.5 shows an analysis of the lessons that were taught by the teachers.

Table 5.5: An analysis of the lessons taught by the mathematics teachers.

Concept taught	**Teaching aids used**	**Teaching method and learning activities used**	**Learning style classes catered for**
Foreign currency exchange	Chart showing foreign currency exchange rates 	**Expert presentation** -a resource person from a local bank explained and demonstrated on how to interpret exchange rates -students were given problems to solve in pairs -students reported back	• Mastery maths learners • Interpersonal maths learners
Statistical data collection and presentation (bar graphs)	Recording sheets 	**Excursion** -students were taken out to a point near a busy road -students used tally system to record number of vehicles that passed through the point under the following groups; buses, lorries, cars, motor cycles -the students drew bar graphs using the collected data	• Understanding maths learners • Interpersonal maths learners • Self expressive maths learners
Discount	Question strips  	**Simulation** -two students role played a situation in which a storekeeper and a customer argued over wrongly calculated discount -As a class students discussed on who was wrong and why -students took turns to pick question strips and solve the questions on the strips	• Interpersonal maths learners • Understanding maths learners • Self expressive maths learners • Mastery maths learners
Determinants	Chalkboard with matrices	**Demonstration**	• Mastery maths

of 2x2 matrices		-the teacher demonstrated on how to find the determinant of a 2x2 matrix -students were given some work to do as individuals	learners • Understanding maths learners
Total surface area of rectangular prisms	Cardboard box and a cabinet  	**Discussion and visual tactile** -students identified rectangular prisms(they identified chalk boxes, cereal boxes and cabinets) -students measured the dimensions of the identified rectangular prisms -students calculated the area of the faces of the prisms - students added the area of the faces in order to find total surface area of the prisms	• Mastery maths learners • Interpersonal maths learners
Distance-time graphs	Chart with a distance-time graph 	**Discussion and peer interaction** -the teacher introduced a distance-time graph -the teacher and the students discussed on how to interpret the graph -students assisted each other in groups to answer given questions from the graph.	• Interpersonal maths learners • Mastery maths learners • Understanding maths learners
constructing angles of 15^o,30^o, $45^o$and 60^o	Video tape (The video demonstrated on how to construct an angle of 60^o and how to bisect the angle)	**Demonstration and e-learning** -Students saw a video that demonstrated on how to draw an angle of 60^o and then use a technique of bisecting angles in	• Self expressive maths learners • Understanding maths learners • Mastery maths

		order to get angles of 15^o, 30^o and 45^o -students practised drawing angles of 75^o, 90^o and 105^o using the bisection of angles technique.	learners
Translation of objects	Chart showing plane shapes and their images under translation 	**Illustration and lecture** -the teacher illustrated how a plane shape is translated -the teacher explained how a translation matrix is used to translate plane shapes - students were asked to translate triangles using given matrices and draw the images of the triangles	• Mastery maths learners • Understanding maths learners
Volume of a cylinder (v=hA) Where A is base area and h is height	Cylindrical bottle 	**Guided discovery** -the teacher introduced the formula ($v=\pi r^2h$) for volume of a cylinder to the students - students analysed the formula and discussed on the relationship between base area and the volume of the cylinder -students developed the formula Volume=base area x perpendicular height -students used the formula to calculate volume of given cylinders	• Mastery maths learners • Understanding maths learners • Interpersonal maths learners
Solving simultaneous equations	Audio tape	**Interactive e-learning** -the students got instructions from an audio tape on how to solve simultaneous equations using the elimination method - the students followed the	• Mastery maths learners

		instructions from the audio tape step by step - the students were given equations to solve as individuals (15minutes was given to finish the work) -the students were given the solutions to the equations and they marked their own work	

- **Lesson number 1**

During lesson number one, the students were taught to convert Zimbabwean dollars to South African rand. This was a thirty minute lesson. The teacher introduced the lesson by asking the students to give the names of the currencies used in the following countries: Japan, Zambia, Britain and United States of America. The teacher then introduced a resource person from a local bank. The resource person took over the lesson and introduced foreign currency exchange rates to the students. With the aid of a chart showing some exchange rates, he explained the concept of selling and buying currencies. He then demonstrated how to convert Zimbabwean dollars to South African rand. In one of the examples, he converted $5, 00 (five Zimbabwean dollars) to South African rand using simple proportion as follows:

1: 12.3541

5: more

$$\frac{5}{1}\text{xR}12.3541 = \text{R}61.7705 \approx \text{R}61.77$$

The students were then given the following question to solve in pairs.

A vendor wanted to buy Zimbabwean dollars from a local bank.

(i) How much money would he get from R52.00?

(ii) If he borrowed US$9.30 from a friend so that he gets more Zimbabwean dollars from the bank, how much money would he buy altogether?

A student was then asked to give feedback to the class. The other students observed and were asked to comment on the feedback given.

In that lesson the teacher fully catered for two groups of learners. These were the *mastery maths learners* and the *interpersonal maths learners*. *Mastery maths learners* were given an opportunity to make some mathematical computations and apply some formula as they converted rands to Zimbabwean dollars. The given exercise required them to apply simple proportion in converting the given currencies from one form to the other. *Mastery maths learners* prefer such activities. *Interpersonal maths learners* on the other hand got an opportunity to solved problems that apply to real life situations. They were also allowed to socialise as they solve the given problem in pairs. However, students were not given work to do as individuals. There were no patterns to be identified. As a result of this *understanding maths learners* were passive in this lesson. *Self expressive maths learners* were also not fully catered for. These students should have been given project-like tasks or tasks that could have allowed them to develop some mathematical models.

- **Lesson number 2**

The lesson was on statistical data collection and presentation on bar graphs. The teacher introduced the lesson with a recap on the tally system of recording data. She then took the students to a point on a busy road. Students were given some recording sheets and were asked to record the number of vehicles that passed through the point. The data were recorded under the headings: buses, lorries, motor cycles and cars. The students did this exercise for ten minutes and were asked to go back to the classroom. The teacher then introduced the concept of using bar graphs as a way of presenting data. She demonstrated to the students how a bar graph is drawn. The students were then asked to present the data they had collected on number of vehicles on a bar graph.

In that lesson, the teachers took the students out for an excursion, asked them to record data and use it to draw a bar graph. The exercise assisted the students to realise that bar graphs can be used in real life situations. Such an exercise was meant for *interpersonal maths learners* and *understanding maths learners*. *Interpersonal maths learners* enjoy activities that help people solve real life problems therefore in that lesson they realised that bar graphs can be used to solve a real life problem. *Understanding maths learners* liked the practical aspect of the lesson when they collected data and then used it in drawing graphs. The lesson itself proceeded in a project-like fashion which made it suitable for *self-expressive maths learners*.

However, *mastery maths learners* did not get an opportunity to apply any formula. There were no computations for them to carry out.

- **Lesson number 3**

In that lesson students were taught to calculate discount. The lesson was introduced by a simulation by two students. The simulation was prepared well before the lesson. In the role play, one of the students pretended to have bought a shirt with marked price of $88, 00 from another student and was promised a 10% discount for paying in cash. A hundred dollar note was used to pay for the shirt. The student who bought the shirt was given $5, 30 as change. The two students quarrelled over the amount given as change. The teacher asked the other students to comment on the amount of change given. They were asked to make correct calculations. The teacher went round to check the students' calculations. The students were then asked to take turns to pick some question strips, at random, from a box. They read the questions on the question strips and provided answers to the questions. The question strips had questions that required students to calculate discount. Calculations were done on the chalkboard by the students who picked the question strips while the other students observed and probed the student.

The teacher brought the calculation of discount into a real life situation when he made use of a simulation. The simulation helped the students to realise how correct calculations help to solve problems in people's lives. This part of the lesson captured the interest of *interpersonal maths learners* and *understanding maths learners*. *Self-expressive maths learners* on the other hand enjoyed the teacher's creativity which made the lesson different from other lessons in which the teacher writes exercises on the chalkboard. Picking question strips from a box appeared like a game to most of the students. The students could actively express themselves to their peers as they made calculations on the chalkboard. The inclusion of calculations was ideal for *mastery maths learners*. The researcher noted that in this lesson most of the students were active.

- **Lesson number 4**

The students were taught how to find determinants of 2x2 matrices. The lesson was introduced by a recap on the order of matrices. The teacher then introduced the formula for calculating determinants of 2x2 matrices. The formula was introduced as

$$|A| = ad - bc \ \ for\ a\ matrix\ given\ in\ the\ form\ A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

The teacher demonstrated on the chalkboard by calculating the determinant of matrix

$$B=\begin{pmatrix} 2 & -4 \\ -1 & 5 \end{pmatrix}$$

Students were then given some work to calculate determinants of matrices, which were given on the chalkboard.

The researcher noted that the activities done by the students in this lesson were mostly suitable for *mastery maths learners*. These students enjoyed the application of the given formula. They also enjoyed the calculations that were involved. Although *understanding maths learners* could not get an opportunity to prove the formula, they could realise that the formula given appeared like a pattern which they could apply in calculating the determinants. The teacher did not consider *interpersonal maths learners* and *self expressive maths learners* when he planned his instruction. There was no provision given for group discussions in the lesson. The work given was done by the students as individuals. As a result the lesson left *interpersonal maths learners* and *self expressive maths learners* passive.

- **Lesson 5**

The students were taught to calculate the total surface area of rectangular prisms. The students were asked to identify rectangular prisms in the local environment. The students identified different objects which included cereal boxes, metal book cabinets and chalkboard boxes. The students were instructed to measure and record the dimensions of the prisms they had identified. They were then asked to find the surface area of the rectangular faces on the prisms. The teacher instructed them to add the area of the faces in order to get the total surface area of the prisms. The students were given the instruction in a step-by-step manner and they performed the given tasks as individuals.

The lesson took a project like trajectory in which students had to be involved in activities of identifying and measuring objects. This brought the concept learnt to a real life situation. As a result, the teacher catered for *interpersonal maths learners*. However, these learners did not get an opportunity to interact with their peers in the lesson. *Mastery maths learners* were also taken care of in this lesson as the tasks given involved making some calculations which were based on application of some formula. The step-by-step way of receiving instructions was also good for them. In this lesson the teacher did not consider *self-expressive maths learners*.

The activities done in the lesson were not suitable for them. The teacher did not give them an opportunity to show their creativity, solve non-routine questions nor to use their imaginations.

- **Lesson 6**

The teacher taught the students to interpret a distance–time graph. She introduced the lesson with a recap on how to calculate distance when given speed and time. With the aid of a distance-time graph drawn on a chart, the teacher taught the students how to get distance travelled at given times on a distance-time graph. The teacher asked the students to use the graph to find distance travelled after 1hour, two hours and three hours. Students were given the following questions which they answered in groups using the given distance–time graph:

(i) What happened between 1100 and 1200?

(ii) Calculate the speed at which the person was walking between 1000 and 1100.

(iii) Calculate the general speed at which the person was walking between 1200 and 1300 in Km/hr.

In this lesson, the teacher made use of group activities. This made the lesson suitable for *interpersonal maths learners*. The lesson also involved making some calculations. The calculations were ideal for *mastery maths learners*. The questions given to the students were taken from a real life situation. This was suitable for *understanding maths learners* as they could see the logic behind learning to use distance-time graphs. *Understanding maths learners* could also realise how the concepts learnt in the lesson work in practical situations. The researcher however noted that in this lesson no activity from the activities done by the students was suitable for *self-expressive maths learners*.

- **Lesson 7**

The teacher played a video which demonstrated to the students how to draw an angle of 60^0 and bisect it to get angles of 30^0. After playing the video, the students were instructed to follow the demonstration and practise drawing angles of 60^0 and 30^0. The teacher and the students discussed on how they could draw angles of 90^0, 105^0 and 75^0. The students were then instructed to draw the angles.

Activities done by the students in this lesson required them to use their logic and creativity in joining or bisecting angles in order to get the required angles. For instance, to construct an

angle of 105^0 the students needed to join an angle of 90^0 and an angle of 15^0. However, there were other alternatives of doing it. The existence of different alternatives required the creativity of *self-expressive maths learners*. *Understanding maths learners* applied their ability to identify patterns in constructing the angles. *Mastery maths learners* liked the individual work and the application of the technique of bisecting angles. The researcher however did not observe any activity suitable for *interpersonal maths learners*. The concept learnt was not linked to any real life situation and no opportunity to interaction with peers was given. Teacher-students interaction was observed but there was no student- student interaction during the lesson.

- **Lesson 8**

A chart showing plane shapes and their images was used as a teaching aid in this lesson. The teacher used the chart to explain how the plane shapes were translated. He explained how matrices translated the plane shapes. The students were asked to find the matrices that translated the plane shapes on the chart onto the given images. Student were then asked to translate a triangle with vertices A (2, 5), B (3, 5) and C (4, 7) using a translation matrix $T = \begin{pmatrix} 3 \\ -5 \end{pmatrix}$

The tasks done by the students in this lesson were suitable for *mastery maths learners* and *understanding maths learners*. The computations which the students performed as individuals were suitable for *mastery maths learners*. *Understanding maths learners* to some extend benefited from the activities done by the students since translating shapes follows a particular model and pattern. The teacher however did not cater for *interpersonal* and *self-expressive maths learners*. This was because the students were not allowed to work in groups. The concept learnt was not linked to a real life situation and the students could not use their creativity and imagination in the lesson.

- **Lesson 9**

In that lesson students were taught how to calculate volume of a cylinder. The teacher started the lesson with a recap on calculating area of a circle. The teacher then introduced the formula for volume of a cylinder, $V = \pi r^2 h$. The teacher asked the students to find the relationship between the base area of a cylinder and its volume. The students deduced that the volume of a cylinder is equal to the product of its base area and its height. The students were then asked to complete the table below:

Base area	**Height**	**Volume**
$40m^2$	3.5m	
	1.2m	$4.8m^3$
$0.6m^2$		$3.6m^3$

The activities done by the students in this lesson were suitable for *mastery maths learners* and *understanding maths learners*. *Mastery maths learners* used the formula for volume of a cylinder in calculating the required dimensions. The teacher allowed the students to identify the relationship between base area and volume of a cylinder. This activity was suitable for *understanding maths learners*. The teacher allowed the students to discuss when they identified the relationship between base area of a cylinder and the volume of the cylinder. This activity was meant for *interpersonal maths learners*. In this lesson *self-expressive maths learners* were not catered for by the teacher.

- **Lesson 10**

The students were taught to solve simultaneous equations using the elimination method. The teacher played an audio tape which gave instructions to the students. The audio tape gave the students steps to follow to solve the following system of equations using the elimination method:

$$2x + 3y = 5$$

$$4x - y = 3$$

The students followed the steps given from the audio tape. Students were then given ten minutes to solve the following system of equations:

$$3x - y = 0$$

$$x - 2y = -5$$

After ten minutes, the students were given the solution of the system and were instructed to mark their own work.

In this lesson, the teacher provided activities that benefited the *mastery maths learners* only. Students were compelled to follow given steps. This did not give an opportunity for

understanding maths learners to find why they were supposed to follow the steps. The students were also not allowed to interact as they listened to the audio tape. All the students had to pay attention and listen carefully.

5.7 Sub question 3: The mathematics teachers' views on teaching mathematics according to students' learning styles

This section reports on the findings on the views of the mathematics teachers on the effectiveness of the strategy of teaching mathematics according to students' learning styles. The researcher found that the teachers had mixed views. Some had positive views, others had negative while another group of teachers had both negative and positive views. Table 5.6 shows a summary of the teachers' views on using students' learning styles in mathematics teaching.

Table 5.6: Summary of the teachers' views on teaching mathematics according to students' learning styles.

Teachers' views on teaching mathematics according to Students' learning styles	**Number and % of Teachers sharing the view**
Motivates students	11(36.67)
Improves students' performance	23(76.67)
Improves students' attitude towards mathematics	*23(76.67)*
Improves students' self efficacy	7(23.33)
Removes mathematics anxiety in students	21(70.00)
Makes it easy for the teacher to introduce difficult concepts	23(76.67)
It is student–centred	11(36.67)
Facilitates individualised teaching	15(50.00)
Enables the teachers to foresee students' challenges	11(36.67)
It is learner friendly	4(13.33)
Makes students active in their learning process	18(60)
Is difficult to implement when working with large classes	15(50.00)
It demands more time than tradition methods of teaching	4(13.33)
It makes students less flexible in solving problems	3(10.00)

The following were the teachers' views and the statements that were shared by the teachers during face to face interviews with the researcher.

- It improves the performance of the students

Twenty-three (76.67%) mathematics teachers shared the view that if mathematics is taught according to students' learning styles, then the performance of the students would improve. According to the teachers, teaching students according to their learning styles makes learning easier and enjoyable for the students to an extent that the students can easily comprehend what their teachers teach them. Two of the teachers made the following sentiments:

> *"Teaching students using their preferred learning styles helps to improve results. It makes learning enjoyable, comfortable and simple for the students. " (Mr FT_1, pers. comm.).*

> *"Definitely there should be positive correlation between students' performance and matching students' learning styles with teaching strategy."(Mr BT_2, pers.comm.).*

- It motivates the students

Some of the teachers felt that teaching mathematics students' according to their preferred learning styles assists the teachers to motivate their students. The teachers thought that motivation is enhanced if students realise that they are able to get things right. When they realise that they are capable of achieving good results, students get motivated to keep on trying. Eleven (36.67%) teachers shared this view. Two of the teachers clarified the point by saying the following statements:

> "*Teaching according to students' learning styles reduces boredom in students as they learn in the most comfortable way to them. Normally boredom is caused by continuous failure. Nobody wants to be associated with failure. It is common practice that people avoid it. If you utilise your students' abilities and allow them to test success, you will see that they will look for more challenging work to do."(Ms CT_1, pers.comm.).*

> *"Teaching students in their preferred way makes them enjoy the lesson. It creates a friendly environment for them. Students get motivated to learn if such an environment is created."(Mrs ET_2, pers.comm.).*

- It reduces mathematics anxiety in students

The teachers thought that the strategy reduces mathematics anxiety in their students. According to the teachers, anxiety is associated with failure. Fear of failure causes anxiety. The teachers thought that teaching students according to their learning styles helps the student to perform better and it also reduces fear of failure in them. One of the teachers had the following to say:

> *"Students realise their potential and effectiveness in solving problems in mathematics. Fear of failure is reduced hence anxiety is eradicated. If students are not taught in their preferred learning style, the learning process becomes so complex to them. They end up doubting their potential in mathematics and as a result they develop fear of the subject."(Mr FT_1, pers. comm.).*

- It improves students' self efficacy and attitude towards mathematics

Twenty-three (76.67%) of the teachers believed that self efficacy and attitude towards mathematics can be improved when students' learning preferences are considered when teaching mathematics. The following statements by Ms DT_1 clarified this point:

> *"When you consider your students' preferences in learning you make them realise their abilities. They know what they are capable of doing and what they are not capable of doing. At times you need also to let the students know their learning styles too. By so doing, the students know themselves better and they capitalise on their strengths and improve on their weaknesses. Otherwise if they do not know themselves and their weaknesses they hate the subject and anything associated with it, including the teacher."(Mr AT_1, pers.comm.).*

- It makes it easy for the teacher to introduce new and difficult mathematics concepts

Some of the mathematics teachers believed that new and difficult concepts in mathematics are easy to introduce to students in the students' preferred style of learning. When students grasp the concepts then they can be exposed to other styles of learning. Mr GT_1 was one of the teachers with that belief and he had the following point to make:

> *"Using students' learning styles makes it easy for mathematics teachers to introduce concepts that maybe difficult to the students. Difficult concepts are likely to be grasped easily if they are taught in the students' most preferred way*

of learning. The teachers take advantage of the students' learning preferences as a springboard. Once the concepts are grasped, reinforcement can be done through other learning styles."(Mr GT_1, pers.comm.).

- It is student centred

Some of the teachers thought that making use of students' learning styles is a child centred strategy. According to these teachers, using the students' learning styles ensures that the teacher's own learning style does not dominate the learning process. They thought that the strategy ensures that the teacher's instruction is determined by the students' needs and not the teacher's abilities. One of the teachers said:

"In my view, the strategy is student sensitive. It is a child centred method. It reduces a situation in which the teacher teaches by the book. The teacher's role is reduced to that of a facilitator. It makes sure that the teacher's own learning style does not override the learning process. The teacher teaches with the students in mind. Planning of instruction is also done with student in mind. The students' learning styles determine every learning process."(Mr HT_1, pers.comm.).

- It allows the teachers to foresee students' possible learning challenges

According to some of the teachers, using students' learning styles in teaching mathematics enables the mathematics teachers to foresee problems or challenges that their students are likely to face as they learn. The teachers felt that they gain full knowledge of their students and their challenges, attitudes, feelings and possible reactions. As a result they prepare possible remedies to the challenges before they cause serious damage to the students. Mr CT_2 had the following to share:

"When a teacher uses this strategy, it means the teacher develops full knowledge of his or her students. It also follows that the teacher knows the challenges that the students are likely to face in their learning. The teacher becomes alert. The teacher can also predict how students are likely to react to a learning situation. It is different from a situation in which the teacher realises a challenge when the damage is already done."(Mr CT_2, pers.comm.).

- It is learner friendly and it makes students active during lessons

The teachers thought that when students are taught in their learning preferences, they become active during their learning process. In other words, the teachers believed that the method reduces boredom and passiveness in their students. One of the teachers had the following argument:

> *"It creates a student friendly environment in which every student becomes active. Lessons taught in the traditional way result in students being tired and passive due to boredom. It is common to see students sleeping in such lessons. When they learn in their preferred way they enjoy every bit of the lesson."(Mrs DT_1, pers.comm.).*

- It facilitates individualised teaching

Half of the mathematics teachers (50%) claimed that using their students' learning styles in mathematics teaching enabled them to individualise their instruction so that each students was taught in ways that suited his or her unique ways of learning. As expressed by these teachers, it discouraged the use of one teaching method for all students in the class despite their differences. Mr AT_2 raised the following point:

> *"The 'one size fits all' method of teaching is not effective in mathematics teaching. We should consider that all learners are unique in some way. Considering their learning styles in teaching is one way of making sure that we differentiate our teaching in order to meet the demands of our individual students."(Mr AT_2, pers. comm.).*

- The strategy is difficult to implement when teaching a large class

Although some of the mathematics teachers believed that using students' learning style in teaching mathematics have many benefits, half of the teachers concurred that the method is not easy to implement when teaching a large class. The teachers expressed that the method requires teachers to continuously assess their students in order to closely monitor changes in the students' learning styles. It also involves differentiating instruction or using a variety of learning activities so that each student is fully catered for. The following statements came from two of the teachers:

"With this strategy the teacher should work very hard. It calls for the teacher to go an extra mile. The teacher needs to regularly assess the learning styles of the students. The instruction should be well thought of and be carefully planned so that the activities done by the students are varied in order to meet the demands of the students. When a teacher works with a large class it means more work to the teacher."(Mr DT_3, pers.comm.).

"Teaching according to learning styles does not work in my case. The number of students in my class is big. The number makes it difficult for me to utilise the varying learning styles of my students."(Mrs IT_1, pers.comm.).

- It needs more time than the traditional ways of teaching mathematics

Some of the teachers pointed out that the strategy of teaching students according to their learning styles needs more time than teaching in the traditional ways. The teachers said that more time is needed for planning, mobilising resources and assessing the students. This point was stressed by one of the teachers as he said:

"The teacher needs enough time so that he or she plans with each and every student in mind. Each student should be assisted in his or her own way. Resources that meet the demands of each student should be sought."(Mr ET_1, pers. comm.).

- The strategy can create learners who are not flexible

Three teachers (10%) felt that if not implemented properly, the method creates students who are not flexible in solving mathematics problems. The point raised by these teachers was that even though teaching them in their preferred learning styles may appear to be the best, the students should also be taught in the ways they do not prefer so that they become flexible when dealing with mathematical problems. In other words they said that mathematics students should be taught to work in different ways. Two of the teachers said:

"Students also need to be taught in their less preferred ways for them to be flexible. Take for instance a student who prefers learning as an individual and the teacher allows the student to work alone all the time. Such a student will never get an opportunity to work with his or her peers. Will that student be able to fit well in the society tomorrow? The student should be taught to fit in the

world because there are so many things in life that the student will never change even if they do not suit his or her needs."(Mrs JT_1, pers.comm.).

"I believe best students are those that use different styles in learning. Therefore if a teacher knows his or her students' learning styles he or she should try to assist the students to develop skills that are linked to the learning styles that maybe less preferred by the students."(Ms JT_1, pers.comm.).

5.8 Discussion

The results of this study revealed that although the mathematics teachers did not have knowledge of formal learning style models, they had some basic knowledge of their students' learning styles. The teachers could not remember learning style models but when they were asked to explain what they knew about students' learning styles, the researcher found that their descriptions of learning styles were related to the formal definitions of learning styles found in the reviewed literature. For instance, some of the mathematics teachers described learning styles as students' preferred learning methods. This description was almost similar to the definition of learning styles given by Markova in Albalham (2007), who defined learning styles as ways in which students feel comfortable to learn. The fact that the mathematics teachers who participated in this study could correctly describe learning styles made the results of this study different to those found by scholars like Geche (2009), Abu-Asba, Azman and Mustafa (2014) and Haar, Hall, Schoep and Smith (2002). Those scholars found that mathematics teachers in their areas of study did not have knowledge of students' learning styles.

The results of this study revealed that some of the opinions that the mathematics teachers held about their students' learning styles were similar to those held by some of the scholars found in the reviewed literature. For instance, in this study, mathematics teachers thought that their students had differences in learning preferences. As a result of that thinking, the mathematics teachers who participated in this study defined students' learning styles as students' differences in abilities to learn from teachers' instructions. From the reviewed literature, the fact that learners have different learning preferences forms the basis of the learning styles theory (Chandler, 2019; Felder, 2010; Kolb & Kolb, 2013). The theory of learning styles recognise that learners have different learning styles and it is because of these differences in learning styles that learners should be treated as unique individuals.

According to the mathematics teachers, one way in which students differ is in their abilities to understand abstract ideas. As stated by some of the teachers, some of their students could easily understand instructions presented to them in abstract form while others could only understand instructions through concrete or practical experiences. Concrete experiences were preferred by some of the students for them to understand concepts. To the mathematics teachers, these differences were a result of differences in learning style. In fact, the teachers pointed out that their students' learning styles were determined by the students' abilities to learn from either concrete or abstract experiences. The mathematics teachers concurred with Kolb (1984) and Honey and Mumford in Mobbs(2010). Kolb stated that students grasp new information through either concrete experiences or abstract conceptualisation. According to Kolb, *convergers* and *assimilators* grasp new information through abstract conceptualisation whilst *divergers* and *accommodators* grasp new information through concrete experiences. In support of Kolb's ideas, Honey and Mumford stated that *theorists* learn from abstract ideas whilst *pragmatists* and *activists* learn through concrete experiences.

The results of this study revealed that some of the mathematics teachers described learning styles as students' abilities to learn as individuals or in groups. The teachers felt that some of their students could learn better when they were given tasks to perform as individuals while others preferred learning with others in groups. The teachers agreed with kolb (1984), Honey and Mumford in Mobbs (2010) as well as Perini, Silver and Strong (2000). Kolb stated that *divergers* prefer learning through discussions and interaction with peers in groups. Those students can hardly learn on their own. *Accommodators* prefer taking risks as they try their own ideas. They do not like working with others in groups. On the other hand, Honey and Mumford reported that *activists* enjoy working in groups with peers. They always want to take leading roles in the groups. According to Honey and Mumford, *pragmatists* dislike group work. They need opportunities to use their practical skills. Perini, Silver and Strong (2000) also supported by stating that *interpersonal maths learners* learn better when they discuss and work with others in groups while *understanding maths learners* have problems in working with others. *Understanding maths learners* always criticise other people's ideas. They can hardly accept ideas from others before they prove that the ideas work in real life.

The teachers who participated in this study felt that the learning styles of their students determined the type of assistance that the students required. In other words, the teachers meant to say that the teaching aids and the instructions that they used when teaching mathematics were determined by the learning styles of their students. Lohri-Porsey (2003)

had similar views. Lohri-Porsey reiterated that the tips that the teachers gave to their students depended on the learning styles of the students. The point was further stressed by Markova in Al-balhan (2001) who then generalised by stating that the teachers' knowledge of students' learning styles assists them in determining teaching and learning strategies that suit the students. According to the teachers who took part in this study, knowledge of students' learning styles assisted them to plan suitable teaching tools for different individuals. This was supported by Markova who suggested that the choice of teaching aids or tools should be guided by the teacher's knowledge of the learning styles displayed by students in his or her class.

The teachers believed that the learning styles of their students were determined by a number of factors. Amongst the factors they mentioned, was the students' social background. On this point, the teachers agreed with Kolb and Kolb (2013). Kolb and Kolb stated that the learner's social background which depends on the culture in which the learner was nurtured affects the learner's learning style. According to Kolb and Kolb, culture forms the core of the learner's social life hence we cannot talk of the students' social background without talking about the cultural background of the student. Felder (2010) partly concurred with the mathematics teachers when he stated that the environment in which the students grow or learn has some influence on the learning styles of the students. The environment socialises students and develop in them characteristics that shape the learning styles of the students. Elements of the learning environment that can influence the learning styles of the students include people who interact with the student and the learning materials available for them to learn.

Kolb and Kolb also stated that in addition to the social background of the students, learning styles are also influenced by students' personality type. According to Kolb and Kolb, personality type referred to observable behaviour which is displayed by student. However, the term personality type is broad. As stated by the Kolb and Kolb it includes a number of factors like attitude, self-esteem and self control. Related to the points raised by Kolb and Kolb, the mathematics teachers stated that students' attitudes towards mathematics and towards their teachers influenced their learning styles. Some similarities were observed on the mathematics teachers' views on the effects of students' attitude on their learning styles and the ideas found from Kolb and Kolb.

The mathematics teachers agreed with Chandler (2019) on some of the factors that determined their students' learning styles. The teachers thought that the students' biological

make up and the way the students used their senses played a pivotal role in shaping their learning preference. As stated by some of the teachers, their students had dominant and dormant senses which they used in mathematics learning. Chandler, on the other hand, mentioned that a learner's cognitive processes influence how the learner learns. Cognitive processes refer to how the brain functions. Chandler and the mathematics teachers partly agreed on cognitive processes as a factor that determines students' learning styles. The teachers went further to point out other biological factors that they thought affected the learning styles of their students. These included the students' physical abilities and disabilities. Chandler and the teachers also agreed that students' learning styles are a result of the students' attitude towards mathematics. In their opinion, the students' attitude plays a part on how the student reacts when he or she faces a problem. As a result, when a student is given a task in mathematics, the student's attitude towards the subject determines how the student reacts to the task given.

When the teachers were asked to explain how they learnt about students' learning styles, the researcher realised that the teachers got the information from three sources (peers, internet and teachers' training). The researcher found that some of the teachers learnt about learning styles when they trained as teachers. An analysis of the teachers' teaching experience showed that teachers who had more than ten years of teaching experience did not get a chance to learn about learning styles at college level. This suggested that when they trained as teachers, the curriculum by then did not include studies on learning styles. The researcher also noted that some of the teachers got the knowledge from the internet. This showed the importance of the internet in keeping mathematics teachers up dated with current trends in mathematics teaching. Peer interaction also proved to be very important as some of the teachers explained that they got information about learning styles during workshops and panel meetings.

The results on how the mathematics teachers used their knowledge of students' learning styles in mathematics teaching had very interesting points in the teaching of mathematics. The teachers reported that their knowledge of students' learning styles helped them to select suitable teaching strategies to use so that all their students were catered for. As put forward by the teachers who took part in this study, their decisions to use group work or individual work was determined by the learning styles of their students. The mathematics teachers concurred with Gilakjani (2003) and Lohri-Porsey (2003). Lohri-Porsey reiterated that knowledge of students' learning styles help the teacher to give learning tips to his or her students. Gilakjani supported by saying that the knowledge enables the teacher to avoid

mismatches between his or her teaching strategies and the learning preferences of his or her students by planning for strategies that suit all students.

In this study, the mathematics teachers pointed out that their choice of teaching aids and the pace at which they covered the concepts in the mathematics syllabi were also based on their knowledge of their students' learning styles. The points raised by the teachers agreed with ideas from Lohri-Porsey (2003) who stated that knowledge of students' learning styles enables teachers to make research and to decide on how to conduct lessons in ways that are enjoyed by all the students. Lohri- Porsey added on to say that the knowledge also assists the teachers in preparing learning tools or learning aids. The point was also supported by Solvie and Sungur (2012) and Dasari (2016). Those scholars reported that when the mathematics teacher has knowledge of his or her students' learning styles, he or she can plan for teaching tools that suit all students. They went further to suggest that when the teachers are equipped with knowledge of students' learning styles they know the anticipated challenges that their students are likely to face hence they find suitable teaching aids and other remedies to assist them in overcoming the challenges. Powell and Kusuma-Powell (2011) and the mathematics teachers also concurred in suggesting that the approach of teaching students according to their learning styles enables the teachers to foresee challenges and opportunities that the students face in learning mathematics.

The results of this study showed that the mathematics teachers brought in new ideas that were not found in the reviewed literature, for instance, the teachers reported that knowledge of students' learning styles assisted them in selecting suitable ways of assessing their students' progress in learning. As put forward by the teachers, they used their knowledge of students' learning styles to vary the questions that they included in assessment tests. According to the teachers, they made sure that the question items were varied enough to cater for all their students despite their learning styles. This helped the teachers and their students to realise the students' strengths and weaknesses so that they could look for suitable ways in which learning could be improved.

Another interesting point that was found in this study but was not found in the reviewed literature was that knowledge of students' learning styles assisted mathematics teachers to make decisions on the pace at which they had to teach their students. According to the teachers who participated in this study, their decisions on the time they had to spend on particular concepts were determined by the learning styles of their students, for instance,

students who preferred learning through hands-on needed more time than those who could easily learn through lectures.

Results obtained by the researcher in this study showed some inconsistencies between what the teachers said during the face to face interviews and how the knowledge of learning styles was reflected in the classroom. During face to face interviews, the teachers claimed that they used their knowledge of learning styles to make decisions on planning and delivering lessons. As explained by the teachers who were interviewed, they varied their teaching strategies and teaching aids in order to meet the demands of their students' learning styles. Observations made by the researcher during some of the lessons that were taught by the mathematics teachers indicated that not all lessons were varied enough to meet the demands of all learners. *Self expressive* and *interpersonal maths learners* were not fairly treated. Most of the mathematics lessons observed involved using stated formula or rules. In fact nine out of the ten (90%) lessons observed involved use of algorithms and formulae in solving problems. As observed by the researcher, *Mastery maths learners* enjoyed these lessons. *Self expressive learners* required the teachers to give them opportunities to use other alternatives and show their creativity. They were supposed to be allowed to express themselves to their peers and to the teachers as suggested by McTighe and Silver (2019). However in more than half of the lessons observed, the activities done by the students did not allow *self expressive* students to utilise their abilities. *Interpersonal maths learners* needed to interact with their peers during the lessons so that they understand the concepts taught. In four of the ten (40%) lessons, the teachers allowed them to interact either in pairs or in large groups. However in the other six lessons (60%), students were not given a chance to interact. *Understanding maths learners* were somehow fairly treated as in seven of the lessons (70%) observed they were allowed to use their logic to find how the concepts work practically or to find some mathematical patterns. However, in all the ten lessons observed, the students did not prove any formula or any mathematical statements.

The results of the study established that the participating mathematics teachers agreed with McLeod (2007) and Cho (2016) in thinking that teaching mathematics according to students' learning styles had more advantages than disadvantages. An analysis of the teachers' views revealed that more than half of the teachers felt that teaching mathematics according to students' learning styles improves students' performance. This point was also raised by Tulbure (2011) who indicated that teaching students in their preferred way improves their achievement and satisfaction. Naimie, Shagoholi Siraj and Abuzaid (2010) also agreed to the

fact that teaching students according to their learning styles improves the performance of the students. In their report, Naimie et.al. stated that there is congruency between teaching students according to their learning styles and the performance of the students. They found a positive impact on the use of students' learning styles in mathematics teaching. The mathematics teachers who participated in this study, concurred by saying that the strategy improved the performance of their students by motivating them and instilling in them positive self efficacy. Those teachers thought that students got motivated when they learn comfortably and when they got things right. Some of the mathematics teachers pointed out that teaching according to students' learning styles creates conducive environment for free and fair learning. The teachers also agreed with Tulbure who claimed that success enhances self awareness and self motivation. The same point was stressed by Csapo and Hajen (2006) who added that teaching students according to their learning styles motivates students and it enhances satisfaction in them.

The teachers also thought that if students are taught in their preferred way, their chances of getting things right are increased leading to improved attitude towards mathematics. The teachers raised the same point as Bosman and Schulze (2018). Bosman and Schulze argued that prolonged failure caused by mismatches between teaching styles and students' learning styles causes negativity towards mathematics. Felder and Silverman (1988) also had the same view that teaching students according to their learning styles instils positive attitude in the students towards mathematics. Felder and Silverman stated that if a mismatch exists between students' learning styles and their teacher's teaching style, the students become bored and they dislike the subject.

Another interesting result of this research was that the teachers felt that teaching mathematics according to students' learning styles makes it easier for the teachers to introduce new and difficult concepts to the students. They thought that difficult concepts should be introduced to students in the students' preferred ways of learning. However, once the concept is grasped, the students can then be exposed to other learning styles that may not necessarily be preferred by them. Such an approach uses students' learning styles as a 'springboard', as stated by one of the teachers, to expose the students to the real world. Practical problems in real life cannot be solved in only one way hence a student needs to be exposed to other approaches to problem solving. For instance *interpersonal maths learners* prefer group discussions but they should later be exposed to individual work and hands-on experiences. The teachers' point was partly aligned to the position of Mkonto (2015). Mkonto stated that an intentional

mismatch should be sometimes promoted so that a balanced teaching strategy that accommodates various learning styles is maintained.

The mathematics teachers felt that teaching students according to their learning styles is a way of creating a learning environment that is friendly to the students. They also thought that the approach is student centred as the activities done by the students are determined by the behaviour and the characteristics of the students in the class. The teachers went further to point out that using this strategy enables the teacher to individualise his or her teaching instruction for the benefit of all the students. The use of differentiated instruction to meet the demands of the learning styles of all the students was supported by Bender and Waller (2011).

Although most of the teachers viewed the use of students' learning styles in mathematics teaching positively, they also revealed some disadvantages that are associated with the approach. According to the teachers, the strategy has problems if the class is large. The teachers thought that in order for them to effectively utilize students' learning styles, they need to develop full knowledge of all the students in the class. According to them, it can be very difficult to closely monitor the learning styles of all the students when dealing with a large number of students.

Another disadvantage given by the teachers was that the approach requires enough time for it to be implemented effectively. According to the teachers the approach demands enough time for planning, assessing the students, mobilising resources and delivering individualised instruction. Although the researcher found that the point was very important, the point was not found in the reviewed literature.

The results of this study revealed that the mathematics teachers had basic knowledge of their students' learning styles. This was in contrary to the findings in Ethiopia by Geche (2009) where teachers were reported to be lacking knowledge of their students' learning styles resulting in mismatches between teachers' teaching styles and students' learning styles. Although the researcher observed that some of the teaching methods used by the teachers were not tailored enough to cater for all learning styles, the researcher found that the teachers had some knowledge of their students' learning styles. In the researcher's view, the reasons why they did not fully utilise their knowledge was not lack of knowledge. Further studies were therefore necessary in order to establish the possible barriers that were affecting the teachers' effective use of their knowledge of learning styles.

5.9 Implications of the findings for the mathematics teachers

The findings of this study had the following implications for the mathematics teachers:

(i) The internet is very important in keeping mathematics teachers up dated with current trends in the teaching of mathematics. In this study, it was found that some of the mathematics teachers who participated in this study got information on students' learning styles from the internet. The teachers had not learned about the theory before. Had it not been for the internet, the teachers would have been found lacking the essential knowledge.

(ii) Mathematics panel meetings and workshops should be held and they should be attended by all mathematics teachers. The data obtained from the mathematics teachers showed that some of the teachers learnt about students' learning styles during panel meeting discussions. As teachers discuss during panel meetings and workshops they share information which assists them to become competent mathematics teachers.

(iii) A balanced mathematics lesson should include both group activities and some individual work. The analysis of the lessons observed showed that self expressive and interpersonal maths learners were not fully catered for in some of the lessons. It was because the teachers did not give the students opportunities to interact amongst themselves. Allowing students to interact is a way of reducing 'teacher talk' during the lessons.

(iv) Knowledge of learning style models assists teachers to plan instruction which reaches all students. Although the mathematics teachers who participated in this research had some basic knowledge of their students' learning styles, some of them did not fully utilise the knowledge for the benefit of all the students. The reason could be that the teachers did not have knowledge on the demands of the students. Knowledge of learning style models assists a teacher to classify his or her students according to their learning styles and then give them the assistance according to their learning style classes.

(v) Teaching students according to their learning styles has more benefits than problems. The analysis of the teachers' views on the use of learning styles in teaching mathematics shows that the teachers came out with more advantages than disadvantages of using the

strategy. The most important advantages mentioned were reduction in students' anxiety in mathematics and improvement in students' performance.

5.10 Chapter summary

This chapter reported on the results of the study on the mathematics teachers' knowledge of their students' learning styles. This part of the study was guided by one research question and three sub questions. Nine female teachers and eleven male teachers participated in this study. The data used in the study were collected through face to face interviews and through lesson observations. The results revealed that the teachers had some basic knowledge of their students' learning styles. The teachers identified a number of factors which they thought determined their students' learning styles. Data obtained from the lessons observed showed that not all the lessons taught by the teachers, possibly benefited all their students. The teachers' views of the strategy of using students' learning styles in teaching mathematics were given. A discussion on the findings of the study was provided. The chapter then ended with the implications of the findings of this study for the mathematics teachers.

CHAPTER 6

FINDINGS AND ANALYSIS OF THE MATHEMATICS TEACHERS' USE OF STUDENTS' LEARNING STYLES WHEN TEACHING MATHEMATICS

6.1 Introduction

This chapter reports on how secondary school mathematics teachers used their knowledge of students' learning styles when teaching functions. The study was guided by one research question which was then split into three sub questions. The first part of the chapter states the research question and the three sub questions. It goes on to give a description of the research participants. A summary of the participants' biography is given. The chapter goes on to give a report on the results on the strategies that the secondary school mathematics teachers used when teaching functions. In this section, it is highlighted that a variety of strategies were used by the teachers. The report also points out that different teaching aids were used by the mathematics teachers. The strategies that were used by the teachers to assess their students are also described in this chapter. This is followed by an overall discussion of the results of the study. The chapter is concluded by some implications of the results for mathematics teachers.

6.2 Research question

This phase of the study was guided by the following research question:

- How do secondary school mathematics teachers use their knowledge of students' learning styles in teaching mathematics?

The objective of this phase of the study was to explore how secondary school mathematics teachers utilised their knowledge of students' learning styles when they were teaching mathematics. In order to get an in-depth understanding of how the teachers used their knowledge, the researcher chose to consider how the teachers taught a topic in mathematics. The topic chosen was functions. The study focused on the teaching of one common topic, functions, so that similarities and differences on how the mathematics teachers used their knowledge of students' styles in teaching mathematics could easily be established. The reason for considering the teaching of functions was that, in the researcher's point of view, functions form a very important component in mathematics. In fact, functions are the core of mathematics concepts studied from senior secondary level and beyond. This point was

supported by Haas (2003) who stated that the understanding of the theories on functions is very vital for advanced mathematics.

In order to carry out the study, the research question stated above was split into the following three sub questions:

- What are the teaching strategies used by the secondary school mathematics teachers when teaching functions?
- What are the teaching aids used by the secondary school mathematics teachers when teaching functions?
- How do the secondary school mathematics teachers assess their students' progress during lessons on functions?

6.3 Definition of a function

Haas (2003) defined a function as a mapping or an operator that defines a relationship between two sets, an input set and an output set, so that each element of the input set is related to only one element of the output set. The input set is called the domain set and the output set is referred to as the co-domain set. According to Haas, the relationship between the two sets can be represented in different forms which include graphs, mapping diagrams, verbal statements, tables and notations like $f:x\rightarrow y$ or $f(x)=y$ (where x is from the input set and y is in the output set).

6.4 Participants

Twenty five secondary school mathematics teachers gave their consent to participate in this study. Those teachers completed a consent form. They included both male and female teachers with teaching experience ranging from three to forty years. All of them were qualified to teach mathematics at secondary school level. Table 6.1 shows the demographic information of the teachers who participated in this study.

Table 6.1 Demographic information of the teachers who participated in phase two of the study (n=25)

Sex	Teaching experience in years			Highest professional qualification		
	Less than 5	Between 5 and 10	More than 10	Diploma	Bachelor's degree	Masters' degree
Females	2	1	5	4	7	0
Males	5	6	6	4	8	2
Total	7	7	11	8	15	2

6.5 Data collection and analysis procedure

Semi structured face to face interviews and document analysis were the data collection strategies that were used in this phase of the study. An interview guide was used to guide the researcher during the face to face interview sessions (see appendix 18). A document analysis checklist given in appendix 16 guided the researcher to get the required data from the documents analysed. For data analysis purposes, the learning style model developed by Perini, Silver and Strong (2000) was used. The data obtained from the documents were analysed using Perini et al. model in order to determine the classes of learners that were catered for by the activities that were planned by the mathematics teachers.

6.6 Teaching strategies used by the mathematics teachers when teaching functions

This section reports on the strategies that the secondary school mathematics teachers used when teaching functions.

6.6.1 Findings from face to face interviews

The data obtained from face to face interviews revealed that when teaching functions the mathematics teachers used the strategies outlined in Table 6.2.

Table 6.2: Summary of the findings from face to face interviews on the teaching strategies used by the mathematics teachers when teaching functions. (n=25)

Strategy used by the mathematics teachers	Frequency	Percentage
Peer group discussions	25	100%
Individual work	25	100%
Projects	15	60%
Guided discovery	11	44%
Demonstration and illustration	25	100%
Interactive e-learning and ICT	3	12%
Inquiry	2	8%

- Peer group discussions

Data obtained from the mathematics teachers during face to face interviews revealed that all (100%) the mathematics teachers who participated in this study used both individual and group activities when teaching functions. The researcher found that twenty (80%) of the participating teachers reported that they allowed their students to work in pairs while five (20%) said they allow them to work in groups of three. When asked to explain how he used group work when teaching functions, one of the mathematics teachers gave the following response:

> *"I use both group work and individual work. When I use group work, I give them tasks to perform in groups of three. I always keep the groups small so that each member of the group gets a chance to participate. If the groups are too large some of the students become passive. I give individual tasks after group discussions as a way of checking if the students would have understood the concept taught." (Ms BT_1, pers. comm.).*

The researcher asked Ms BT_1 to comment on the effectiveness of using group work when teaching functions. She had the following to say:

> *"When students work in groups, they get an opportunity to discuss on what they consider solutions to given problems unlike in situations where they learn*

as individuals or as a whole class. In groups, they learn to interact, communicate and express themselves to their peers. Some of the students like to lead in the discussions. However, I normally do not use group work due to shortage of time. Discussions need enough time which may not be available. Thirty five minutes allocated to a mathematics lesson is not enough for me to use group work effectively. The time is not enough for me to allow them to discuss and then get feedback from them. I propose that the lessons be allocated enough time, even up to an hour per lesson. Imagine students who want to make a table of values for the function f(x) = 3x +5, draw the graph to a given scale and then give feedback to the class. It cannot be done in thirty five minutes."(Ms BT_1, pers.comm.).

- Projects

The mathematics teachers also reported that they sometimes used projects as learning tasks. Fifteen (60%) teachers claimed that they gave their students tasks to collect data and then use the data to draw graphs. Another group of mathematics teachers indicated that they gave tasks in the form of projects in the early stages when they introduced concepts on functions. The following statements were said by two of the mathematics teachers:

"I sometimes give assignments or projects to my students which they do over a period of one or two days. For instance, last time I assigned them to collect information on daily temperatures in the month of June. I further instructed them to use the data they collected to draw a line graph on graph paper. They also drew a line that showed the general trend of the temperature on the graph. They went further to find the equation of the trend line." (Mr FT_1, pers. comm.).

"Normally I teach concepts on sets before I teach functions. My understanding is that functions depend on sets of values. It is during this period that I give students some projects to do."(Mr ET_2, pers.comm.).

- Guided discovery

Eleven (44%) of the mathematics teachers indicated that they used the guided discovery method when they teach functions. Those teachers reported that they guided their students to discover patterns and trends in the concepts they teach. One of the teachers gave the following explanation:

> *"I believe that one of my role as a mathematics teacher is to lead the students to make logical mathematical conclusions. They should find patterns that arise from using particular formula. When they learn about functions, they can find the patterns created by the functions. For example, they can find the relationship between the coefficient of x^2 in a quadratic function, ax^2+bx+c, and the shape of the graph produced by the function. I mean the fact that when the coefficient is negative the graph faces downwards and when it is positive it faces upwards. The concept sticks well in their minds if they discover these patterns and relationships on their own."(Mr FT_1, pers.comm.).*

- Demonstration and illustrations

All (100%) the mathematics teachers who participated in this study indicated that they used demonstrations in their lessons on functions. According to the teachers, demonstrations were done by either the mathematics teachers themselves or by other students. One of the teachers had the following comment on the use of demonstrations in mathematics teaching:

> *"Demonstrations normally help in giving my students direction. I normally demonstrate on the chalkboard while explaining to them how calculations are done or how graphs are drawn. Even my students sometimes demonstrate to their peers."(Mr AT_2, pers. comm.).*

- Interactive e-learning and information and communication technology systems (ICT)

Three (12%) of the mathematics teachers claimed that they used electronic learning systems as well as information and communication technology when teaching functions. Those teachers said that they used video tapes, audio tapes and computer software to teach their students concepts on functions. They reported that they got some of the video and audio tapes from the internet. One of the three teachers said:

"Another effective strategy is using electronic systems. These can be in the form of videos which are obtainable on the internet. On the internet we get videos that demonstrate on quite a number of concepts on functions. For example, there are videos that demonstrate how to draw graphs of given functions. Each time I use these videos, I find my students quite eager to learn. Excel and other computer software can also be used to teach students how to draw graphs of functions."(Mr GT_1, pers. comm.).

The researcher probed the other teachers who did not mention ICT as one of the strategies they used when teaching functions. This was done in order to establish the teachers' reasons for failing to use ICT system. Table 6.3 summaries the reasons that were given by the teachers.

Table 6.3: The teachers' reasons for not using ICT as a teaching strategy. (n=25)

Reason for not using ICT	Frequency	Percentage
Shortage of time	5	20%
The teacher not computer literate	17	68%
Shortage of required equipment	19	76%
Lack of training on the use of ICT	13	52%
Supply of electricity not constant	5	20%
School authorities or leadership not supportive	2	8%
Teacher having negative attitude towards use of ICT	2	8%

The data obtained from the mathematics teachers revealed that the most common reason for not using ICT in teaching functions was shortage of ICT equipment in schools. At three (30%) of the schools that were selected for this study, the teachers reported that they did not have computers and other information and communication technology equipment at their schools. The researcher also found that computer illiteracy, on the part of the teachers, was also a major cause for the teachers' failure to use computers or other information and communication technology systems. The following were some of the statements that were mentioned by some of the teachers concerning the use of ICT:

"I need to learn to use a computer. My students are far ahead of me in terms of technology. How can I try to use ICT in my lessons when my students know better than me? I will end up embarrassing myself."(Mr DT_1, pers. comm.).

"Computers in this area are not very common. We do not have even a single computer set at this school."(Ms HT_1, pers.comm.)

The researcher observed that some of the mathematics teachers had negative attitude towards the use of computers in teaching mathematics. Two of the mathematics teachers interviewed frowned before responding when they were asked about the use of computers in mathematics teaching. The other teachers blamed the school authorities for not being supportive in sourcing computers for them. Two of the teachers were quoted as follows:

"mmmmm information and communication technology systems do not really work with the students I teach. I do not consider them effective."(Mr ET_1, pers.comm.).

"We have been requesting for laptops to use in the department for a long time now. Nothing has been done for years. We are tired of making the same requests again and again."(Mr FT_1, pers.comm.).

- Inquiry learning

Two of the three teachers who claimed that they used ICT when teaching functions reported that they used ICT when they used the inquiry method of teaching. According to those teachers, inquiry method meant that the teacher gives a mathematics problem to the students and ask them to seek solutions through investigation and online researching. The students could make use of online sites or social media for inquiry purposes. The teachers said that the students could connect with people in the outside community for possible solutions. The teacher's role in this case was that of facilitating the inquiry process. Mr GT_1 explained the strategy as follows:

"At times I ask my students to make use of social media or sites that are online to find solutions to given problems. All I do as their teacher is to give them tasks. In most cases I give each student a different task. The students look for

possible solutions from different sources even from distant people. They use the 'anytime-anywhere' mode of learning. This method is very effective as it ensures that the student looks for his or her own possible solutions to problems. It means the student becomes an active learner."(Mr GT_1, pers.comm.).

6.6.2 Findings from the mathematics teachers' lesson plans

In order to triangulate the data obtained through face to face interviews, the researcher analysed the mathematics teachers' lesson plans. One hundred and twenty six (126) lesson plans were analysed. Table 6.4 shows a summary of the teaching strategies that were employed by the mathematics teachers when teaching functions as obtained from the teachers' lesson plans.

Table 6.4: Summary of the teaching strategies used by the mathematics teachers as found in the teachers' lesson plans (n=126 lessons)

Teaching strategy	Frequency	Percentage
Demonstration	42	33.33%
Illustration	23	18.25%
Exposition	5	3.97%
Problem solving	12	9.53%
Guided discovery	13	10.32%

- Demonstration

In forty-two lessons (33.33%) planned by the teachers, demonstrations were the major teaching method employed by the teachers. Those the lesson plans indicated that the teachers demonstrated how to make calculations from given problems involving functions and how to represent given functions on a two dimensional cartesian plane. Figure 6.1 shows an extract from one of the mathematics teachers' lesson plans.

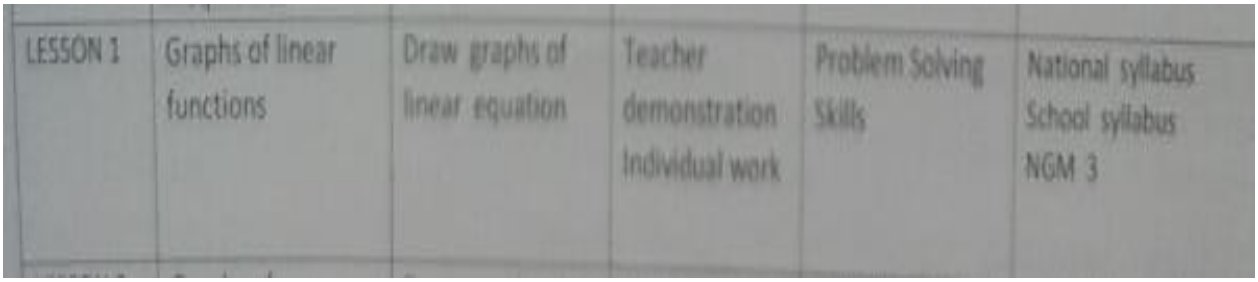


Figure 6.1: An extract of a lesson plan with demonstration as a teaching strategy

- Illustration

Data obtained from the mathematics teachers' lesson plans implied that the teachers also used illustrations when teaching functions. The researcher found that these illustrations were used in twenty- three (18.25%) lessons. One of the lesson plans is shown in Figure 6.2.

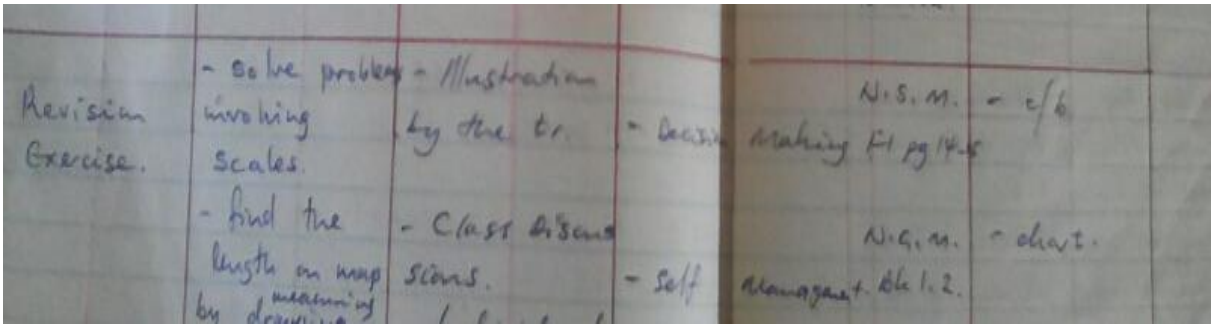


Figure 6.2: An extract of a lesson plan with illustration as a teaching strategy

- Exposition

Another method that was used by the mathematics teachers to teach functions was the expository method. This method entails that the teacher teaches using lectures and students takes notes from the teacher's presentation. The teacher can read texts from textbooks while students listen and take notes. This strategy enables the mathematics teacher to teach many concepts in a short space of time as compared to other teaching strategies. Figure 6.3 shows a lesson plan in which a teacher used expository method for teaching functions.

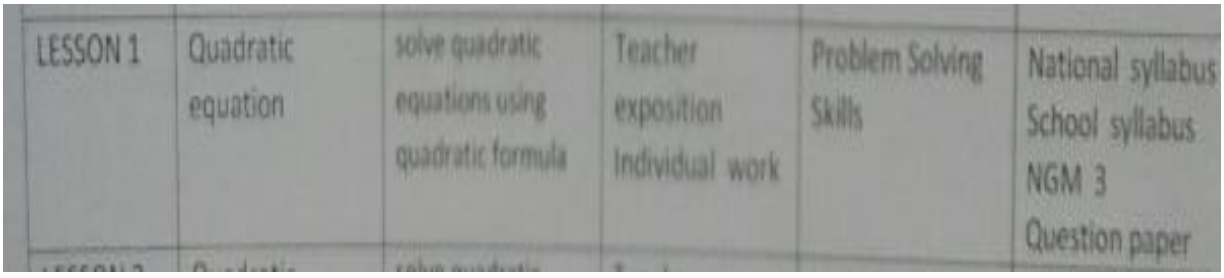


Figure 6.3: An extract of a lesson plan with exposition as a teaching strategy

- Discussion

Discussions were also used by the mathematics teachers as teaching strategy. Data obtained from the teachers' lesson plans revealed that discussions were either held by the students as an entire class or in small groups. In some of the lesson plans, the number of students per group was not specified. However, in more than half of the lesson plans that had discussion as a teaching strategy, the teachers indicated that the students discussed in pairs. Figure 6.4 shows a lesson plan with discussion as a teaching strategy.

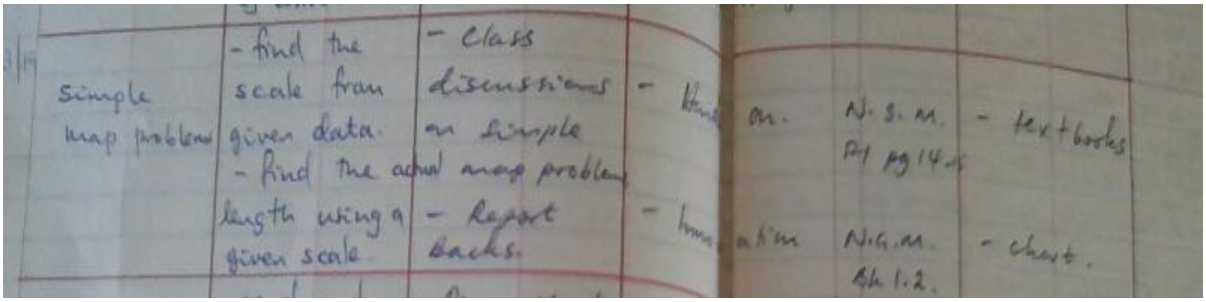


Figure 6.4: An extract of a lesson plan with peer discussions as a teaching strategy

- Problem solving

Twelve of the lesson plans analysed by the researcher had problem solving as a major teaching strategy. Those lesson plans indicated that students were given problems to solve. A lesson plan in which one of the mathematics teachers used problem solving as a teaching strategy is shown in Figure 6.5.

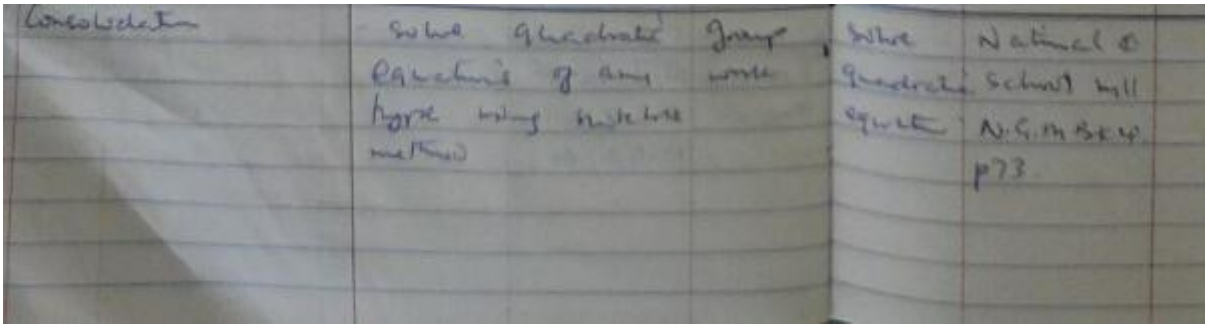


Figure 6.5: An extract of a lesson plan with problem solving as a teaching strategy

- Guided discovery

Guided discovery was also one of the strategies that were used by the mathematics teachers. The teachers used guided discovery in thirteen lessons. Figure 6.6 shows an extract of a lesson in which one of the mathematics teachers used guided discovery as a teaching strategy.

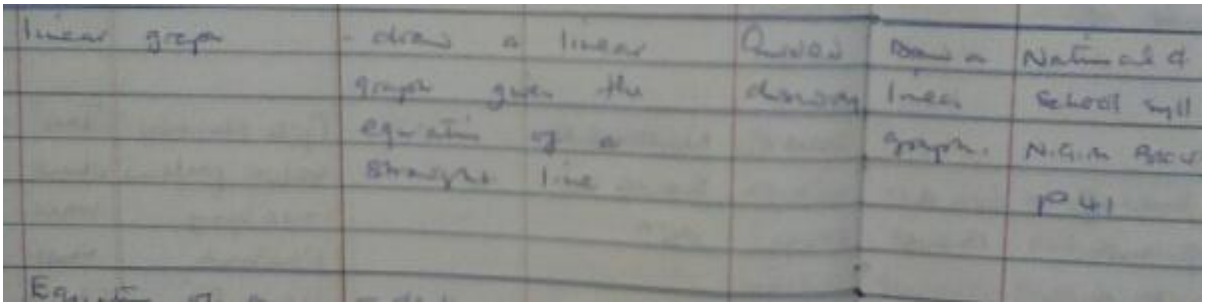


Figure 6.6: An extract of a lesson plan with guided discovery as a teaching strategy

- Group tasks and individual tasks

Data obtained from the mathematics teachers' lesson plans revealed that in fifty-nine (46.83%) lessons, the teachers used individual tasks to teach their students. These tasks were either given to students during lesson time or at the end of the lessons. On the other hand, in forty-seven (37.30%) of the planned lessons, the mathematics teachers allowed their students to work in groups. In some of the cases, the number of students expected to be in these groups was specified. However, the groups were kept small. Pairs or groups of three were used by the teachers. In twenty (15.87%) of the planned lessons, the teachers indicated that they used both individual tasks and group tasks.

6.6.3 Findings on the activities that were done by mathematics students during lessons on functions

Data used in this section were obtained from the participating mathematics teachers' lesson plans and from their students' exercise books. The data revealed that varying activities were done by the mathematics students. A summary of the activities done by the students during lessons on functions is given in Table 6.5.

Table 6.5: Summary of the activities that were done by the students during lessons on functions (n=126 lessons)

Activities done by the mathematics students	frequency	Percentage
Identifying mathematical patterns and relationships	5	3.97%
Applying concepts learnt in solving real life situations	52	41.27%
Drawing ,sketching and plotting graphs of given functions	107	84.92%
Solving non- routine problems	7	5.56%
Solving project-like problems	27	21.43%
Using graphs of functions to make estimations of given variables	7	5.56%
Locating points on Cartesian planes	13	10.32%
Using their own imagination in solving real life problems	6	4.76%
Using logic or mathematical reasoning	5	3.97%

- Identifying mathematical patterns and relationships

The students were given tasks that required them to identify patterns that arose from mathematical calculations. The students were also asked to identify relationships between given variables. Figure 6.6 shows a lesson plan prepared by one of the mathematics teachers with the objective of enabling students to find relationship between points on a plane.

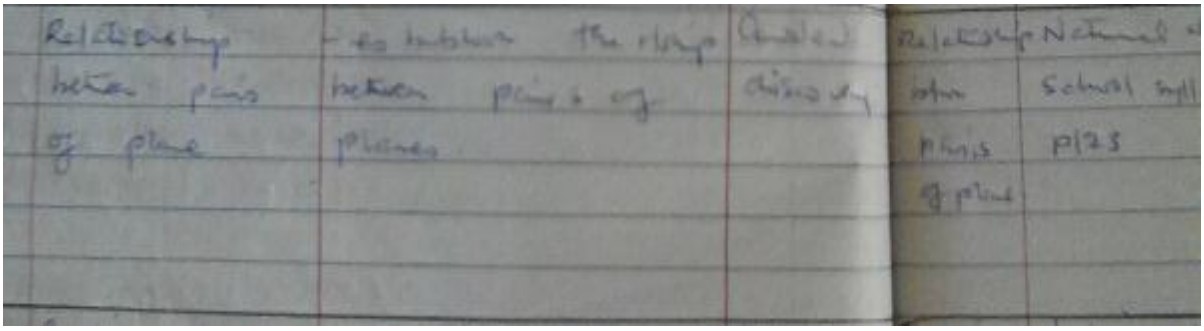


Figure 6.7: An extract of a lesson plan with learning activities that led students into establishing relationship between points on a plane

Mr DT_1's plans of instruction had the following exercise. The researcher observed that the exercise was done by his students. It was found in the students' exercise book.

Draw the graphs of the following functions on graph paper using a scale of 1cm representing 1 unit on both axes for $-5 \leq x \leq 5$ *and* $-5 \leq y \leq 5$

(i) $3x^2 + 4x - 2 = y$

(ii) $-3x^2 + 4x - 2 = y$

Comment on your observation from the two graphs.

Mr DT_1 wanted his students to draw the graphs of the two functions and observe that the coefficient of x^2 determines whether the graph is concave downwards or concave upwards. Most of the students were able to notice that the graph with 3 as coefficient of x^2 was ∪-shaped and the graph with -3 as coefficient of x^2 was ∩-shaped.

- Applying concepts learnt in solving real life problems

In fifty-two of the lessons planned by the mathematics teachers, the researcher found that the teachers gave their students activities that required them to apply concepts learnt on functions in solving real life problems. The following exercise was given by Ms ET_1 to her mathematics students. The exercise was found in the students' exercise books.

> *In order to maintain a balance on his farm, Mr Gotora made sure that the number of goats on his farm is always equal to twice the number of cattle on the farm. Take the number of cattle as x and the number of goats as y.*
>
> *(i) Express the number of goats as a function of the number of cattle*
>
> *(ii) Find the number of goats on the farm if he had 17 cattle.*
>
> *(iii)Find the number of cattle on the farm if he had 32 goats.*

- Drawing, sketching and plotting graphs of functions

The data obtained from the mathematics teachers' lesson plans and from their students' exercise books showed that in one hundred and seven lessons the teachers taught their students to draw, sketch or plot graphs of functions. The students drew graphs of linear, quadratic and cubic functions. Figure 6.7 shows one of the lessons planned by one of the mathematics teachers.

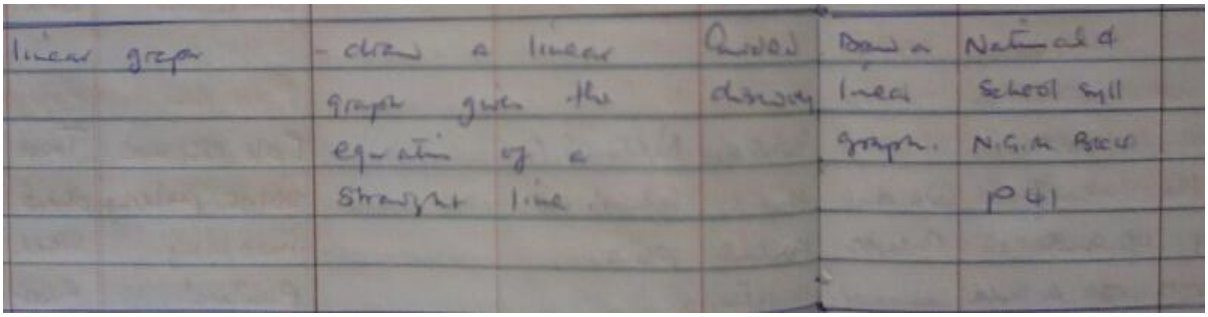


Figure 6.8: An extract of a lesson plan prepared by a teacher who wanted students to draw a graph of a linear function

In another lesson, Mr GT_2's students were asked to perform the following task.

The following is a table of values for $y = x - x^2$ from x= -2 to x=3.

X	*-2*	*-1*	*0*	*1*	*2*	*3*
Y		*-2*		*0*		

(i) Complete the table

(ii) Choose a suitable scale and draw the graph of y= $x - x^2$ for the values of x given in the table.

- Using graphs to estimate variables

The researcher found that in seven of the one hundred and twenty-six lessons that were analysed, the mathematics teachers instructed their students to use graphs to find estimates of given variables. The students were asked to estimate values from both the domain and the co-domain sets. The following is an example of such exercises:

Using a scale of 2 cm to represent 1 unit on both axes draw the graph of $y = 2x^2 + 3x - 1$ from x= -4 to x= 1. Use the graph to find

(i) The minimum value of y

(ii) The value of y when x= 3.5

(iii) The value of x when y=3

- Locating points on Cartesian plane

Some of the mathematics teachers who participated in this study asked their students to locate points on Cartesian plane. The students were either asked to draw graphs of functions and

then locate given points or were given graphs of functions on a graph paper and then were asked to locate points on the graphs. The following exercise was done by Mr AT_1's students.

(a) Draw the graphs of the following functions on the same graph paper.

$$y = \frac{5}{3} - \frac{2}{3}x$$

$$y = 4 - 3x$$

(b) Determine the point of intersection of the graphs on your graph paper. Give the coordinates of the point of intersection.

(c) Hence find the solution of the following system of simultaneous equations

$$3y + 2x = 5$$

$$y + 3x = 4$$

- Solving non routine problems

Data obtained from the students' exercise books revealed that the mathematics teachers used non routine problems as they taught concepts on functions. In seven lesson plans analysed by the researcher, the researcher found that students were given exercises on non routine problems. For instance, Mrs BT_1's lesson plan indicated that she gave the following exercise to her students in one of the lessons she taught.

Many numbers can be written in the form

$$n = x + (x + 1) + (x + 2) + (x + 3) + (x + 4) + \cdots \ldots\ldots\ldots\ldots$$

For example 9= 2+3+4 where x=2 and 10=1+2+3+4 with x=1.

Find the expressions for the following numbers:

12, 13, 15 and 18

The researcher probed some of the mathematics teachers on the use of non routine problems when teaching functions. Twenty one teachers (84%) indicated that they rarely gave non-routine questions to their students. One of the teachers had the following to say:

"Non-routine and project-like questions are time consuming and challenging to our students. I do not think my students are able to solve these questions. I

do not give such problems to my students. However, with the newly introduced curriculum, there is no way out. I have to find time for my students to solve non routine problems."(Mr BT_1, pers.comm.).

- Using logic or mathematical reasoning

Although use of activities that prompted students to use logic in making conclusions was not common in the lesson plans that were analysed, the researcher found that in five of the lessons taught by the teachers, students were exposed to mathematical reasoning. The following example was obtained from exercise books for students taught by Mr CT_2. The teacher was teaching sets as a prerequisite for functions.

Consider $\mathcal{M}$=$\{all\ animals\}$, $\aleph$=$\{snakes\}$ and $\mathbb{D}$=$\{friendly\ animals\}$ .Given that $\mathcal{M}$=$\mathbb{D}\cup\aleph$ and $\mathbb{D}\cap\aleph\neq\emptyset$, what conclusion can you make about snakes?

- Solving project-like problems

Data obtained from the students' exercise books showed that students taught by the mathematics teachers who participated in this study were sometimes given project-like problems. The students were given real life situations in which they were expected to research, for them to get workable solutions to given problems. The following task was given to students by Mr HT_1.

Record sales made by a vegetable vendor at any vegetable stall for a full week. Draw a graph to show the sales against the days of the week. Draw a trend line on the graph. Find the equation of the trend line. Use the line to decide if the vendor's business was improving or not.

6.7 Teaching aids used by the mathematics teachers when teaching functions

This section reports on the teaching aids that were used by the mathematics teachers when they taught functions. The teaching aids were classified as visual, audio, tactile and information and communication technology (ICT).

- Visual teaching aids

Data obtained from the teachers' lesson plans and from face to face interviews revealed that the mathematics teachers used visual teaching aids when they taught functions. The visual teaching aids that were used by the teachers included charts, question strips and chalkboard. As stated in the teachers' lesson plans, the charts used had some diagrams or graphs of functions. Question strips had questions on the concepts learnt. The chalkboard was used for demonstrations. It was also indicated in the lesson plans that the chalkboard was also used for writing instructions and exercises for the students Visual teaching aids were used in ninety-one (72.22%) of the one hundred and twenty- six lesson plans that were analysed by the researcher. The researcher noted that visual teaching aids were the most common type of teaching aids used by the mathematics teachers that participated in this study.

When asked to comment on the type and effectiveness of the teaching aids that he used when teaching functions, one of the teachers said:

> *"Teaching aids like charts and illustrations on the chalkboard are easy to prepare. I prefer using them because they can easily be found in our locality. Although I know that there is need for a variety of teaching aids, the administration at this school does not provide for them, hence we use what is available to us."(Mr* $JT_{1,}$ *pers.comm.).*

Although sixteen (64%) of the mathematics teachers thought that visual teaching aids were very effective when used in teaching functions, five (20%) of the teachers reported that they used visual teaching aids simply because of their availability.

- Audio teaching aids

Only two of the teachers indicated that they sometimes used audio teaching aids. When the researcher asked them to give examples of the audio teaching aids they used when teaching functions, the teachers mentioned audio tapes and radio. The teachers said they made use of audio tapes that they got from the internet. They also said they sometimes instructed their students to listen to radio lessons broadcasted over the radio. One of the teachers said:

"At times my students learn from some tapes that I play for them. I get the tapes from the internet. This form of learning is effective in the sense that my students can learn in my absence. Apart from the tapes, I sometimes make use of radio lessons that are broadcasted between 0900 and 1000 every Wednesday on our national radio station."(Mrs IT_1, pers.comm.).

However, some inconsistencies over the use of audio teaching aids were noted between the data obtained through face to face interviews and the data obtained through document analysis. Data obtained from the mathematics teachers' lesson plans did not show evidence of the use of audio teaching aids. None of the mathematics teachers had planned to use audio teaching aids even though they claimed during face to face interviews that they sometimes used audio teaching aids.

- Tactile teaching aids

Tactile teaching aids refer to teaching aids that teachers or their students can touch and manipulate. These teaching aids include mathematical instruments like rulers, pairs of compass and protractors. The mathematics teachers reported during interviews that they used tactile teaching aids mostly when drawing graphs of functions. Data obtained from the teachers' lesson plans showed that the teachers had planned to use tactile teaching aids in one hundred and seven (84.92%) lessons. One of the teachers had the following to say on the use of tactile teaching aids:

"When drawing diagrams, students mostly use mathematical instruments. They have no choice in most of the cases. They have to use the instruments whether they like it or not. However, most of the students enjoy using drawing instruments as using them does not demand too much reasoning on their part. Drawing makes them active in the learning process." (Mr CT_2, pers.comm.).

- Information and communication technology (ICT) systems

The researcher found that use of information and communication technology systems in teaching mathematics was generally not common among the teachers who took part in this part of the study. The only electronic gadget that was commonly used by students as shown by the teachers' plan of instructions was a scientific calculator. As mentioned before in this

report, only three (12%) of the mathematics teachers claimed that they sometimes used ICT when teaching functions. One of these teachers shared the following statement:

> *"My students enjoy learning through use of computers. I sometimes ask them to use excel to draw graphs. For instance, if you check on the exercise that I gave them on Monday, I asked them to draw bar graphs showing marks they obtained in this month's tests. Each student had to show his or her marks on a bar graph."(Mr TC_3, pers.comm.).*

The researcher observed that in some of the lessons planned by the mathematics teachers, the teachers did not indicate any intension to use teaching aids during their lessons. No teaching aids were indicated in seventeen (13.49%) lesson plans prepared by the teachers who participated in this study.

6.8 How the mathematics teachers assessed their students' progress during lessons on functions

This section reports on how the mathematics teachers used their knowledge of students' learning styles to assess their students' performance during lessons on functions. The teachers reported that they were guided by the requirements of the secondary school mathematics syllabi for forms 1 to 4 developed by the Ministry of Primary and Secondary Education (MOPSE) in Zimbabwe when they assessed their students. The syllabi stated the skills or competencies that were expected to develop in students as they learnt mathematics. The data used in this section were obtained through face to face interviews with the teachers and from the students' exercise books. The data revealed that both formative and summative assessments were done by the mathematics teachers. Formative assessment was done during lessons while summative assessment was done at the end of the teaching period. The teachers made use of daily exercises for formative assessment. Tests and examinations that were given at the end of the term were used as instruments for summative assessment. Table 6.6 shows a summary of the competencies that were assessed by the mathematics teachers and how the teachers assessed these competences.

Table 6.6: Summary of the competencies assessed by the mathematics teachers and how the teachers assessed the competencies

Competency assessed	**Example of the tasks done by the students**	**Learning style catered for**	**Time taken**
Using mathematical symbols, notations, terms and definitions	$suppose\ f(x) = 2x^2 + 3$ $\forall x \in \mathbb{Z}$ 1) Construct a table of values for $-2 \leq x \leq 4$ 2) Using a scale of 2cm representing 2 units on both axes, draw the graph of the function, f(x) for the given values of the domain set. 3) Use the graph to find the coordinates of the turning point of the graph in the form$(x, f(x))$.	Mastery maths learners	25mins
Drawing graphs, plots and sketch diagrams			
Drawing graphs to a given scale		Understanding maths learners	
Interpreting graphs of functions			
Using ICT to solve mathematical problems	Use excel to draw a line graph of the marks that you obtained in the monthly tests in 2018	Understanding maths learners	20mins
Using mathematical formulae, rules, algorithms and procedures	Solve the following equation using the quadratic formula $3x^2 - 5x + 2 = 0$	Mastery maths learners	10 minutes
Identifying mathematical patterns and drawing inferences from the patterns	1. Draw the graphs of $y = mx + 5$ for m=2, m= -2, m=3 and m= -3 using the values of x from -2 to 8 2. Compare and contrast the graphs	Understanding maths learners Mastery maths learners	30minutes

	1. Given $f(x) = ax^2$ a) Draw the graphs of $f(x)$ for the values of x from $-4 \leq x \leq 4$ for each of the cases below. i. $a = 2$ ii. $a = -2$ b) Comment on the shapes of the two graphs.		30minutes
Applying concepts to real life situations	The number of goats on Mr Chitiyo's farm is four less than twice the number of sheep on his farm. (i) Express the number of goats on the farm in terms of the number of sheep. (ii) Find the number of goats if there were 10 sheep on the farm.	Interpersonal maths learners	10minutes
Applying concepts in other learning areas	Imagine you are a statistician and you want to assist a vegetable vendor to decide whether he needs to remain in his business or not. Data collected from the vendor's sales in the first five days indicated that he got the following profit \$3, \$5, \$7, \$9 and \$11 from his business. Fit a model for the profit made by the vendor in relation to the number of days spent in the business.	Interpersonal maths learners	20 minutes
Constructing mathematical models		Self expressive maths learners	
Communicating mathematical ideas clearly	Pick a question strip at random from the box on the table and respond to the instruction on the strip. Explain each step as you make the required calculations.	Self expressive maths learners	
Solving non routine problems	Tendai had a basket of oranges for sale. He sold them to four customers. The	Self expressive maths learners	30minutes

	first customer bought half of Tendai's oranges and half an orange. The second one bought half of the remaining oranges and half of an orange .The third bought half of the remaining oranges and half of an orange. The fourth bought half of the remaining oranges and half of an orange. Tendai had 8 oranges left in the basket. (i) How many oranges did he start with? (ii) How many oranges were bought by each customer?		

The results of this study revealed that the mathematics teachers assessed their students' abilities to comprehend and correctly apply mathematical symbols, terms, notations and definitions. This was found in thirty-seven (29.37%) of the lesson plans analysed by the researcher.

As shown in Table 6.6, students were also assessed on their abilities to draw, plot or sketch graphs of functions. The researcher found that students were asked to draw graphs of linear, quadratic and cubic functions. The graphs were drawn to some scale. The scale was either given or chosen by the students. By giving such exercises, the teachers also tested their students' abilities to use scale in drawing diagrams. The data obtained from the students' exercise books revealed that the teachers also assessed their students' abilities to interpret graphs of functions. The researcher found that the students were instructed to respond to questions that required them to use graphs to find solutions to given problems on functions, for instance, the students were asked to locate some points on graphs or to give coordinates of given points on the graphs. In some of the cases they were asked to identify maximum points, minimum points or points of intersection.

The researcher also found that some of the teachers assessed their students' abilities to use information and communication technology systems in learning functions. However, only three of the teachers used ICT when teaching functions. Data obtained from the students'

exercise books showed that these teachers assessed their students on the use of Excel in drawing graphs of functions.

The teachers proclaimed during face to face interviews that they assessed their students' abilities to follow rules, procedures, algorithms and formulae in solving problems in mathematics. As put forward by the mathematics teachers, the students followed given rules and algorithms and they identified imaging patterns and trends. The students were sometimes required to make some inferences based on the patterns and trends that they observed from their calculations.

The researcher noted that all the mathematics teachers who participated in this study used presentations as a way of assessing their students' ability to communicate ideas. According to the teachers, they gave their students opportunities to present to their peers after group discussions. However, the teachers reiterated that not all students got the opportunity to present to their peers due to lack of time. One of the teachers said:

> *"I allow students to work in groups. This enables them to learn to communicate their ideas to their peers. Due to shortage of time, not all of them get the opportunity to express themselves to their peers. At times I reduce the number of students in a group so that I increase the chances for every student to at least say something during the group discussions."(Mr BT_2.pers.comm.).*

Apart from the competencies given in Table 5.6, the mathematics teachers reported that they also assessed their students' neatness, accuracy in making calculations and ability to perform given tasks within given timeframes. According to the teachers, neatness was assessed in the context of graphs and diagrams that were drawn by the students. Students' accuracy in making calculations was assessed when they performed some calculations in given questions. The following were statements from some of the teachers:

> *"Accuracy is an important aspect in mathematics. I assess this aspect whenever my students make calculations. For instance when they construct a table of values, I always insist on accuracy."(Mr FT_1, pers. comm.).)*

> *"I also assess neatness of the graphs and sketch diagrams drawn by the students. Diagrams should be clear and presentable."(Mr CT_2. pers.comm.).*

"I am very particular about the time my students take to perform given tasks. Time management is very important for my students to pass examinations. However it is a case of being fast and accurate. Calculations must be done accurately especially when constructing tables of values." (Ms CT_1.pers.comm.).

6.9 Discussion

The findings of this study revealed some few inconsistencies in the data obtained through face to face interviews and the data obtained through lesson observations. Although some inconsistencies were observed, the data obtained in this study showed that the mathematics teachers who participated in this study used a variety of teaching strategies when they were teaching mathematics. The teachers made some effort to teach their students according to the students' preferred learning styles.

The study found that the mathematics teachers used both individual and group activities when they taught concepts in mathematics. According to the data obtained from the study, the teachers used small groups which had less than four members. The teachers felt that group discussions were very important in mathematics learning. However, they thought that keeping groups small served to give each student an opportunity to participate in the group activities. In the reviewed literature, the use of group work was supported by a number of learning style theorists. Discussing in groups enabled *interpersonal maths learners* to learn in their preferred way (Perini, Silver and Strong, 2000). According to Perini et al. these *interpersonal maths learners* prefer learning mathematics through discussions with others to performing individual tasks. The use of group work in teaching mathematics was also supported by Kolb (1984). Kolb suggested that teachers use group work in order to assist *divergers.* According to Kolb *divergers* learn better when they discuss with their peers in groups. Honey and Mumford also supported the use of group work by stating that *activists* and *reflectors* enjoy working in groups. According to Honey and Mumford, *activists* actual enjoy to be the group leaders in the group discussions. *Reflectors* enjoy working in pairs, interviewing each other and getting feedback from their colleagues.

Although all the mathematics teachers indicated that they used group discussions as a teaching strategy, the researcher observed that data obtained through analysis of their lesson plans revealed that the mathematics teachers rarely used group discussions in their lessons. When asked to explain on the effectiveness of group discussions in mathematics teaching,

one of the mathematics teachers stated that it was not possible to use group discussions in all lessons due to lack of time. The teacher explained that using group work required time for students to discuss and give feedback. According to the teacher, the time allocated for their maths lessons was not enough to allow them to use group work regularly. The researcher's observation concerning the use of group work by the mathematics teachers in this study was in contrary to a report by Umugiraneza and Bansilal (2017) who reported that cooperative learning was the mostly used method in mathematics teaching. The results obtained by the researchers were partly agreeing with those obtained by Nziramasanga, Malaba, Kachingwe and Gerbeck (1999). Nziramasanga et al. found that teachers in Zimbabwe used teacher-centred approaches like lecture method in their lessons.

As observed in this study, in the cases where students were allowed to interact, they were then given some individual work after the group discussions. Giving students individual tasks to perform was in line with suggestions given by Kolb (1984), Honey and Mumford (1992) and Perini, Silver and Strong (2000). According to Perini et al, *understanding maths learners* have difficulties in working with other. Therefore the best teaching strategy suitable for those students is giving them tasks to perform as individuals. Perini emphasised on the use of individual tasks by affirming that *understanding maths learners* learn better if they learn as individuals than in groups while *interpersonal maths learners* learn better in groups than as individuals. Kolb suggested that individual work was suitable for two groups of learners. The two groups were the *assimilators* and the *accommodators. Assimilators* enjoy working on their own doing some independent researches. *Accommodators* prefer exploring new experiences through doing some experiments in a trial and error way.

This study revealed that the mathematics teachers sometimes used demonstrations and illustrations when they taught concepts in mathematics. This was confirmed by the data obtained from face to face interviews and from an analysis of the teachers' lesson plans. All the teachers used demonstrations and they believed that demonstrations, done by either the teachers or some of the students, were very effective in giving their students some directions. Use of demonstrations and illustrations as a way of teaching students according to their learning styles was supported by some scholars found in the reviewed literature. Honey and Mumford (1992) found demonstrations helpful to a group of students called *reflectors*. As expressed by Honey and Mumford, *reflectors* grasp mathematics concepts better if they are allowed to follow demonstrations done to them. Kolb (1984) also supported the use of

demonstrations and illustrations by reiterating that apart from discussing in groups *assimilators* prefer following demonstrations.

Problem solving was another common approach that the mathematics teachers reported using in teaching mathematics. The data obtained from the mathematics teachers revealed that with this approach, the mathematics teachers gave their students a problem and then they asked them to look for possible solutions to the problem. Perini et al also advocated for the use of the problem solving approach to mathematics teaching. According to Perini et al. problem solving was ideal for *interpersonal maths students*. This was also supported by Honey and Mumford who thought *pragmatists* can also be taught using the problem solving approach.

Other teaching approaches that were used by the mathematics teachers when they tried to vary their teaching approaches in order to cater for the different learning styles of their students included inquiry and guided discovery approaches. The reviewed literature on the learning style approaches to mathematics teaching did not give any details on these teaching strategies. The mathematics teachers who participated in this study however, felt that the inquiry and guided discovery strategies were useful in ensuring that their students grasp concepts in mathematics. One of the teachers felt that the inquiry method could be combined with the use of information and communication technology systems. According to the teacher, students could look for solutions to problems using ICT gadgets.

Data obtained from the students' exercise books revealed that the students performed a variety of activities that were meant to develop different skills in them. The activities that were done by the students were in line with the requirements of the Ministry of Primary and Secondary Education Mathematics Syllabus in Zimbabwe for Forms 1-4 (2015). The syllabus stipulated that by the end of the learning period, students were supposed to be able to draw and interpret tables, graphs, charts and diagrams accurately. The results of this study showed that the students drew graphs of functions on graph paper. They were also instructed to use the graphs to locate given points. In some of the cases, the students were asked to identify patterns that imaged from the graphs they drew. Such exercises were suitable for *understanding maths* learners as suggested by Perini et al (2000). According to Perini et al. (2000), *understanding maths* students prefer learning by identifying patterns in mathematical concepts. However, the results of the study revealed that only 3.97% of the lessons planned by the mathematics teachers gave these students an opportunity to identify patterns.

The Ministry of Primary and Secondary Education Mathematics syllabus in Zimbabwe also required students to solve non-routine problems. This requirement was supported by Perini, silver and Strong (2000). According to Perini et al., s*elf-expressive maths learners* prefer solving non routine. Those students' abilities to explore different alternatives to solve problems in mathematics enable them to solve non-routine problems. *Self-expressive maths* learners are not good at using mathematical formulae since they normally use hunch and guessing when solving problems in mathematics. However, the results of this study revealed that only seven (5.56%) of the mathematics lesson plans analysed had activities that required students to solve non-routine problems. In the researcher's opinion, this was a disservice to *self-expressive maths* students. They required more practice by being given an opportunity to solve non-routine tasks.

The researcher found from the students' exercise books that the students were given problems that were drawn from real life situations, for example, the task in which students solved a problem at Mr Gotora's farm. The use of problems drawn from real life situations was in line with the suggestions given by Mangwende and Maharaj (2018) who suggested that *interpersonal maths* students should be given problems that are drawn from real life situations since those students judge mathematics learning by its potential in helping people. Perini, Silver and Strong (2000) as well as Honey and Mumford (1992) also supported the use of learning activities which are drawn from real life situations. According to Perini et al. problems drawn from real life situations are suitable for *interpersonal maths students* and *understanding maths students*. *Understanding maths students* always seek to find how concepts learnt work in practice. They understand concepts better if they are used in situations that relate to real life. *Interpersonal maths students* value mathematics by its ability to assist in solving real life problems. As a result, in order to keep them on board they need to be guided on how the concepts they learn can assist in solving problems in people' lives. Honey and Mumford on the other hand suggested that *pragmatists* are students who always want to find the practical application of mathematics concepts. To them, problems that have real life application are more useful to solve than any other problems.

As found in this study, activities which required students to use logic or gather evidence to prove or explain concepts were not commonly done by the students. This was against suggestions given by McTighe and Silver (2019). McTighe and Silver found that

understanding maths learners grasp mathematics concepts better if they are allowed to use their logic to prove how and why concepts work practically. From the researcher's point of view, more exercises that required the use of logic could have been given to the students in order to assist the understanding maths learners to comprehend the concepts learnt. Apart from proving concepts, *understanding maths* students needed an opportunity to analyse and criticise each other's thoughts. That means their exposure to group discussions was essential as this gave them an opportunity to make critics on the ideas from their colleagues.

In this study, the researcher found out that the mathematics teachers gave their students some projects to do when they learnt mathematics concepts. According to some learning style theorists, use of projects was very important as it enabled the students to realise that learning is not only confined to the four walls of the classroom (Honey & Mumford, 1992, Kolb, 1984). From my point of view, projects were also helpful in bringing in the real life aspect of mathematics learning since projects require students to get data from real life situations and use it to solve given problems. Those suggestions were aligned with the suggestions of Perini, Silver and Strong (2000) who intimated that project-like problems enable *self expressive maths* learners to grasp mathematics concepts well. According to Perini et al., project-like problems affords *self expressive maths* learners an opportunity to look for different alternatives to problem solving. Kolb (1984) also supported the use of projects in teaching mathematics when he suggested that teachers give their students opportunities to do some independent research projects. According to Kolb, a class of students who fall under a group referred to as *assimilators* enjoy doing projects that involve performing some mathematical researches. Adding on to the importance of using projects in mathematics teaching, Honey and Mumford reiterated that *theorists* enjoy gathering facts and data. As a result Honey and Mumford suggested that, for the sake of the students who fall under a group of *theorists*, teachers give their students some projects that require the students to gather data.

The reviewed literature indicated that Tinker (2017) found that computer software packages like Stella were commonly used in schools in United States of America in mathematics teaching. Those findings by Tinker were in contrast with what was found in this current study, in Zimbabwe. Use of information and communication technology (ICT) systems was not common in Zimbabwe, the area in which this study was done. Only three of the mathematics teachers who participated in this study reported that they used computer software when teaching mathematics. The most common electronic gadget that was used by

the mathematics teachers in their lessons was an electronic calculator which was used in rare cases. Similar results were obtained by Agyei and Voogt (2010) in Ghana. Agyei and Voogt observed that mathematics teachers in Ghana did not use computer software in mathematics teaching. The limited use of ICT systems had negative effect on the performance of mathematics students (Mohanty, 2011). Mohanty argued that using ICT systems in mathematics teaching had many benefits to the students and the teachers. In this study, different reasons were given by the mathematics teachers for not using computers in mathematics teaching. The most common ones were shortage of computer related equipment and computer illiteracy on the part of the mathematics teachers. Other reasons given by the teachers were shortage of time, lack of support from school authorities and negative attitude towards use of computers held by the mathematics teachers. However, the researcher realised that most of the reasons were teacher related.

An analysis of the teaching aids that were used by the mathematics teachers revealed that in most of the lessons taught by the teachers who took part in this study, the teachers used tactile teaching aids. These tactile teaching aids were mostly drawing tools that were used by the students for drawing graphs, plots and sketches. The tools included rulers and set squares. Tactile teaching aids were used in one hundred and seven lessons (84.92%). Visual teaching aids were also commonly used by the mathematics teachers. These included charts with graphs, chalkboard with illustrations and strips of paper with questions. Visual teaching aids were fairly utilized by the teachers. They were used in ninety one (72.22%) of the lessons taught by the mathematics teachers. The researcher found, however, that audio teaching aids were not commonly used by the mathematics teachers. These were used in only two lessons. The teaching aids used by the mathematics teachers were partly in line with suggestions given by Moore (2012). Moore suggested that the mathematics teachers should use manipulatives when teaching concepts in mathematics. White (2012) supported the suggestion by saying manipulatives like drawing instruments create more concrete representations of mathematical concepts in the students. Moore went on to also suggest that the teachers use ICT and games. Moore thought that games enhance mathematical thinking in most of the students despite their learning styles. However, data obtained from the teachers' lesson plans showed that none of the teachers who participated in this study utilised mathematics games when teaching mathematics. The researcher also found that in some of the lessons that the mathematics teachers who took part in this study planned to teach, no teaching aids were utilised. In the researcher' point of view, the mathematics teachers did not

consider the learning styles of their students in the cases in which they did not use teaching aids. Their lesson planning in those cases was not student-centred. Dasari (2006) emphasised on the need to use relevant teaching aids by stating that aligning teaching tools with students' learning styles ensures that students retain the new information learnt for a longer time.

According to the data obtained in this study, the mathematics teachers used both formative and summative assessment methods to check on the progress of their students during mathematics learning. Formative assessment informed the teachers on the areas that the students needed more help from the teachers while summative assessment was mostly used for the grading of the students. The mathematics teachers' views were aligned to those of Boaler (2016) who emphasised on the use of formative assessment as a way of identifying the students' weak and strong learning areas by reiterating that mathematics teachers should assess their students so that they use the mistakes made by the students as a spring board to successful learning. The teachers who took part in this study assessed different competencies in the students. The assessment was guided by the requirements of the Ministry of Primary and Secondary Education Mathematics Syllabus in Zimbabwe for forms 1 to 4 (2015). The competencies that were stipulated in the mathematics syllabus were partly in line with the suggestions given by Perini et al. (2000) on the activities that are suitable for mathematics learners. Among other competencies, the teachers assessed their students' abilities to use mathematical symbols, terms, notations and formulae. By assessing the use of formulae and mathematical algorithms, the teachers catered for *mastery maths* students. Although the mathematics teachers could have done it unknowingly, their assessment items were in line with the suggestions given by Perini et al. who stated that *mastery maths* learners prefer applying mathematical formulae, rules and symbols and algorithms. Some of the assessment items used by the mathematics teachers assessed the students' competencies in drawing graphs of functions and using the graphs to answer questions that required them to interpret the graphs. These items were meant to cater for *understanding maths* learners. According to Perini et al., *understanding maths* students are always interested in getting the logic behind mathematical concepts. They always seek explanations for the existence and authenticity of mathematical concepts hence giving them an opportunity to interpret graphs helps them to understand how graph work in practice.

The mathematics teachers also assessed their students' abilities to apply concepts learnt to real life situations. This assessment was very important for *interpersonal maths* learners since

such students always link mathematics learning with people's lives (Mangwende & Maharaj, 2018). Applying mathematics concepts to real life situations meant that the students would make some inferences to the real world after learning a mathematical concept. Making inferences sometimes involved using logic. Use of logic was ideal for *understanding maths* students as stated by Perini et al.(2000). Application of mathematics concepts to real life situations helped the teachers to integrate mathematics with other learning areas. The mathematics teachers also used assessment items that tested how the students applied concepts learnt in mathematics to other learning areas. These areas included Statistics. Application of mathematics to other learning areas and to real life situations was meant for *interpersonal maths* students. It helped the students to understand that mathematics is a useful tool in life and is applicable in various aspects of people's lives.

The data obtained also revealed that the teachers also tested the students' abilities to formulate mathematical models from the concepts learnt. Such activities were in line with the suggestions by Perini et al. (2000). They were meant to assess *self-expressive math*s students. In addition to construction of mathematical models, s*elf-expressive maths* students were challenged further when the teachers included non-routine problems in the test items. *Self-expressive maths* learners were also given tasks that required them to express themselves clearly to the teachers and to their peers as they communicate mathematical ideas.

As explained earlier in this report, some of the mathematics teachers assessed their students' skills in using information and communication (ICT) systems. However, as shown by the data obtained in this study, these skills were rarely tested. Various reasons were given by the mathematics teachers for their failure to assess ICT skills.

The results of the study showed that the strategies and activities used by the teachers in mathematics teaching varied from teacher to teacher and from school to school. The researcher also observed that the individual teachers' teaching strategies were biased towards certain classes of learners. The lessons taught by the mathematics teachers who participated in this study were not balanced since no single lesson was found to be catering for all the classes of learners. Mkonto (2015) emphasised the need for mathematics teachers to maintain a balanced strategy when they teach mathematics. According to Mkonto, a teaching strategy is balanced if it accommodates various learning styles in a single lesson. In phase one of this study, it was found that the mathematics teachers had basic knowledge of students' learning styles, therefore it was expected that their lessons could be balanced by ensuring that the

learning styles of the students could be accommodated in order to keep all of them active. Solvie and Sungur (2012) also thought that the teachers' knowledge of students' learning styles could enable them to assess their students in ways that match the learning styles of the students. From the researcher's point of view, the teachers' failure to effectively utilize their knowledge of students' learning styles could be caused by some barriers that impinged on their work.

The results of this study revealed that although the mathematics teachers could believe that their students had different learning styles, the mathematics teachers did not use standard tools to assess their students' learning styles. According to the literature reviewed, standard assessment tools can be used to assess the learning styles of the students. The tools include Kolb's learning styles inventory (LSI) and Honey and Mumford learning style questionnaire. In the researcher's opinion, it was important for the mathematics teachers to make use of the standard assessment tools so that they could classify their students according to their learning styles. The classification could assist the teachers to establish the number of their students who belonged to particular learning style group. The knowledge could be used by the teachers in lesson preparations. Boaler (2016) even suggested that the teachers assess the learning styles of the students regularly so as to find changes in the ways the students learn. According to Boaler, continuous assessment of students' learning styles ensures that the teacher makes sure that his or her teaching strategies are always tailored to meet the learning styles of the students.

6.10 Implications of the study findings to mathematics teachers

The results of this study have the following implications to the mathematics teachers:

(i) When teaching concepts in mathematics, teachers should use both group activities and individual tasks. Group activities enable students to learn to clearly express their mathematical ideas and views. *Interpersonal maths* students and *self expressive* students learn better if they are given an opportunity to interact in groups. Individual tasks assist students to develop independent decision making skills. *Mastery maths* students and *understanding maths* students learn better if they perform individual tasks.

(ii) Strategies and activities used in mathematics teaching should be varied so that all students benefit from the teacher's instruction despite their learning styles.

(iii) Mathematics teachers should include non routine questions in their assessment tests. This study exposed that the mathematics teachers who participated in this study did not effectively use non routine problems as they taught functions. This was a setback to *self expressive maths* learners.

(iv) Mathematics teachers should allow their students to use their own imagination or to carry out independent research. Projects-like tasks are of great importance to mathematics students. These tasks allow them to consider different alternatives in problem solving.

(v) Mathematics teachers should make use of information and communication technology systems when teaching mathematics. If the teachers are not computer literate, they should be in-serviced so that they know how mathematics learning and ICT can be integrated.

(vi) Test items should be varied so that they assess all students fairly despite their learning styles. Test items that require students to use specific algorithms or formulae are good only for *mastery maths* learners.

6.11 Chapter summary

This chapter discussed on the results of the stage two of the study. The chapter started by outlining the research question that guided this part of the study. In this phase of the study the researcher wanted to find out how secondary school mathematics teachers used their knowledge of students' learning styles when teaching functions. In order to carry out the study, the research question was split into three sub questions. Twenty five secondary school mathematics teachers participated in the study. Those were eight female and seventeen male teachers who were all qualified and experienced to teach mathematics at secondary school level. In this chapter, the researcher gave a report of the strategies that were used by the mathematics teachers when they were teaching functions. Data obtained through face to face interviews, the teachers' lesson plans and from the students' exercise books were analysed separately for triangulation purposes. The researcher went further to report on the teaching aids that were used by the teachers in the mathematics lessons. A report on the assessment strategies employed by the teachers was also given. This was followed by a discussion on the findings. The last section of this chapter gave an outline of the implications of the results of this phase of the study to a mathematics teacher.

CHAPTER 7

FINDINGS AND ANALYSIS OF THE BARRIERS TO THE MATHEMATICS TEACHERS' USE OF THEIR KNOWLEDGE OF STUDENTS' LEARNING STYLES IN MATHEMATICS TEACHING

7.1 Introduction

This chapter reports on the barriers that affected mathematics teachers' effective use of their knowledge of their students' learning styles in mathematics teaching. The chapter starts with an outline of the research question and the research sub questions that guided this phase of the study. It goes on to give a brief description of the mathematics teachers who participated in this phase of the study. Eight female and seven male teachers took part in this phase of the study. A brief explanation on the instruments that were used to obtain data from the participants is given. Face to face semi structured interviews and lesson observations were used to obtain the required data from mathematics teachers. The results of the study are reported under teacher related barriers, students related barriers, curriculum related barriers and socio-economic barriers. After a report on the results, the researcher provides a discussion of the results. The chapter is then concluded with an outline of the implications of the findings of this phase of the study to mathematics teachers and to policy makers in general.

7.2 Research question

This phase of the study was guided by the following research question:

- How do barriers impact on mathematics teachers' effective use of their knowledge of their students' learning styles when teaching mathematics?

In order to provide an answer to the research question, four sub-questions were formulated from the research question given above. The sub questions were:

(1) What are the teacher related barriers and how do they impact on the mathematics teachers' use of their knowledge of students' learning styles when teaching mathematics?
(2) What are the student related barriers and how do they impact on the mathematics teachers' use of their knowledge of students' learning styles when teaching mathematics?
(3) What are the curriculum related barriers and how do they impact on the mathematics teachers' use of their knowledge of students' learning styles when teaching mathematics?

(4) What are the socio-economic barriers and how do they impact on the mathematics teachers' use of their knowledge of students' learning styles when teaching mathematics?

7.3 The research participants

Fifteen secondary school mathematics teachers comprising eight females and seven males gave their consent to participate and they took part in this phase of the study. All of those mathematics teachers were fully qualified and had useful experience in teaching mathematics at secondary school level. Table 7.1 shows the demographic information of the mathematics teachers who participated in this phase of the study.

Table 7.1: Demographic information of the teachers who participated in phase three of the study (n=15)

Sex	**Teaching experience in full years**			**Highest professional qualification**		
	Less than 5	Between 5 and 10	More than 10	Diploma	Bachelor' degree	Master's degree
Females	1	1	6	4	4	0
Males	1	3	3	2	3	2
Total	2	4	9	6	7	2

7.4 Data collection and analysis

Data used in this phase of the study were collected through face to face semi structured interviews and from lesson observations. Fifteen lessons taught by the mathematics teachers were observed. An observation checklist was prepared in advance and it guided the researcher during the lesson observations. The observation checklist or guide used in this phase is given in appendix 15. An interview guide that guided the interviewer during face to face semi structured interviews is given in appendix 19. In each section on research findings, a summary of the data obtained from the mathematics teachers was presented in table form and a detailed explanation of the points presented in the table was given. The analysis of the data was supported by statements that were quoted directly from the mathematics teachers.

7.5 Sub question 1: Teacher related barriers that affected the secondary school mathematics teachers' use of their knowledge of students' learning styles when teaching mathematics

This section presents on the barriers that were related to the secondary school mathematics teachers' pedagogical skills and personal attributes.

7.5.1 Data obtained from face to face semi structured interviews

The secondary school mathematics teachers revealed a number of barriers that were related to their teaching skills and personalities as mathematics teachers. Table 7.2 gives a summary of the teacher related barriers and how they affected the mathematics teachers' use of their knowledge of students' learning styles in mathematics teaching.

Table 7.2: Teacher related barriers and how they affected the mathematics teachers' effective use of their knowledge of their students' learning styles in teaching mathematics (n=15 teachers)

Teacher related barriers	Effects of the barriers on the teachers' use of students' learning styles	Frequency	Percentage
Lack of exposure	Teachers could not keep pace with the dynamic world of technology and mathematics teaching	3	20%
Lack of experience	Teachers' abilities to use variety of teaching strategies to meet the demands of the varying learning styles of the students were limited	5	33.33%
Lack of in-service training and self advancement	Teachers failed to match their teaching styles with the learning styles of their modern students. Teachers rely on traditional teaching methods.	7	46.67%
Lack of subject content knowledge	Teachers relied on textbooks for subject content knowledge and they failed to match the subject content with the students' learning styles.	7	46.67%
The teachers' own learning styles	The teachers disregarded their students' learning styles and taught in ways which they preferred being taught.	3	20%
Failure to integrate mathematics and other learning areas	Students who preferred solving problems linked to real life situations were disadvantaged.	3	20%

Failure to link mathematics concepts	Concepts learnt became too abstract for the students. Only those talented to learn from abstract could grasp the concepts	5	33.33%
Unfavourable relationship between mathematics teachers and their students	No free exchange of ideas between mathematics teachers and their students. Students feared their teachers to an extent of failing to seek assistance from them.	6	40%
Failure by the mathematics teachers to assess the learning styles of their students	Mismatches existed between the mathematics teachers' teaching styles and their students' learning styles.	3	20%
Lack of commitment to work by the mathematics teachers	The mathematics teachers lacked patience to individualise or differentiate their teaching strategies in order to meet the demands of their students.	7	46.67%
Lack of collaboration among the mathematics teachers	No cross pollination of ideas among the mathematics teachers on how best they could assist their students.	9	60%

- Lack of exposure by the mathematics teachers

Three mathematics teachers (20%) who participated in this study pointed out that lack of exposure on the part of the mathematics teachers was a barrier that affected their effective use of their knowledge of students' learning styles in mathematics teaching. According to the participating mathematics teachers, mathematics teachers needed to be exposed to different teaching environments in which they meet different students with different learning styles. As they get into the different environments they share ideas with their colleagues in those environments. The mathematics teachers thought that exposure to different teaching environments could equip them with skills that were essential in enabling them to

differentiate their teaching strategies so that they suit the different learning styles of their students. One of the mathematics teachers who had this view had the following to say:

> *"Travelling to different places is vital for us as mathematics teachers. There is need for teachers to visit their colleagues at other schools for them to learn from the ways they do things. Staying at one station for a long time without seeing how others work is not good for a mathematics teacher. There is a possibility of repeating the same ways of teaching for years when they could have been overtaken by events. Business visits by teachers should be encouraged among teachers."(Mrs, CT_2, pers.comm.).*

- Lack of teaching experience

According to the mathematics teachers, lack of teaching experience was one of the barriers that affected them when they used their knowledge of students' learning styles in mathematics teaching. Five of the mathematics teachers who participated in this study had this feeling. The teachers thought that they needed more teaching experience for them to be able to differentiate their teaching strategies so that each student was taught in his or her learning preference. One of the mathematics teachers who had this feeling shared the following statement during a face to face interview session:

> *"Teaching each student according to his or her learning preference requires a teacher to be well experienced in working with students of different capabilities. Novice teachers face challenges." (Mr HT_1, pers.comm.).*

- Lack of in-service training and lack of self advancement

Data obtained from the mathematics teachers revealed that they felt that lack of self advancement and lack of in-service courses affected their use of students' learning styles in mathematics teaching. The teachers argued that they needed to keep pace with current trends in mathematics teaching. They thought attending some in-service courses would equip them with skills needed to assess their students and teach them according to their learning styles. To these teachers, their students required modern strategies of teaching. They thought that their teaching styles did not match the students' learning styles hence there was need for them to develop their teaching skills. The following argument was shared by one of the mathematics teachers:

> *"Researchers are busy carrying out studies on how best mathematics can be taught. New discoveries are made every day. If we do not develop and equip ourselves with knowledge on current trends in mathematics teaching, it will always be difficult for us to teach these students in the required way. Our students are different from yesterday's students. We need to leave our traditional ways of teaching and move with time. Regular attendance to some in-service courses is important."(Mr GT_2, pers.comm.).*

Mr GT_2 went further to give the following explanation on why he thought his students needed special attention as compared to the students he taught before them. The following was his explanation:

> *"I believe that the way one is socialised shapes one's learning style. As a result, the way we are socialising our children today is different from the way we were socialised during our time, so what it means is that the way I prefer being taught is quite different from the way my child prefers being taught. I noticed over the years that the learning styles of the students I used to teach and those of the students I am teaching now are slightly different. For instance my current students do not like long lectures they enjoy making discoveries on their own."(Mr GT_2, pers.comm.).*

- Lack of subject content knowledge

Seven of the mathematics teachers (46.67%) believed that lack of subject content knowledge on the part of the mathematics teachers was one of the barriers that affected them from effectively utilizing their knowledge of their students' learning styles when teaching mathematics. One of the teachers thought that teachers who lacked basic content knowledge over relied on sources like textbooks. However, according to those mathematics teachers, the content that teachers got from textbooks was not suitable for all their students. The teachers suggested that mathematics teachers be knowledgeable in their subject area so that they become flexible when using examples found in their local environment. According to the teachers, students understand concepts better if the examples that teachers use in their lessons are drawn from situations that are known to the students. It assists students to link new knowledge with existing knowledge in them. One of the teachers illustrated this point by saying that a student in a farming community learns better from questions drawn from a

farming community while a student from an urban setting learns better if the teacher uses questions drawn from an urban setting. Mr AT_3 explained the point as follows:

> *"If a mathematics teacher lacks required knowledge on mathematics concepts, it can be difficult for the teacher to be flexible in using a variety of teaching strategies. Knowledge of the subject reduces over reliance on textbooks. Textbooks were prepared for all students despite their learning styles. It is the duty of the teachers to select the content suitable for their students and add more flesh to the content so that all students benefit from the learning process. Textbooks should only be used as guide by the mathematics teacher. Otherwise the teacher should link mathematics concepts with the students' daily experiences at home and at school. It makes learning easier for most of them. However it cannot be possible if the teacher's knowledge is limited."(Mr AT_3, pers.comm.).*

- The teacher's own learning style

Some of the mathematics teachers thought that their own learning styles affected the way they taught their students. Three (20%) of the teachers had that opinion. Those teachers thought that it takes some expertise and experience for a mathematics teacher to disregard his or her own learning style and teach his or her students according to their learning styles. Two of the mathematics teachers who participated in this study went further to explain that the way they were taught by their teachers had an effect on the way they taught their students. According to those participants, it was unfortunate for students whose learning styles were different from their teacher's since it is likely that a mismatch existed between the way the teachers taught their students and the way the students preferred being taught. The teachers thought the mismatches that resulted led into learning problems in students. The following statement came from one of the mathematics teachers:

> *"Most teachers teach in ways they prefer being taught themselves or in ways they were taught by their teachers. In my opinion this is a source of a problem in mathematics teaching. If I teach students according to my own learning styles I will be in-sensitive to my students' needs. Those who match my learning style will be fortunate. I believe that it is the reason why some students like certain teachers and hate others."(Ms DT_2, pers.comm.).*

- Failure to integrate mathematics with other learning areas

Data obtained from the interviews held with the mathematics teachers revealed that three (20%) of the mathematics teachers felt that if mathematics teachers fail to integrate mathematics with other learning areas, teaching students' according to their learning styles becomes a problem to them. According to this group of teachers, mathematics should be integrated with other learning areas so that students' learning styles can be fully utilised. Ms AT_1 was one of the teachers who had this feeling and she had the following to say:

> *"Mathematics should not be taught in isolation. A teacher who lacks this knowledge can hardly teach according to the students' learning styles."(Ms AT_1, pers.comm.).*

The interviewer asked Ms AT_1 to explain her point further by means of examples. She continued as follows:

> *"I mean to say that mathematics teachers should make use of skills learnt by students in other learning areas. For instance a teacher can link mathematics and Agriculture by asking students to calculate perimeter or area of a garden plot. Instead of teaching perimeter in abstract sense, students can be asked to measure and then use the dimensions to calculate perimeter or area as required by the teacher."(Ms AT_1, pers.comm.).*

- Unfavourable relationship between mathematics teachers and their students

The existence of an unfavourable relationship between mathematics teachers and their students was believed by some of the mathematics teachers as one of the barriers that affected their effective use of their knowledge of their students 'learning styles in mathematics teaching. Six of the mathematics teachers who took part in this research had this opinion. Those six teachers thought that if a bad relationship exists between the teacher and his or her students then the students are not free to seek help from the teacher. According to the mathematics teachers, bad relationship between the teacher and the students makes it difficult for the teacher to effectively assist students. It compromises communication between the two parties. Students fail to open up to the teacher if they face problems. The mathematics teachers felt that for teachers to effectively teach their students according to their learning styles, they need to create friendly learning environments in which all students feel safe, free and loved. One of the teachers said;

"Lack of student friendliness bars students from seeking help from their teachers. That is one of the barriers which affect us when we try to effectively utilise our knowledge of students' learning styles. We need to create classroom environments that are friendly to all students so that all of them open up to us and become free to learn."(Mr BT_1, pers.comm.).

- Failure to assess students' learning styles

Some of the mathematics teachers who participated in this study believed that failure by some of their counterparts to assess students' learning styles was a barrier to their use of students' learning styles in teaching mathematics. The teachers reported that some of their counterparts failed to assess their students' learning styles due to various reasons which included lack of sound knowledge of the students' personalities and learning habits. Another reason given by the teachers was use of ineffective assessment methods by the mathematics teachers. The teachers thought that if ineffective assessment methods are used by teachers, students can be classified into wrong learning style classes. The following is a response from one of the mathematics teachers shared during an interview session:

"Teachers who are unable to rightful assess their students' learning styles often face problems when they intend to teach their students according to their learning styles. This is normally caused by using diagnostic test items which do not effectively test the learners' styles of learning or which are not varied enough to test different skills in the learners. Teachers may think they know their students when in fact they do not know them."(Mr BT_1, pers.comm.).

- Lack of commitment to work and negative attitude towards work

Seven (46.67%) of the mathematics teachers thought that lack of commitment to work affected their use of their knowledge of students' learning styles in mathematics teaching. According to the teachers, lack of commitment by the mathematics teachers resulted in them teaching their students for the sake of teaching. Such teachers did not mind if their students failed to perform according to set standards. No effort was made in differentiating teaching instruction. As expressed by the teachers, some of them lacked patience to consider students' learning styles and assist them to learn. The teachers who raised this point thought that teaching students according to their learning styles required a lot of patience by the teacher. However, such patience was hard to find in some of the mathematics teachers. They were not

prepared to go an extra mile in assisting their students. The mathematics teachers who participated in this study linked the teacher's commitment to work with their attitude towards work. Those with negative attitude towards work were not committed to work. The following is a statement from one of the mathematics teachers:

> *"Teaching students according to their learning styles calls for patience on the part of the mathematics teacher. However some of our colleagues are not really committed to work. They teach mathematics without their students at heart."(Mrs AT_1, pers.comm.).*

- Lack of collaboration among mathematics teachers

According to the mathematics teachers, collaboration among mathematics teachers was very important. They thought mathematics teachers should not compete amongst themselves but should share ideas on how best they can assist their students. Nine of the mathematics teachers believed that the much needed collaboration among the mathematics teachers did not exist. One of the mathematics teachers said:

> *"We need to share ideas as mathematics teachers. It is unfortunate that we do not work together as a team. Failure to share ideas amongst ourselves is one of the causes why as mathematics teachers we are failing to teach our students as they expect us to teach them."(Mr DT_2, pers.comm.).*

7.5.2 Data obtained from lesson observations

The researcher observed some lessons that were taught by the mathematics teachers who participated in this study. In the process possible barriers to the teachers' effective use of students' learning styles were noted. The following were the possible teacher related barriers that were noted by the researcher during lesson observations:

- Failure by the teachers to create a learner-friendly environment

The researcher observed during the lessons taught by the mathematics teachers that some of the teachers could not effectively teach their students according to their learning styles because they failed to create an environment which was conducive to free and fair learning. In three of the lessons observed by the researcher, rapport between the teachers and their students was not friendly to most of the students. The mathematics teachers did not give their students time to ask questions. The environment did not allow students to express themselves

freely. The students were too passive. They pretended to have understood the concepts that were taught. However the researcher could see some signs of confusion in them. It was evident from the way they performed given tasks that they needed more help from the teachers. Although the teachers needed to be in control of the students, they were too autocratic to an extent that they reduced their students to passive recipients of knowledge.

- Failure to budget lesson time

In two (20%) of the lessons that were observed by the researcher, the mathematics teachers failed to utilised their lesson time well. In one of the two lessons, the teacher spent most of his time introducing his lesson through a recap. It took him almost half of the lesson time to introduce the lesson to the students. The time left after the introduction was not enough for his students to perform the activities that he had planned for the students. In the other lesson, it appeared like the teacher was not really prepared for his lesson. The teacher spent most of his lesson time writing an exercise on the chalkboard whilst students were idle.

- Over usage of the rote methods of teaching

The researcher also observed that over usage of the lecture method by the mathematics teachers was one of the teacher related barriers that impinged on the mathematics teachers' use of their students' learning styles. Out of the ten lessons that were observed by the researcher, in six (60%) of them, the mathematics teachers used rote methods of teaching. They did not give their students enough time to work in groups or to find their own knowledge. The lessons were teacher centred.

7.6 Sub question 2: Student related barriers to the mathematics teachers' effective use of their knowledge of students' learning styles in teaching mathematics

According to the mathematics teachers, unfavourable behaviours displayed by their students made it difficult for the teachers to effectively utilise their knowledge of students' learning styles when they teach mathematics.

7.6.1 Data obtained through face to face semi structured interviews

Data used in this section were obtained by the researcher through face to face semi structured interviews. Table 7.3 shows the student related barriers and how they affected the mathematics teachers' use of their knowledge of their students' learning styles when they were teaching mathematics.

Table 7.3 Students related barriers and how they affected the teachers' use of their knowledge of students' learning styles (n=15 teachers)

Student related barriers	How they affected the teachers' use of students' learning styles	Frequency	Percentage
Absenteeism	It reduced contact time between the teachers and their students	11	73.33%
Indiscipline	Made it difficult for the teachers to assist the students	7	46.67%
Negative self esteem	Some students accepted their failure and they did not put effort in their work	3	20%
Negative attitude towards mathematics	Student with negative attitude towards mathematics did not put effort in their work	6	40%
Lack of concentration	Concepts taught could not be easily grasped by the students	7	46.67%
Lack of continuous practice	Retarded the learning progress of the students	9	60%

- Absenteeism by the students

Eleven of the mathematics teachers who participated in this research reported that absenteeism by their students prohibited them from effectively utilizing their knowledge of students' learning styles when they taught mathematics. According to the teachers, their students sometimes absented themselves and they missed some of the lessons they taught. When the students missed some of the lessons taught by the teachers, it was difficult for the teachers to assist the students while at the same time they needed to teach those who did not miss the lessons. The students were operating at different stages. One of the mathematics teachers had the following to say:

> *"Students who absent themselves from school make it very hard for us to utilise our knowledge of their learning styles. They cause some discord in the sense that we end up with a class of students who operate from different stages.*

Those who miss lessons operate from behind the rest of the class." (Ms CT_2, pers.comm.).

- Indiscipline by the mathematics students

Indiscipline by the mathematics students was considered one of the problems that mathematics teachers were facing as they tried to teach their students according to their learning styles. Seven of the mathematics teachers reported that they got disturbed by the level of indiscipline displayed by their students. The teachers explained that indiscipline created bad relationship between them and their students. They reported that indiscipline resulted in poor communication between the two sides. One of the teachers suggested that for them to effectively teach their students according to the students' learning styles, they required some measures to be put in place so that indiscipline among students be reduced. Ms DT_1 had the following points to make on students' discipline.

"It is very difficult to work with students who lack discipline. Some of them are disrespectful. They do not follow given instructions. You tell them to perform a certain task, they do their own thing. You end up losing patience. " (Ms DT_1, pers. comm.).

Another teacher who had the same complain about students' behaviour had the following to say:

"As a teacher I may be enthusiastic to teach my students in the rightful way, but sometimes I will be put off by the way the students behave. Some of them are not serious with their school work. They learn mathematics at school and it ends there, no further practice at home. If you give them homework they do not do it wholeheartedly. They just lack self discipline."(Ms HT_1, pers.comm.).

- Negative self esteem

Three mathematics teachers who took part in this study believed that their students lacked positive self esteem. As explained by the teachers, they failed to teach their students effectively because their students were not optimistic about their achievements. The teachers thought that some of their students seemed to have accepted that they were not able to score

high marks in mathematics. The students did not put effort in their school work as they believed that it was not possible for them to pass. Mr CT_1 explained how negative self esteem by their students affected the way they taught their students.

> *"It disappoints to plan for students who dislike mathematics. Some of our students are good in mathematics but they are not disciplined or they lack positive self-esteem. They are so convinced that they are failures. Most of them do not put any effort. The teachers work tirelessly to teach them in ways they think can assist the students but they do it in vain." (Mr FT_1, pers.comm.).*

- Negative attitude towards mathematics

Data obtained from this study revealed that some of the mathematics teachers felt that they failed to utilise their knowledge of students' learning styles due to negative attitude by their students towards mathematics. Six mathematics teachers (40%) reported that their students had negative attitude towards mathematics. According to them, the attitude displayed by those students impinged on their effective utilisation of students' learning styles to the best advantage of the students. The mathematics teachers believed that the attitude held by their students towards mathematics had an effect on the amount of effort exerted by the students in the learning process. The following is a statement from one of mathematics teachers:

> *"Regardless of how much effort you put in your work as a teacher, as long as your students have a negative attitude towards learning you will not succeed in making them pass. That is the problem I have with my students. They seem to dislike mathematics and they do not even see its importance in life." Mr DT_1, pers. comm.).*

- Lack of concentration by the students

According to seven of the mathematics teachers (46.67%), their students sometimes lacked concentration. The teachers said that lack of concentration in their students was caused by a number of factors. Some were social factors. The other one was boredom caused by bad relationship between the teachers and their students. The teachers felt that bad relationship

between the teachers and their students resulted in their students losing concentration. The following statements were shared by two of the mathematics teachers.

> *"Relationship between us and our students needs to be positive. A positive relationship facilitates effective students' assessment. The assessment enables us to employ suitable teaching strategies that suit our students' learning styles. However, suitable teacher-student relationship does not exist if our students have negative attitude towards us or when we hold a negative attitude towards some of our student."(Mr CT_2, pers.comm.).*

> *"Some students have social problems that affect their work at school. Imagine a student who comes to school on an empty stomach. Especially in this area where the harvest for the last season was very poor, we often notice that our students are affected. It is hard for them to concentrate when the stomach is empty."(Mr IT_1, pers.comm.).*

- Lack of continuous practice

The researcher found that nine participants felt that lack of continuous practice by their students was one of the factors which affected their use of students' learning styles in teaching mathematics. They thought that when their students learnt mathematics at school they did not practise on their own elsewhere. According to the teachers, when they teach their students they expect them to continue looking for more knowledge related to what they teach them. They felt that their students should not wait for them in order to learn. This point was clarified by one of the teachers as follows:

> *"It takes a lot of practice for students to grasp concepts fully. We may teach them in their preferred way but as long as they do not work on their own as individuals or in groups after the lessons it will remain a challenge. The students should supplement what we teach them with what they gather elsewhere. Some of the students fail even to do home work given by their teachers."(Mr HT_1, pers.comm.).*

7.6.2 Data obtained through observation

During lesson observations, the researcher found that some of the mathematics students did not pay attention to their teachers' instructions. In two of the lessons observed, some students

who were sitting at the back of the classes did not pay attention to their teachers' instructions. The teachers did not notice that not all their students were attentive. The researcher noted that the classes which had this problem were large. One of the classes had fifty students and the other one had fifty-two students.

The researcher observed that some students missed some lessons or part of the lessons taught by the teachers. All the lessons that were missed by the students were taught in the morning. The students missed the lessons because they reported late for the lessons. One of the students who were late arrived when the teacher had already demonstrated to other students on the chalkboard. The other students in the class were doing some group discussions when the student arrived. The student could not actively participate in the group discussions. The student did not benefit much from that lesson.

7.7 Sub question 3: Curriculum related barriers to the mathematics teachers' effective use of their knowledge of students' learning styles in teaching mathematics

The results of this study revealed that some of the barriers that impinged on the mathematics teachers' effective use of their knowledge of students' learning styles were related to the curriculum. This section reports on the curriculum related barriers that were found in this study.

7.7.1 Data obtained from face to face interviews

Table 7.4 gives a summary of the curriculum related barriers to the mathematics teachers' use of their knowledge of students' learning styles and how the barriers affected the teachers' use of their knowledge in mathematics teaching.

Table 7.4 Curriculum related barriers and how they affected the mathematics teachers' use of their knowledge of students' learning styles.

Curriculum related barriers	How they affected the teachers' use of students' learning styles	Frequency	Percentage
Long syllabus	The teachers rushed to cover the syllabus within the required time frame	6	40%
Number of written exercises expected by policy	Teachers became biased towards written exercises even when practical tasks were appropriate	8	53.33%

Frequent changes	More time was taken to adjust to the new policies than to the teaching of mathematics concepts	7	46.67%
Dictated curriculum	Activities set in the intended syllabi did not match the learning styles of the students	5	33.33%

- Long syllabus

Six of the mathematics teachers complained that they were failing to teach their students according to the students' preferred learning styles because they needed to cover long syllabuses within given time. Information shared by the mathematics teachers was that the mathematics syllabus they were following was too long to be covered during the time stipulated by the syllabus. According to them, they needed enough time to cover all the compulsory topics in the syllabus. As a result of this, they failed to get enough time to individualise their instruction in order to cater for their students with varying learning styles. Ms BT_1 explained this point by saying:

> *"Time required for us to cover the mathematics syllabus makes it difficult for us to teach each and every student according to his or her learning style. It is only possible for us to individualise our teaching instruction to suit the learning styles of our students when we have enough time to do so. In most cases we use lecture method not because it is the best method of teaching but because we need to cover large ground within a short space of time. We expect the students to assist each other after lessons or to seek more help from other sources."(Ms BT_1, pers.comm.).*

- Policy on number of written exercises to be given to students per week

The mathematics teachers who took part in this study pointed out that a policy that stipulated the number of written exercises to be done by students per week was also a form of barrier to their use of their knowledge of students' learning styles in mathematics teaching. The teachers said that the policy stipulated that they were supposed to give one written exercise per day to their students from Monday to Friday. On top of these exercises, a revision exercise was expected per every fortnight. According to the teachers, the policy indirectly

forced them to avoid practical exercises and maintain a bias on written exercises in order for them to meet the standard required on written work. The teachers explained that although they maintained a bias towards written exercises, they were fully aware that they were doing a disservice to some of their students who preferred practical tasks to written exercises. The following was a sentiment from one of the mathematics teachers:

> *"A circular on written exercises states that I should give a written exercise each day from Monday to Friday. That means when my supervisor inspects my books he expects to see five written exercises in each week. Failure to meet the required standard means I may be deemed incompetent. As a result I give more written exercises than practical exercises so that I safeguard myself and my job."(Mr ET_1, pers.comm.).*

- Frequent changes on policies

Seven of the mathematics teachers (46.67%) who participated in this study felt that frequent changes in education regulations, policies and curricula contributed towards creating mismatches between their teaching styles and the learning styles of their students. One of the teachers said:

> *"While adjustments to the curriculum help schools to keep pace with the fast changing world, they need to be done properly and within reasonable time. If not done well it causes confusion to the learners and their teachers. More time is wasted by the teachers and their students studying the new syllabi or curriculum than in the actual learning of the students."(Ms BT_2, pers.comm.).*

The interviewer probed Ms BT_2 to give examples of the policies that she thought were imposed on them without considering the time factor. The following was her response to the interviewer's question.

> *"For instance we recently received a written instruction that the curriculum has changed with immediate effect. Students are now expected to do practical projects during the secondary school ordinary level course as part of their examination requirements. Personally I feel that it needs time for students and teachers to adjust to these requirements before the policy comes into effect.*

Abrupt changes are normally associated with problems."(Ms BT_2, pers.comm.).

- Dictated syllabuses

Five mathematics teachers blamed the syllabus they were following for their failure to utilize their knowledge of students' learning styles. The teachers felt that the mathematics syllabus was imposed on them without them making an input. They also felt that the syllabus was compiled without carrying out thorough research on how students learn. The teachers thought that the ideas that were used to compile the syllabus came for non practising teachers who had lost touch on the modern trends in mathematics education. Some of the mathematics teachers even suggested that in future curriculum developers should comprise teachers in the field of teaching and not those who retired from work or those who were promoted to other duties other than teaching. The following points were shared by two of the mathematics teachers during interview sessions.

"Syllabuses that are developed by people who are no longer teaching mathematics have problems in terms of fully assisting the students to learn. The tasks that are set in the syllabus that we are using right now have bias towards certain classes of learners. The tasks were supposed to be balanced so that students of varying talents and interests are kept challenged. In fact, serious consultation should be done before coming up with such documents."(Mr FT_1, pers.comm.).

"Some students are good at solving non-routine problems. However, most of the activities stated in the current mathematics syllabi do not give the students an opportunity to practise solving non-routine problems. It is the same to the use of research in mathematics. Modern learning should be done through research. The syllabus does not emphasis on use of research in mathematics learning." (Mr CT_1, pers.comm.).

7.7.2 Data obtained from observation

Data obtained through observation revealed that the mathematics teachers had a newly introduced curriculum framework which had been produced by the Ministry of Primary and Secondary Education in Zimbabwe. This was the framework that some of the mathematics

teachers thought had brought more problems than solutions to them. They complained that the government through its Ministry of Primary and Secondary Education developed the curriculum framework without consulting them. They felt they were an indispensable stakeholder and had better knowledge of how students learn than the people who developed the framework they were following. According to them, the concepts and the assessment criterion set in the mathematics syllabi under this framework did not consider the diverse nature of their students. They thought that the assessment criterion was not varied enough to challenge students of different learning styles. The teachers also complained that tasks suitable for students with certain learning styles were omitted.

As pointed out earlier in this report, data obtained through observation revealed that the mathematics teachers who participated in this study overused the lecture method. The use of lecture method and other rote methods of teaching was caused by the mathematics teachers' need to rush through their syllabus since they needed to complete it within specified timeframe. The researcher observed that the mathematics teachers used teacher centred strategies in order for them to cover as many concepts as they could within short space of time. This was however done at the expense of some of the students in the teachers' classes. In other words, the teachers concentrated more on covering the syllabus than on ensuring that their students understood the concepts they taught.

7.8 Sub question 4: Socio-economic barriers to the mathematics teachers' effective use of their knowledge of students' learning styles in teaching mathematics

Apart from teacher related, curriculum related and student related barriers, the researcher found that some of the barriers were related to the socio-economic status of the schools and that of the communities surrounding the schools. This section reports on the socio-economic barriers that affected the mathematics teachers as they used their knowledge of students' learning styles in mathematics teaching.

7.8.1 Data obtained from face to face semi structured interviews

A summary of the socio-economic barriers that were given by the mathematics teachers during face to face interviews is given in Table 7.5.

Table 7.5: Summary of the socio-economic barriers and how they affected the mathematics teachers' use of their knowledge of their students' learning styles in teaching mathematics.

Socio-economic barriers	How they affected the teachers' use of students' learning styles	Frequency	Percentage
Shortage of learning materials	The teachers did not have the required materials to use in mathematics teaching	8	53.33%
Financial background of the learners	Students did not have additional learning materials to use when they were out of school	7	46.67%
Unfavourable working conditions	The teachers did not go an extra mile in assisting students who needed extra help from the teachers	3	20%
Poor time tabling	Time for lessons was reduced by other activities that were done at the schools	4	26.67%
Large classes	Teachers found it hard to plan and teach each and every student in the class according to his or her learning style	11	73.33%
Overloading of teachers	The teachers could not find time for planning and interacting with their students	15	100%
Negative perception of mathematics	Parents who had negative perception of mathematics did not support their children's learning. Students with negative perception of mathematics did not put effort in their learning.	5	33.33%

- Shortage of learning materials

Eight mathematics teachers (53.33%), who taught at rural schools, attributed their failure to teach their students according to their learning styles to lack of teaching and learning resources. According to the mathematics teachers, resources that suited the learning styles of their students were not available in the required quantities and qualities in their schools. The researcher observed that this point was raised by mathematics teachers who were teaching at

schools that were in rural areas. Two teachers who were teaching at one of the schools that were chosen for this study said:

> *"We know that our students need to be attended to. The attention depends on the students' preferred ways of learning but we do not have enough resources to teach them effectively."(Mrs CT_1, pers.comm.).*

> *"Shortage of resources makes it difficult for us to fully utilise our knowledge of our students' learning styles as expected. Given all the resources we can attend to all of them."(Mr ET_1, pers.comm.).*

Mrs CT_1 was asked to give examples of the materials that she said were in short supply at their school. She responded as follows:

> *"I am referring to things that we use as teaching aids for instance calculators, computers, internet, drawing instruments and many other things. As you can see at this school, we do not even have electricity hence we are far away from receiving internet here." (Mr AT_1, pers.comm.).*

- Financial background of the students

Data obtained from the mathematics teachers revealed that the teachers expected their students to use resources at their homes to supplement resources that are available at school. However, some of the students came from poor families which could not afford to purchase any supplementary learning material for the students. When the interviewer asked the teachers to give examples of the additional materials that the teachers wanted their students to purchase for themselves, the teachers mentioned personal laptops, calculators and mathematics drawing instruments. The following is a statement from one of the mathematics teachers.

> *"I expect my students to practise even at home. I give them homework so that they get assistance from home. It is also a way of forcing them to revise the concepts covered at school. Unfortunately, some of the students fail to do homework because they do not have the required materials at home."(Mr BT_1, pers.comm.).*

- Unfavourable working conditions

The mathematics teachers complained of what they referred to as unfavourable working conditions. They attributed their failure to utilize their students' learning styles in mathematics teaching to some working conditions which they thought were not favourable to them. The mathematics teachers felt that the conditions did not motivate them to work. Some of the teachers mentioned bad conditions of work that resulted from imposed policies that they followed at work, for instance, they pointed out that they were supposed to attend to other duties like maintaining students' discipline at church seminars. They also said that they were forced to participate in extra curriculum activities like sporting despite having large classes to teach. The mathematics teachers felt that they were robbed of valuable time to effectively use teaching strategies that could assist their students. A teacher at one of the schools complained as follows:

> "*There are too many programmes to be done at this school that often affect my work. I am forced to go for other programmes so it is difficult for me to attend to each and every student. We go for morning devotions, sporting and other programmes." (Mr* $BT_{2,}$ *pers.comm.).*

Apart from school policies that the teachers felt were wasting their valuable time to teach their students according to their learning styles, the teachers also complained of poor relationship amongst themselves as colleagues. According to the teachers, poor relationship among mathematics teachers was an indirect barrier to their effective utilisation of students' learning styles in mathematics lessons. As put forward by two of the mathematics teachers, mathematics teachers were not working as teams. They were not free to consult each other on matters concerning how best they could teach their students. No cross pollination of ideas existed among the teachers. One teacher commented on their relationship as teachers as he says:

> *"Teachers choose to compete with each other instead of collaborating for the benefit of the students. This has created unfavourable relationship among mathematics teachers in schools. I think we need to change our attitude as teachers so that we improve on how we teach our students. We need to share ideas. We can even exchange students so that our students benefit from our*

expertise. No one of us is an expert in all the areas across the curriculum."(Mr AT_1, pers.comm.).

- Poor time tabling

Four of the mathematics teachers blamed their school administration for poor timetabling. The teachers felt that the way their time tables were crafted had a negative effect on the way they taught their mathematics students. The teachers said that they preferred morning lessons for mathematics teaching but most of their morning lessons were disturbed by other school activities. As a result the mathematics teachers were left with little time to teach their students. They ended up disregarding their students' learning styles and resort to using teacher centred methods which suited the time left for them. One of the teachers said:

"Mathematics lessons are normally put in the morning on the timetable. They are however disturbed by other morning activities done at school. Instead of six lessons per week per class we end up with five or four lessons per week per class. This seriously reduces the time required for us to interact with our students."(Mr GT_1, pers.comm.).

- Overloading of teachers

All the mathematics teachers who participated in this study felt that they were overloaded. According to the teachers, overloading was a serious barrier to their use of their knowledge of students' learning styles in mathematics teaching. Data obtained from the mathematics teachers showed that they were overloaded in three ways. One way in which they were overloaded was by having large classes. This made it difficult for them to teach all students in their preferred styles of learning. The other form of overloading was in the form of the duties they were expected to perform. The teachers reported that they were expected to perform other duties like attending to sporting activities. The mathematics teachers were also overloaded in terms of the number of lessons they were expected to teach per week. Two of the teachers pointed out that they were expected to teach thirty forty-five minute lessons per week. According to the teachers, overloading reduced the time available for them to interact with their students. The following statements were shared by some of the mathematics teachers during face to face interviews.

"I am teaching five classes with fifty-five students each. Teaching each student according to his or her learning style and attending to each student's needs is almost impossible with the number of students that I deal with. I teach thirty lessons a week. The load is heavy for me although I try to work tirelessly." (Mr CT_1, pers.comm.).

"Time is normally not on my side. I am in charge of sporting. I am a softball trainer. I have to balance my mathematics teaching and sporting. So teaching each student according to his or her learning style is not very easy for me."(Mr DT1, pers.comm.).

- Negative perception of mathematics

According to the mathematics teachers, negative perceptions of mathematics as a learning area held by members of the community was also a barrier to the effective use of students' learning styles by the mathematics teachers. The teachers thought that some members of the community including some of the mathematics teachers viewed mathematics as a difficult subject that could only be done by the gifted ones. This perception of mathematics led to lack of seriousness on the part of the mathematics teachers and their students. It also resulted in parents failing to give the much needed moral and financial support to the learning of their children. One of the teachers who shared this view had the following to say:

"Many people perceive mathematics as a difficult subject. As a result of this perception, mathematics teachers tend to move with the gifted students and ignore those who need extra help. On the other hand, parents seem to have accepted that only a few students pass mathematics. They withdraw their support to students who struggle in mathematics. The students themselves have accepted failure. They do not put effort in their learning."(Ms P, pers.comm.).

7.8.2 Data obtained through observation

Data obtained through observation confirmed that the mathematics teachers were working with very little resources. In eight (53.33%) of the lessons observed by the researcher, the mathematics teachers did not use any other teaching aids in their lessons other than the chalkboard. Individual work given to the students was written on the chalkboard. No textbooks were used by the students. The researcher observed that the average textbook-

students ratio for all the lessons observed was 1:6. The researcher also observed that information and communication technology systems (ICT) were not used in all the lessons observed.

The researcher noted that the classes which some of the participating mathematics teachers were teaching were large. The largest class that the researcher witnessed had sixty-six students. During a lesson observed in this class, the teacher could hardly control the students in the class especially during the time when the students were performing some group activities. The teacher went round supervising the activities in the groups but some of the students were not performing the tasks given according to the instructions given by the teacher.

During the time when the researcher observed some lessons taught by the teachers, no lesson was disturbed by any other school activities as claimed by the teachers. However, the researcher noted that most of the mathematics lessons were in the morning. Of the fifteen lessons that were observed by the researcher, nine of them were in the morning before tea break. Only one lesson was observed in the afternoon after lunch time.

7.9 Discussion

According to the data obtained in this study, barriers which impeded on the mathematics teachers' utilisation of their knowledge of students' learning styles in mathematics teaching could be classified into four classes. The four classes were teacher related barriers, student related barriers, and curriculum related barriers and socio-economic barriers. However, the results of the study pointed to the fact that teacher related barriers were the most common. Teacher related barriers were a result of the mathematics teachers' personal traits and pedagogical skills.

Differences and similarities were noted in the results obtained in this study and those that were obtained by other researchers in studies done in the past. One of the similarities was that the mathematics teachers who participated in this study thought that perceptions on mathematics held by members of the community, especially those held by mathematics teachers and their students had a negative effect on mathematics teachers' use of their knowledge of students' learning styles in mathematics teaching. The mathematics teachers reported that members of the community perceived mathematics as a subject that is meant for gifted students only. According to the mathematics teachers who participated in this study,

such perceptions resulted in mathematics teachers and their students exerting little effort to mathematics teaching and learning. Teachers disregarded their students' learning styles on the belief that the students could not perform better even if they were taught according to their learning styles. On the other hand, their students accepted their failure and they thought they were not good enough to perform any better. Almost similar results were obtained by Kaniz (2015) in a study carried out in Bangladesh. In that study, Kaniz found that negative perceptions held by members of the society were a barrier to mathematics teaching. Kaniz (2015) observed that members of the society in Bangladesh thought mathematics was a subject suitable for boys and not for girls. Although the perceptions held by the members of the society in Bangladesh and those held by the members of the society as found in this study were different, the effect of the perceptions were similar in that they had a negative effect on the teaching of mathematics.

Another similarity on the findings of this study and the findings from other studies was that shortage of time affected mathematics teaching. The mathematics teachers who participated in this study reported that they did not a have enough time to teach their students according to their learning styles due to other commitments. The findings were similar to those found by Weselby (2014). Weselby found that shortage of time was a barrier to effective mathematics teaching. Lyuch and Star (2013) also concurred with the mathematics teachers. Lyuch and Star added on by saying that shortage of time resulted in teachers speeding up in order to cover syllabi within the period stipulated. As a result of the speed at which the teachers cover the syllabi, the teachers disregarded the learning styles of their students. According to the mathematics teachers, they needed time to assess their students, plan instruction that suited the learning styles of their students, deliver lessons and evaluate their teaching strategies. However, this was not possible due to time limits caused by poor time tabling and policies at their schools that required them to attend to other duties which included attending to morning briefings and devotions. Analysis of the data obtained in this study revealed that mathematics teachers who were teaching at schools that were owned by churches were mostly affected by morning activities since students and teachers at these were forced to attend to morning devotions. Due to shortage of time, the mathematics teachers ended up teaching their students for examination purposes and not for understanding. The teachers made sure that they covered the intended syllabi in the given timeframe despite the low level of understanding displayed by their students and the challenges faced by the students. However while the mathematics teachers complained that lack of time affected their teaching strategies, the

researcher observes during lesson observations that some of the teachers failed to budget the time allocated to them. Essential time was lost with the teachers emphasising on things that were not very important to the students, for instance when a teacher spent the larger part of a lesson introducing a lesson

The researcher found that the mathematics teachers who participated in this study thought that lack of experience, lack of exposure and lack of in-service courses on the part of the mathematics teachers were barriers to the mathematics teachers' use of their knowledge of their students' learning styles in mathematics teaching. Similar results were obtained in a study carried out in Kenya by Oisebe (2012). Oisebe found that lack of in-service courses by the mathematics teachers impinged on the teaching of mathematics. The results were confirmed by Lyuch and Star (2003) who reported that one of the barriers that affected the teaching of mathematics was knowledge constraint on the part of the teachers. Lyuch and Star suggested that mathematics teachers should be regularly send for in-service courses in order to keep them equipped with current trends. According to the data obtained in this study, mathematics teachers believed that in-service courses could assist in bringing exposure to them on how best they could assist their students despite their varying learning styles.

Although the mathematics teachers who participated in this study claimed that lack of experience affected how they taught their students, an analysis of the participating mathematics teachers' length of teaching experience revealed that only two of the teachers (13%) had less than five years of teaching experience and nine (60%) had more than ten years. The data on the teachers' lengths of teaching experience showed that the claim by the teachers that teaching experience was a barrier to their effective use of students' learning styles in teaching mathematics was in contrast to the evidence shown by data on the teaching experience possessed by the teachers.

According to the results of this study, the mathematics teachers' attitude towards their work had an effect on their use of their knowledge of students' learning styles when teaching mathematics. According to the results obtained from the current study, a teacher maybe well experienced and well trained but if the teacher is not committed to his or her work then no meaningful teaching can take place. Teachers with negative attitude towards work deliberately ignored their students' learning styles and taught in ways that appeared to give them less work. Such teachers employed rote methods of teaching. In the opinion of the mathematics teachers who participated in this study, the teacher's choice of teaching

strategies and teaching aids depended on the teacher's attitude towards work. A study done on pre-service teachers by Marban and Mulenga (2019) revealed similar results. Marban and Mulenga found that the attitude of the pre-service mathematics teachers affected their choice of teaching aids. The study was done to find out what determined the pre-service teachers' choice of using ICT in mathematics teaching. The two researchers observed that pre-service teachers who had negative attitude towards work did not use ICT when teaching mathematics. Almost similar to the findings the results of the current study confirmed that the mathematics teacher's attitude towards work played a pivotal role in the teacher's choice of teaching strategy. The attitude also determined the teacher's patience in dealing with students of varying learning styles.

This study also exposed that the teachers' own learning styles were a barrier to effective mathematics teachers' utilisation of their students' learning styles. According to the mathematics teachers, in the cases where teachers failed to manage their own learning styles, they ran a risk of being over controlled by their learning styles. As a result, they ended up teaching in the ways they preferred being taught themselves instead of considering the learning styles of their students. Some of the teachers taught in the ways they were taught by their teachers. Sarasin (1999) observed that teachers' own learning styles dominated the teachers' teaching styles. In the cases, the teaching styles were dominated by the teachers' own learning styles, the students' learning styles were ignored. As a result, when outlining steps that a mathematics teacher should follow when teaching students' according to their learning styles, Sarasin suggested that the first step is for the teacher to assess his or her own learning style before assessing the learning styles of their students. This point was supported by Ferrara (2010) who pointed out that the teachers' learning styles impact on their teaching strategies. Ferrara advised that mathematics teachers should assess themselves so that they identify their own learning styles.

Some of the mathematics teachers felt that their failure to assess students' learning styles was a barrier to the effective use of their knowledge of student' learning styles when they taught mathematics concepts. The researcher found that the teachers who took part in this study used non standard test items which they set to assess their students' learning styles. Although the test items used by the teachers in assessing the students were guided by the national syllabus, they were not standard learning styles assessment. In the reviewed literature, the researcher found that different standard tools were invented by different learning style theorists for the

purpose of identifying students' learning styles, for instance, according to Kolb and Kolb (2013) learning styles could be assessed using a Learning Style Inventory (LSI). Honey and Mumford (1992) suggested using a learning styles questionnaire which is self administered. Ellington and Bender (2012) supported the use of the learning styles assessment tools by stating that regular and continuous assessment of students' learning styles helps the teacher to get an understanding of the learning styles which he or she works with.

The current findings showed that lack of parental support, caused by negative perception on mathematics, was a barrier to the effective use of teacher's knowledge of students' learning styles. Crystal (2012) obtained similar results when he carried out a study in Michigan. According to Crystal, members of the society thought mathematics was a suitable learning area for boys. Results of this current study revealed that members of the community thought that mathematics was a learning area for the gifted ones. Although there were some differences in what the people believed, what was found to be common by the researcher was the fact that the perceptions had negative effect on how the mathematics teachers implemented their knowledge of students' learning styles when teaching mathematic. It resulted in lack of support by the parents, lack of seriousness by the students and unfair treatment of slow learners by the mathematics teachers.

The findings of the current study also revealed that shortage of learning resources was a barrier to effective usage of the teachers' knowledge of students' learning styles. Large textbook to students ratio was observed. Shortage of resources at the schools made it difficult for the mathematics teachers to assist their students according to their learning styles. These findings concurred with the results obtained in Bangladesh by Kaniz (2015). Kaniz found that shortage of textbooks and other mathematical instruments was a barrier to effective mathematics teaching in Bangladesh. Although the results found by Kaniz referred to barriers that affected mathematics teaching in general, the findings from his research gave similar results to those that were found in this current study. Lyuch and Star (2003) also found that resources constraints affected mathematics teachers as they taught their students. The mathematics teachers also thought that their students needed extra resources at home so that they could effectively learn in their preferred learning styles. However the financial backgrounds of the students affected them. The students or their parents could not provide the much needed learning resources.

Doskocil (2016) reported that mathematics teachers were affected by a need to balance their teaching duties and need to meet the demands of their schools. This observation was also shared by Duff (2002). The findings by these researchers concurred with the results in this study as the mathematics teachers complained that some policies at their school were affecting the way they taught their students. The demands by some of the schools forced the mathematics teachers to resort to strategies that enabled them to maintain a balance between school demands and their teaching duties. As they maintained this balance, they compromised the way they used their knowledge of students' learning styles in teaching their students. The teachers failed to meet the demands of all their students.

Other barriers reported by the mathematics teachers in this study were lack of subject content knowledge by the teachers and failure by the mathematics teachers to integrate mathematics with other learning areas. The teachers were of the same view with Lyuch and Star (2003) by stating that lack of subject content was a barrier to the mathematics teachers. In their report, Lyuch and Star referred to lack of subject content as 'teacher knowledge constraint'. The mathematics teachers who took part in this study thought that lack of subject content knowledge led to over reliance on textbooks which resulted in mismatches between teaching strategies and learning styles of the students. In my view as a researcher, the mathematics teachers were correct by stating that mathematics could not be taught in isolation. This point was supported by Perini, Silver and Strong (2000) when they pointed out that *understanding maths learners* and *interpersonal maths learners* enjoy applying mathematics skills to real life situations. Applying mathematics to real life situations means referring to other learning areas. Mathematics teachers should take advantage of the skills learnt by their students in other learning areas so that their students grasp concepts in mathematics. This strategy assists students to appreciate the fact that mathematics is a tool used in solving real life problems. Besides integrating mathematics with other learning areas, the mathematics teachers also needed to properly link the concepts they taught so that students' could find relationship between the concepts taught. However the data obtained in this study disclosed that some of the teachers failed to link mathematics concepts and this led to their failure to effectively teach their students according to the students' learning styles.

Although there were a number of similarities in the findings of this study and the findings from other researches, some differences were also noted between the results of the current study and those found in the reviewed literature. For instance, Oisebe (2012) observed that

low expectation by mathematics teachers on their students affected mathematics teaching in Kenya. This point was not clearly found in this research study. Only one of the mathematics teachers who took part in this study felt that her students were not competent in solving non-routine problems.

The current study yielded some results that were not found in the reviewed literature. The results that were obtained in this study were different to those found in the related literature in that the barriers reported in this study were directly linked to mathematics teachers' use of their knowledge of students' learning styles while those found in the related literature were on the teaching of mathematics, in general. However, this study revealed that in addition to the barriers that were reported in the reviewed literature there were other barriers that affected the teachers' effective use of the knowledge of students' learning styles. Among these barriers was overloading of mathematics teachers. Overloading was reported by the teachers as a serious barrier to the teachers' effective use of students' learning styles in mathematics teaching. As stated earlier in this report, overloading occurred in three ways. According to the teachers, they were overloaded by the number of students per class, number of lessons taught per week and duties performed by the teachers. The teachers failed to cater for all their learners due to overload. Although all the mathematics teachers who participated in this study complained of overloading, data obtained from the study revealed that the nature of overloading was related to the responsible authorities of the schools. Teachers who were teaching at government owned schools complained of large classes. Teachers at church owned schools and those owned by private individuals complained of too many duties to be performed.

The researcher observed in this study that the mathematics teachers had long syllabi to cover within stipulated time and some targets to meet in terms of number of written exercises expected to be given to students per week. These observations were not found in the reviewed literature. However, these were found to be serious barriers affecting the mathematics teachers. They added on pressure to the mathematics teachers resulting in them failing to plan for instruction that suited the learning preferences of their students. As reported earlier, the teachers ended up giving written exercises even in cases where practical exercises were suitable. Students who preferred learning through experiments and through hands-on were the most affected by the policies on the number of written exercises to be done by the students. Apart from having long syllabi to cover the teachers complained that the school curriculum

was dictated to them. According to the teachers, proper consultation was not done by the government when the curriculum was introduced. As a result, the teachers felt that the curriculum did not cater for all the learning styles of their students.

Lack of collaboration and unfavourable relationship among mathematics teachers in schools impeded on the ways they utilised their knowledge of students' learning styles. The teachers who participated in this study reported that mathematics teachers in schools were not free to assist each other when they face problems. Instead of working together so that they assist each other and their students, the teachers were competing among themselves. Each teacher felt that he or she should produce better result than other teachers. The teachers also lamented the relationship that existed amongst them. Some of the teachers did not relate well. The bad relationship among them made it difficult for them to share ideas on their work. Relationship between the teachers and their students was also a thorn in the flesh for the mathematics teachers. According to some of the teachers who took part in this study, the relationship with their students affected how they taught the students. They could not effectively teach the students according to their learning styles because their students were not free to share their problems with the teachers. The teachers failed to create friendly environments that promoted free and enjoyable learning for the students. Data obtained through lesson observation confirmed that in some lessons observed rapport between the teachers and their students hampered free sharing of ideas. Students were restricted to an extent of failing to ask questions to the teachers.

It was also important to note that the results of the study revealed that some of the barriers were related to unfavourable behaviours by students. Unfavourable behaviours included lack of practice, negative self-esteem and negative attitude towards teachers. Kaniz (2015) gave an explanation on the causes of such behaviours displayed by students. According to Kaniz such behaviours are a result of too much punishment imposed on the students by the mathematics teachers for failing to perform given tasks. In this study, the teachers did not link the behaviour by their students with how they treated them during lessons. However, in my point of view, there was need, in future, to carry out intensive research on whether those behaviours were caused by the way the mathematics teachers treated their students or by other causes.

Lack of commitment, motivation and concentration on the part of the mathematics students, was found in this study as a barrier to mathematics teachers' use of their knowledge of students' learning styles in mathematics teaching. Almost similar results were obtained in a study done in Michigan by Crystal (2012). Crystal observed that lack of motivation and commitment on the part of the mathematics students in Michigan greatly affected their teachers' ways of teaching mathematics. Although Crystal did not find the causes of the lack of commitment by the students, the data obtained from this study showed that lack of concentration by the mathematics students was caused by bad relationship between the mathematics teachers and their students. It was also caused by boredom in the students. However, apart from lack of commitment by the students, this study revealed that lack of commitment on the part of the teachers also affected how the teachers taught their students. During face to face interviews, the teachers explained that those teachers who were not committed to their work did not have patience to differentiate their instruction so that all of their students benefit from their teaching instructions.

Absenteeism by the students was also found to be one of the barriers that affected the mathematics teachers' use of their knowledge of students' learning styles. The teachers complained that their students sometimes absented themselves from school. According to the teachers, absenteeism made it difficult for the teachers to ensure that the students keep pace with the other students. It reduced the contact time between the students and their teachers. Even the time to interact with peers in class was reduced when the students absent themselves. In some of the lessons observed, some students failed to get important instructions because they reported late for lessons.

The researcher found that some of the points that were raised by the mathematics teachers were confirmed through lesson observation, for instance, the mathematics teachers complained that they were failing to teach their students according to their learning styles because of large classes they were teaching. The researcher noted that some of the classes that were taught by the teachers were too large for the teachers to cater for each and every student in the class. It was also found that some of the mathematics teachers were affected by lack of teaching resources. However, some of the points raised were in contrast to what the researcher observed, for example, the teaching experience possessed by the teachers who participated in this study did not tally with the teachers' claim that lack of experience affected the way they used their knowledge of students' learning styles.

7.10 Implications of the findings to a mathematics teacher

The findings of this study had the following implications to the mathematics teacher:

(i) Mathematics teachers should be exposed to different learning environments and different learners for them to be fully equipped with skills to deal with students of different learning styles. Visits to other schools are encouraged. From the data obtained in this study, the mathematics teachers who participated in this study reported that they lacked exposure and because of that they could not effectively utilise their knowledge of students' learning styles when they taught their students.

(ii) Mathematics teachers should always be equipped with current trends in the teaching of mathematics. They should take note that knowledge is dynamic. As a result it is not advisable for mathematics teachers to continue using traditional methods of teaching. There is need for them to keep pace with the changing world. This can be done through getting ideas from colleagues or through research or from other media like the internet.

(iii) The researcher found in this study that the mathematics teachers reported that their own learning styles were a barrier to their use of students' learning styles in mathematics teaching. It follows that a mathematics teacher should be aware of his or her own learning style. In addition to this knowledge, the teacher should also know the learning styles of his or her students. Equipped with this knowledge the teacher ensures that his or her own learning style does not dominate his or her teaching strategy at the expense of the students' learning styles. If the teachers' learning style dominates his or her teaching strategy there is a possibility that a mismatch may exists between the teacher's teaching style and the learning styles of the students.

(iv) Mathematics should not be taught in isolation. Mathematics learning should be integrated with learning in other areas. It is important that mathematics teachers should equip themselves with knowledge on how they can integrate mathematics with other learning areas. In this study the researcher observed that lack of knowledge on how to integrate mathematics with other learning areas was a barrier to the effective utilisation of the students' learning styles in mathematics teaching.

(v) One of the factors that affected the effective utilisation of the knowledge of students' learning styles was bad relationship between the teachers and their students. It is therefore important for mathematics teachers to create student friendly learning environment all the time so that all students can freely express themselves and show their strengths and weaknesses. The mathematics teacher should take advantage of his or her students' strengths and weaknesses to ensure that the students grasp the concepts taught by the teachers.

(vi) Mathematics teachers should show positive attitude towards their work. Once a teacher develops negative attitude towards his or her work it becomes difficult for the teacher to effectively teach his or her students. The negative attitude can easily be transferred to the students.

(vii) Negative perceptions about mathematics should be discouraged. All students are capable of performing well in mathematics despite their learning preferences or sex. Perceiving mathematics as a learning area for the gifted or for boys serves to discourage some mathematics students from working hard. It becomes even worse when such perceptions are held by mathematics teachers. Mathematics teachers should check for mismatches whenever they observe that a student performs badly. The performance can be a result of a mismatch between the teacher's teaching strategy and the learning preference of the student.

(viii) Mathematics teachers should not compete in their work but they should work together sharing ideas on how they can effectively teach their students. Cross pollination of ideas among teachers improves teaching better than competition. Some teachers may not be able to assist students with particular learning style but can do so with the help from their colleagues. The students can be given to other teachers who can assist in making sure that they get the help they deserve.

(ix) Absenteeism and indiscipline among students were found to be barriers to effective teaching of students according to their learning styles. It is important for mathematics teachers to find ways of reducing these unfavourable behaviours by their students. Teachers can find ways of motivating the students so that they avoid misbehaving. Creating a friendly environment for the students is one way of reducing absenteeism and indiscipline among the students. Students need to be shown love by their teachers.

(x) Mathematics students should be encouraged to continue practising even at home. Learning should not be restricted to the classroom only. Mathematics teachers

should give their students some projects or researches as a way of encouraging them to practise. In this research, the findings show that students were not practising and as a result the teachers were facing challenges in teaching them according to their learning styles

(xi) Mathematics teachers should always improvise whenever learning materials are in short supply. The teachers who participated in this study reported that they could not effectively teach their students according to the students' learning styles because they had shortage of learning materials. However, the mathematics teachers could improvise for the learning materials, for instance they could use cell phones as calculators and in place of computers for internet browsing.

7.11 Implications of the findings to policy makers

The findings of this study had the following implications to the policy makers:

(i) Practising mathematics teachers should always be involved when constructing policies and syllabi. There is need for consultative meetings with the teachers before making final documents. Documents produced without the involvement of the teachers risk resistance from them or failure to produce intended result due to improper crafting. Mathematics teachers interact directly with students therefore they know much about how their students learn than any other stakeholder.

(ii) Changes to existing policies should not be abrupt. Abrupt changes cause confusion among the implementers. The mathematics teachers in this research lamented on changes that were abruptly brought to them. They thought they were taking more time trying to get to terms with the changes instead of teaching their students in the right way.

(iii) There is a need to ensure that learning resources are available for the mathematics teachers to use. Teaching students according to their learning styles means using different teaching aids in order to suit the learning styles of the learners. As a result the mathematics teachers should be provided with the much needed resources.

(iv) Mathematics syllabi should take note of the learning styles of the students. The skills to be tested at the end of the teaching period or that are to be developed during the learning period should be varied enough so that all students are catered for.

(v) Activities done at schools should not affect the teaching of mathematics. Set timetables should be religiously followed so that mathematics teachers can plan their activities and have time to implement the plans. Time lost through other activities caused mathematics teachers to disregard the learning styles of their students and they taught using teacher centred approaches which did not benefit the entire classes.

(vi) Mathematics teachers should not be overloaded. Students have different needs and different learning preferences and for that reason they need differentiated attention from the teachers. It is not easy for one teacher to give differentiated instruction to too many students within a short period of time. The class sizes should be reasonably small so that the teachers can effectively teach the students according to their learning preferences.

7.12 Chapter Summary

In this chapter the researcher reported on the barriers that impinged on mathematics teachers' utilisation of their knowledge of their students' learning styles when teaching mathematics. In the first part of the chapter the researcher gave the research question and the sub questions. Eight female and seven male mathematics teachers participated in this study. It was pointed out that the teachers were all qualified and experienced to teach mathematics at secondary school level. The data that was used in this part of the study were collected through face to face semi structured interviews and through observation. The findings of the study revealed that the barriers that impinged on the teachers' use of their knowledge of the students' learning styles could be classified under four classes. The barriers were reported under the following; teacher related, students related, curriculum related and socio-economic barriers. A discussion of the findings was given in this chapter. The chapter was then concluded by an outline of the implications of the research findings to the mathematics teacher and to the policy makers.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This chapter reports on the following: conclusions from the study and the recommendations that emanated from the study. The conclusions are given according to the three phases of the study.

8.2 Conclusions from the three phases of this study

This section presents conclusions made by the researcher from the finding of this study. The conclusions provided answers to the three research questions that guided this study. The aim of the study was to explore secondary school mathematics teachers' knowledge of their students' learning styles and how the mathematics teachers used that knowledge when they taught mathematics. The study went further to explore barriers that the secondary school mathematics teachers faced and their impact on the teachers' use of their knowledge of students' learning styles in teaching mathematics. In order to achieve the objectives of the study, the researcher sought answers to the three research questions in three phases. The next three sub-sections provide the conclusions for each of the three research questions.

8.2.1The teachers' views on the strategy of teaching mathematics according to students' learning styles

This section reports on the conclusions that were made by the researcher on the findings from the mathematics teachers' views of the strategy of teaching mathematics according to students' learning styles. Before getting the views of the mathematics teachers, the researcher investigated on what the teachers knew about students' learning styles. Therefore, the first part of this section presents conclusions on the knowledge of students' learning styles that the mathematics teachers possessed.

8.2.1.1 The mathematics teachers' knowledge of students' learning styles

The researcher made the conclusion that the secondary school mathematics teachers who participated in this study had some basic knowledge of students' learning styles. The conclusion was based on the findings that all of them were able to describe learning styles in ways that were in line with the definitions of learning styles found in literature. The teachers described learning styles in different ways, but from the descriptions given by the teachers,

the researcher observed that all of the descriptions given indicated that students had different learning preferences. When they described learning styles, the secondary school mathematics teachers gave reasons for the existence of some differences in students' learning styles. Some of the teachers defined learning styles simply as differences that existed in students on how they react to teachers' instructions. That group of teachers thought students' learning styles determine the rate at which a student follows the teacher's instruction. According to those teachers, some students understand instructions at once while others need time to understand the same instructions. Some of the teachers thought learning styles refer to the students' abilities to learn from either concrete or abstract ideas. The researcher also made the conclusion that some of the mathematics teachers believed that learning styles determine the teaching tools which teachers use when teaching mathematics. From the teachers' point of view, the type of learning or teaching tools that the students required depended on the students' abilities to learn from either concrete or abstract ideas. The teachers thought that some of their students needed to be taught using concrete teaching aids while others could learn from abstract ideas. That also meant that whenever possible, the teachers needed to allow their students to work with tangible objects so that those who preferred learning from concrete ideas could grasp the concepts taught. Another group of the mathematics teachers who took part in the study thought learning styles entail the students' abilities to learn either as individuals or as part of a group. A close analysis of the data obtained from the teachers indicated that the teachers thought learning styles explained the differences shown by their students on how they understood concepts.

The researcher concluded that the mathematics teachers who participated in this study had been exposed to formal knowledge on students' learning styles in three ways. They were exposed through the following ways: teacher training courses, peer discussions and the internet. However, despite being exposed to formal knowledge on students' learning styles, the teachers did not have knowledge on learning style models. Although two of the teachers who participated in this study could remember some few facts about the experiential learning style model, none of them could show full understanding of the learning style model. The researcher also concluded from the findings that the mathematics teachers did not carry out researches on their own on students' learning styles. Although some of the teachers indicated that they sometimes used the internet, their failure to show sound knowledge of formal learning style models was an indicator to show that research on how students learn was lacking.

Based on an analysis of the data found from the mathematics teachers, the researcher reached the conclusion that not all of the mathematics teachers had opportunities to attend to some in-service courses, especially on students' learning styles. This study revealed that the older the teachers were, the more they became more ignorant about issues involving their students' learning styles. To be more precise, teachers who had more than ten years of teaching experience could not remember anything about learning style models. That was an indicator that the teachers were not exposed to some in-service or refresher courses. In the researcher's point of view, exposing mathematics teachers to new knowledge by allowing them to go for refresher courses could have made them up-dated with current trends on the use of students' learning styles in mathematics teaching.

The researcher concluded that the teachers thought the learning styles of their students were determined by a number of factors. The factors could be classified into three categories. The three categories were social, psychological and biological factors. Social factors included the environment in which the students lived, including the people who socialised with the students. According to the teachers, the ways their students were socialised determined the ways they preferred to learn. For instance, the mathematics teachers stated that students who grew up in urban settings had different learning styles to those who grew up in rural settings.

Psychological factors comprised the students' personality traits. They included the students' self-esteem and attitude towards their teachers, mathematics as a learning area or towards learning in general. The teachers thought that students who had positive attitude towards their mathematics teachers viewed the teachers as subject experts and they were likely to develop patience to learn through teacher-centred methods. As found from the teachers who took part in this study, students who had positive attitude towards learning were likely to develop styles that enable them to learn even on their own without waiting for others to help or push them.

The researcher concluded that the majority of the secondary school mathematics teachers who participated in this study thought that biological factors played a major role in shaping the learning styles of their students. The biological factors that determined the students' learning styles, as stated by the teachers, included the students' physical abilities and disabilities as well as the ways the students' brains function. The teachers thought that their

students' dominant senses determined the learning styles of the students. For instance, those with strong sense of sight preferred learning through visual aids.

8.2.1.2 How the teachers' knowledge was reflected in the classroom

The results of the study, led to the conclusion that the mathematics teachers' knowledge of students' learning styles was reflected in the ways the teachers planned their mathematics lessons. Most of the teaching strategies that the teachers used in teaching mathematics depended on the learning styles of their students. Their decision to use group activities or individual tasks was determined by their students' learning styles. The researcher also found that the teachers' knowledge of students' learning styles determined the teachers' choices of teaching aids used in their lessons. The results of the study also revealed that the methods that the mathematics teachers used to assess their students were apart from being guided by the national syllabi, were also guided by the teachers' knowledge of their students' learning styles. In a nutshell, the teachers' knowledge of students' learning styles was reflected in the choices of teaching strategies, assessment strategies and teaching aids.

The knowledge was also reflected in how most of the teachers budgeted their teaching time. The study revealed that the teachers used their knowledge of their students' learning styles to decide on the time needed for their students to perform certain tasks. That also included decisions made by the teachers on whether they had to give group or individual tasks to their mathematics students considering the time demanded by the students' learning styles. The time required to teach particular topics in mathematics and the pace at which the mathematics teachers moved with their work were also dependent on the knowledge that the mathematics teachers had on the learning styles of their students.

However, although the teachers' knowledge of students' learning styles was reflected in the ways the teachers planned, delivered and assessed their lessons, the study led to the conclusion that not all of their students benefited from their instructions. An analysis done on the lessons that were observed by the researcher revealed that most of the tasks that were given to students by the teachers required the students to follow mathematical formulae, algorithms and rules. Those activities catered for *mastery maths learners* as stated by Perini, Silver & Strong (2000). Therefore the researcher concluded that *mastery maths learners* were catered for by the teachers' lessons more than any the other learning styles. On the other hand, *self-expressive learners* were not considered in most of the lessons observed. *Self - expressive maths* learners needed opportunities to use their creativity, imaginations and logic

in solving problems in mathematics. However, such activities were not given to the students by the mathematics teachers as observed in this study. The study also revealed that mathematical proofs and non routine problems were rarely given to the students.

The results of the study also led to the conclusion that the teaching methods that were used by most of the mathematics teachers were mostly teacher-centred. Most of the lessons observed during this study were taught using the lecture method. The researcher therefore concluded that students who preferred learning by experimenting or through trial and error were not fully catered for by the teachers. Such students preferred student-centred methods that could keep them active during the lessons. From the researcher' point of view, the lessons taught by the teachers were supposed to be balanced. The researcher considered a balanced lesson as a lesson that allows students to carry out a variety of tasks to meet the demands of the varying learning styles of the students in the class. The tasks should be carefully planned so that each class of learners is kept active during the lessons. However, in some of the lessons observed by the researcher, some of the mathematics teachers used a variety of activities in an effort to meet the demands of their students' learning styles.

8.2.1.3 The mathematics teachers' views on the strategy of teaching mathematics according to the students' learning styles

The researcher concluded that the mathematics teachers thought that teaching students according to their learning styles had more advantages than disadvantages to both the learners and their teachers. According to the teachers, for the students, the strategy ensures that they enjoyed their lessons and became active participants in the learning process. The strategy motivates students to learn as they enjoy all the lesson phases. The mathematics teachers thought that the strategy of teaching students according to their learning styles motivates students as they learn comfortably in their preferred way of learning. Another group of the teachers thought the motivation comes from the success that the students experience in their learning. According to the data obtained in this study, the strategy improves the performance of mathematics students and from the mathematics teachers' point of view, once students' performance improves; the students develop positive self-esteem and become motivated to learn more. The students realise their abilities to get better grades and become more optimistic in their school work. According to the mathematics teachers, development of positive self-esteem in students is an advantage that students get by learning according to their learning styles. The mathematics teachers also thought that the strategy reduces mathematics anxiety in students. According to the teachers, fear of mathematics is caused by

continuous failure. Hence when the students realise that they have the potential to perform well in mathematics, anxiety is reduced in them. In addition to reduction in anxiety, the mathematics teachers also felt that the strategy of teaching students according to their learning styles improves students' self-efficacy and attitude towards mathematics. The teachers thought that the strategy develops positive attitude in the students towards mathematics learning.

The results of the study revealed that teachers thought mathematics teachers also get some advantages from the strategy of teaching students according to their learning styles. By making use of students' learning styles when teaching mathematics, the teachers are able to individualise their teaching instructions so that all their students are kept active during their lessons. As put forward by the teachers who participated in this study, the strategy assists the teachers to use student-centred methods that are determined by the students' learning styles and not by the teachers' independent decisions. When using the strategy, the teachers are able to individualise their instructions so that their instructions suit each and every student in their classes.

Another advantage that the teachers realised from the strategy of teaching students according to their learning styles was that it makes the teachers' work easier and less stressful. From the participants' point of view, when the performance of the students improves, the teacher's work is made less stressful. According to the mathematics teachers, new topics and those topics that are challenging to students can easily be introduced to students in their preferred learning styles. The student will then be exposed to other methods when they grasp the concepts. Data obtained from the mathematics teachers also indicated that by teaching their students in the students' preferred learning styles, the teachers are able to foresee some likely problems that their students face in learning mathematics. The teachers thought that foreseeing problems that students are likely to face during their learning enables the teachers to prepare remedies in advance. Suitable teaching aids can be sought in time so that the students' understanding can be enhanced.

The researcher also made the conclusion that the mathematics teachers felt that the strategy of teaching mathematics according to students' learning styles has its own problems. The problems which the participating teachers identified were the need to have enough time and reasonable working load. Some of the teachers who participated in this study thought that the strategy is time consuming and is difficult to implement when teaching a large class. The

teachers reported that the strategy involves assessing all students in the class and making follow-ups on each one of them in order to make sure that all of them are catered for by the teacher's instruction. According to the data obtained from the mathematics teachers, making follow-ups on each and every student made it difficult for them especially in the cases where the classes were large. The teachers who participated in this study therefore suggested that for the strategy to be more effective, mathematics classes should be kept reasonably small. The teachers also suggested that mathematics teaching be allocated enough time for mathematics teachers to individualise their teaching to meet the demands of their students' learning styles.

Another problem that the participating mathematics teachers thought was associated with the strategy of teaching students according to their learning styles was that the strategy produces students who are not flexible to explore different alternatives to solve problems in mathematics. The teachers felt that students need to develop skills to learn through varying methods used by teachers. According to the teachers with that kind of thought, teaching students in their preferred ways all the time makes them too rigid in their learning. The teachers felt that a good student is one who is flexible in learning and is able to learn through different learning styles. In the researcher's point of view, basing on the findings of this study, the strategy requires the teachers to be more tactful in the ways they utilise their students' learning styles. The teachers should make sure that their students are also exposed to their less preferred learning styles. By so doing, the teachers make sure that students are more flexible when it comes to solving mathematics problems.

8.2.2 How the mathematics teachers used their knowledge of students' learning styles when teaching mathematics

This section gives conclusions that were made by the researcher on how the mathematics teachers who participated in this study used their knowledge of students' learning styles when they were teaching mathematics. The conclusions were made on the teaching strategies, teaching aids and assessment strategies that were used by the teachers.

8.2.2.1 Teaching strategies used by the mathematics teachers when teaching mathematics

The findings of this study led to various conclusions on how the mathematics teachers utilised their knowledge of students' learning styles. Generally, the mathematics teachers made efforts to vary their teaching strategies when they were teaching mathematics. The

strategies they used included peer group discussions, individual tasks, projects, guided discovery, demonstrations, illustrations, interactive e-learning, expositions and inquiry. The data obtained through face to face interviews with the teachers revealed that the most commonly used strategy was peer group discussion. Students were given some activities to perform in groups as they discussed as peers. Small groups with not more than three members in each group were used. All the mathematics teachers confirmed during the interviews that they used peer group discussions when teaching mathematics. The data obtained from the teachers indicated that all the mathematics teachers who took part in this study felt that peer group discussions were very effective in the teaching of mathematics. In their opinion peer group discussions were suitable for the majority of their learners. As expressed by the mathematics teachers, peer group discussions enable students to express their ideas in mathematics. However, they were of the view that discussions require enough time. The teachers complained that they failed to get the required time for them to allow their students to interact amongst themselves. Although the data obtained through face to face interviews indicated that all the teachers who took part in this study agreed that peer group discussions were effective when used in teaching mathematics, the researcher observed during lesson observations that most of the lessons observed were taught using lecture method. The teachers stated during interview sessions that they gave their students tasks to perform as individuals.

Apart from peer group discussions, the mathematics teachers used individual tasks when teaching mathematics. According to the research findings, all the mathematics teachers who participated in this study used individual tasks in their mathematics lessons. The findings of the study indicated that individual tasks were given even after peer group discussions. In so doing the teachers tried to balance their lessons by making sure that those who disliked group discussions found comfort in performing individual tasks.

The teachers also used projects as a strategy of teaching mathematics. Projects were used by more than half of the teachers who took part in this study. According to the teachers, projects were given during and after mathematics lessons. Some of the teachers reported that they normally gave assignments in the form of projects when they introduced new topics. Projects were given to students in twenty seven out of one hundred and twenty-six lessons analysed in this study. The projects were done by the students in either groups or as individuals.

Demonstrations and illustrations were also used by the mathematics teachers. The results of the study revealed that demonstrations and illustrations were used by all the mathematics teachers who participated in this study. The teachers thought that demonstrations gave their students directions on how they could solve given mathematics problems hence they were very effective in the teaching of mathematics. Data obtained from the teachers' lesson plans indicated that demonstrations were the mostly utilised teaching strategy.

Guided discovery, inquiry, expositions and interactive e-learning were the least used strategies by the mathematics teachers. According to the teachers, they guided their students to uncover some patterns or trends in the concepts they learned. They thought students needed guidance for them to make mathematical inferences on relationships, patterns and trends that arise in mathematics. The inquiry method was used by just a few of the mathematics teachers who took part in this study. According to the data obtained in this study, the few teachers who used the inquiry method of teaching mathematics combined it with the use of information and communication technology systems (ICT). Interactive e-learning strategies required the use of information and communication technology (ICT) systems. The majority of the teachers who participated in this study did not use ICT for a number of reasons. The major reason was shortage of computers. Some of the other reasons were computer illiteracy on the part of the mathematics teachers, shortage of time to individualise instruction, shortage of electricity, lack of support from school authorities and negative attitude held by the mathematics teachers towards use of technology.

The researcher concluded, basing on the study findings that the mathematics teachers who took part in this study gave a variety of learning activities to their students although in the lessons observed, the teachers had a bias towards activities that required students to use their drawing skills. The students drew graphs of linear, quadratic and cubic functions. The graphs were drawn to scale. After drawing the graphs, students were asked to use their graphs to identify given points on the graphs. They were also asked to estimate values of variables found on the graphs. In some of the cases the students were asked to locate points on the graphs. The points included maximum points, minimum points and roots of given equations. The students were also asked to give coordinates of points on a Cartesian plane.

Activities that required students to apply mathematics concepts to real life problems were also commonly given to the students unlike learning activities that required students to use their logic, imaginations and creativity. *Interpersonal maths students* benefited from the

activities that required them to apply mathematics concepts to real life situations. The results of this study indicated that there were very few cases when students were required to use logic in solving problems in mathematics. The results also revealed that in very rare cases students were asked to use their imaginations and creativity in solving given mathematics problems. Since students were not given enough practice on activities that challenged them to use logic, imaginations and creativity, the researcher concluded that *self-expressive learners* were not fully catered for by the mathematics teachers' teaching strategies in most of the lessons that were observed by the researcher.

The researcher also concluded that learning activities that required students to identify patterns, relationships and trends that existed among concepts in mathematics were rarely given to the students by their mathematics teachers. The researcher also found that the mathematics teachers did not task their students to prove mathematical formulae. In all the lessons observed by the researcher, the teachers did not give their students tasks which required them to prove the formulae they used. The students were simply asked to apply given formulae. As a result of that, the researcher made the conclusion that *mastery maths students* benefited more than *understanding maths students* in most of the lessons taught by the teachers since according to Perini et.al. (2000), *mastery maths students* prefer solving problems that require them to apply formulae or rules whilst *understanding maths students* prefer proving formulae before using them

8.2.2.2 The teaching aids used by the teachers when teaching mathematics

The researcher concluded that the teaching aids which the mathematics teachers used when they were teaching mathematics were classified into four classes which were visual, audio, tactile and ICT systems. Tactile teaching aids were the mostly used type of teaching aids by the mathematics teachers who participated in this study. Those were teaching aids that could be manipulated by the students and the teacher. They included mathematics drawing instruments that were used by the students when they were drawing graphs and sketches of functions. This was because in most of the lessons observed, the students were asked to draw graphs. Tactile teaching aids were used to perform individual tasks. Visual teaching aids were also used in a number of lessons. The visual teaching aids were in the form of charts with diagrams, question strips and chalkboard with illustrations or exercises. According to the mathematics teachers who took part in this study, visual teaching aids were very effective when teaching most of the concepts in mathematics.

The use of audio teaching aids was not common among the mathematics teachers. Audio teaching aids were used in very few lessons. In the lessons observed, they were rarely used by the mathematics teachers. The forms of audio teaching aids that the mathematics teachers used in the lessons observed were audio tapes and radio lessons.

Information and communication technology (ICT) systems were rarely used by the mathematics teachers when they were teaching mathematics. Only ten percent (10%) of the mathematics teachers who took part in this study used ICT in their lessons. According to the teachers, their failure to use ICT was attributed to a number of reasons which included non availability of computers and computer illiteracy on the part of the teachers

In some of their lessons, the mathematics teachers did not use teaching aids. This was confirmed by the data obtained from the mathematics teachers' lesson plans. However, during face to face interviews, some of the teachers gave reasons that justified their failure to use teaching aids in their lessons. The reason was that they needed to expose their students to their less preferred learning strategies.

Generally, the researcher concluded that most of the teaching aids that were used by the mathematics teachers in most of the lessons observed were carefully chosen to suit the needs of the students' learning styles.

8.2.2.3 How the mathematics teachers assessed their students

The results of the study led to the conclusion that the mathematics teachers were guided by the national syllabi when they assessed the learning progress of their students. The researcher found that some of the tasks given to the students by the mathematics teachers as assessment tasks were targeted for particular learning style classes of the students. The competence levels of the students were assessed during and after a learning process. Both formative and summative assessments were done by the mathematics teachers. In most of the cases, the mathematics teachers used some assessment tasks which were varied to suit the different learning styles of the students. The researcher made an analysis of the tasks given by the teachers and observed that some of them were meant to assess the students' skills to draw and interpret graphs. Those tasks were suitable for *mastery maths learners* and *understanding maths learners*. Some of the tasks tested the students' abilities to communicate ideas in mathematics. Such tasks were specially meant for *interpersonal maths learners* and *self expressive maths learners.* Application of mathematics concepts to real life situations and to other learning areas was also assessed by the mathematics teachers. Those were tasks that

were meant for *interpersonal maths learners.* Students were also assessed on their abilities to identify patterns, develop mathematical models and draw some inferences from the patterns they discovered. Such tasks were targeted for the *understanding maths learners*. Few of the mathematics teachers also assessed the students' use of ICT in solving mathematical problems. In this study, it was revealed that students were sometimes tasked to draw graphs using ICT tools.

Although the mathematics teachers assessed the progress of their students, the results of this study revealed that they did not use standard assessment tools to assess their students' learning styles. Standard tools like Kolb's learning styles inventory (LSI) and Honey and Mumford's learning styles questionnaire were not used by the teachers. These assessment tools help to identify students' learning styles. From the researcher's point of view, the teachers relied on the performance of the students and a set of behaviours displayed by the students when they wanted to identify the learning styles of the students.

8.2.3 How barriers affected the mathematics teachers' utilisation of their knowledge of students' learning styles when teaching mathematics

This section presents the conclusions made by the researcher on the barriers that affected the mathematics teachers' use of their knowledge of students' learning styles. The barriers were classified into the following classes: teacher related barriers, students related barriers, and curriculum related barriers and socio-economic barriers.

8.2.3.1 Teacher related barriers and how they impact on the teachers' use of their knowledge of students' learning styles

The results of the study pointed to the fact that the mathematics teachers were affected by a number of teacher related barriers when they intended to use their knowledge of students' learning styles. Teacher related barriers were the most common barriers that affected the mathematics teachers. They resulted from the personal skills and attributes of the mathematics teachers. The barriers included lack of exposure, lack of experience, lack of self advancement and lack of knowledge to integrate mathematics with other learning areas. The study findings revealed some of the teachers lacked exposure to different learning environments with students of different learning styles. The teachers who lacked exposure had limited knowledge on how best they could assist their students. They were unable to employ a variety of teaching strategies to meet the demands of the learning styles of their students. Those teachers sometimes overused the lecture method of teaching.

Some of the teachers who participated in this study felt that they lacked the required experience to teach their students according to their learning styles. However, an analysis of the mathematics teachers' lengths of teaching experience did not agree with what the teachers stated during interviews that they lacked enough experience to teach their students according to their learning styles. In the researcher's opinion, the teachers had adequate experience to teach students according to their learning styles since most of them had more than five years of teaching experience. The researcher concluded that professional advancement was lacking on the part of the teachers. According to the data obtained in this study, the teachers did not get opportunities to go for in-service courses. The teachers needed to be professionally advanced by attending to some in-service courses that could help to improve their professional conduct with students.

This study led to the conclusion that the mathematics teachers' own learning styles were a barrier to the effective use of the teachers' knowledge of students' learning styles. The results of the study revealed that the participating teachers' own learning styles dominated their teaching styles to an extent that they disregarded the learning styles of their students. The teachers taught their students in the ways the teachers preferred being taught.

Lack of collaboration was also a serious barrier to the teachers' effective utilisation of students' learning styles. More than half of the mathematics teachers who participated in the study stated that they were failing to work together as teachers due to various reasons. They indicated that sharing ideas was not possible in their cases. According to the teachers, some of their colleagues were aloof and they kept their knowledge to themselves.

Apart from failing to share ideas amongst themselves, some of the teachers failed to create friendly learning environments in their classrooms. As put forward by some of the teachers, negative relationship between the teachers and their students made it difficult for the teachers to implement the strategy of teaching students according to their learning styles. They could not maintain effective rapport between themselves and their students. The bad relationship that existed created a boundary between the mathematics teachers and their students. Because of the relationship, students could not seek help from the teachers whenever they faced problems. The teachers on the other hand, could not identify areas where their students needed assistance. In the end, mismatches between the teachers' teaching methods and the students' learning styles resulted.

Another conclusion made from the results of this study was that some of the participating teachers simply lacked passion for work. Lack of commitment affected the effective use of their knowledge of students' learning styles. They were not commitment to go an extra mile to assist their students when they needed assistance. The teacher could not give themselves time to assess the learning styles of their students. Such teachers worked only because of other driving forces behind them. The teachers had no patience at all in taking their time to plan, deliver and evaluate lessons to make sure that no student was left behind.

Lack of subject content knowledge and failure to integrate mathematics learning with other learning areas also impinged on the teachers' use of their knowledge of students' learning styles. The results of the study revealed that lack of subject content knowledge inhibited the teachers' use of relevant examples to enhance students' thinking. Those teachers depended on textbooks as sources of teaching instructions. The teachers were not flexible enough to think of examples drawn from familiar situations to the students so that the students could easily understand the concepts taught.

Failure to assess the students' learning styles was also found to be another barrier that made it difficult for the teachers to teach their students in their preferred learning styles. According to the results of this study, the mathematics teachers lacked knowledge of learning styles models and learning styles assessment tools. As a result, the teachers could not correctly assess the learning styles of their students.

Failure to budget time was also found in this study as a barrier that impinged on the mathematics teachers' use of their knowledge of students' learning styles to the best advantage of the students. The researcher observed that some of the mathematics teachers failed to utilise the time available for them to teach their students. In the lessons observed by the researcher, some of the teachers wasted time allocated to them emphasising on less important aspects of the lessons.

8.2.3.2 Student related barriers and how they impact on the teachers' use of their knowledge of students' learning styles

The results also led to the conclusion that the students themselves also contributed towards the teachers' failure to utilise their knowledge of students' learning styles, during mathematics lessons. The students affected the teachers' work through negative behaviours. Such behaviours, which were displayed by the mathematics students, had a negative effect on the effective utilisation of the mathematics teachers' knowledge of their students' learning

styles. Those were behaviours like too much absenteeism, indiscipline, lack of commitment and lack of practice. Of all the negative behaviours displayed by the students, absenteeism was the most common problem among the mathematics students. The study revealed that more than half of the teachers complained of absenteeism by their students as a factor that let them down when they wanted to teach their students according to their learning styles. The students failed to attend lessons taught by the teachers. As a result, the mathematics teachers could not assist them or they ended up losing patience to assist them. The teachers complained that could not cover the required content within the stipulated duration of the course.

Indiscipline by the mathematics students was also another student-related barrier. According to the data obtained from the mathematics teachers, it was difficult for the teachers to work with students who lacked discipline. The students sometimes refused to follow the teachers' instructions.

Lack of concentration and lack of practice on the part of the mathematics students also betrayed the mathematics teachers' efforts to assist the students. The mathematics teachers expected their students to give themselves further practice after formal lessons. However, not all of the students had time to concentrate with their school work after school learning hours. Some of them were forced to do their school work during lessons. According to the mathematics teachers, the students were not motivated to work on their own without coercion from their mathematics teachers. As explained by the mathematics teachers who participated in this study, lack of concentration was mainly caused by negative self-esteem and negative attitude towards mathematics held by the students. Negative self-esteem on the part of the students was also another barrier to the mathematics teachers' use of their knowledge of students' learning styles. The students with negative self-esteem were not optimistic in their learning. As a result, the teachers found it hard to assist them as the students themselves thought they were not able to perform well in mathematics. In addition to negative self-esteem, the students had negative attitude towards mathematics learning. The students' attitude retarded their learning progress.

8.2.3.3 Curriculum related barriers and how they impact on the teachers' use of their knowledge of students' learning styles

This study revealed that some of the barriers that affected the mathematics teachers when they tried to teach their students according to their learning styles were also related to the

curriculum that guided the teachers' work. Curriculum related barriers included policies that were crafted by the parent ministry as guidelines for the teachers. Of much concern to the mathematics teachers were policies on the minimum expected number of exercises to be done by mathematics students in a week. According to the teachers who took part in this study, the minimum number of written exercises required by the policy they used was too high for them. The policy did not take into consideration for students to perform practical tasks. It focused on written work only. In the teachers' opinion, there was a need to consider include other tasks which students needed to perform when they learn mathematics. The tasks include projects, field trips, experiments and others. As found from the teachers, such policies forced them to give written exercises for the sake of fulfilling the requirements of the policy. The researcher found that the teachers gave written exercises to their students even when practical tasks were appropriate. From the researcher's point of view, the policy affected the development of the psychomotor domain in the mathematics students.

Another curriculum related barrier was long syllabi. Long syllabi resulted in the teachers disregarding the learning styles of their students and resorting to rote methods of teaching that enabled them to cover all the concepts in the syllabi within the required period.

Dictated policies and frequent changes in policies were also some of the barriers to the teachers' use of their knowledge of learning styles. The participating teachers indicated that consulting practising mathematics teachers when crafting policies could ensure that all students despite their learning styles are catered for during the learning process. The teachers thought that dictated curriculum affected them when they tried to assist their students during mathematics lessons. They stated that the curriculum they were following was put in place by non-practising teachers who were no longer teaching mathematics. As a result the curriculum failed to meet the demands of the different learning styles of the students. Results of this study indicated that the mathematics teachers also thought that frequent changes in policies were not supportive to the strategy of teaching students according to their learning styles. The teachers felt that frequent changes to policies wasted their time for teaching their students as they spent valuable time trying to adjust to the changes in the policies.

8.2.3.4 Socio-economic barriers and how they impact on the teachers' use of their knowledge of students' learning styles

The researcher also concluded that socio-economic statuses of the students and that of the schools affected the mathematics teachers when they tried to use their knowledge of students'

learning styles. This study revealed that the most common barrier under this category was overloading of mathematics teachers. The study led to the discovery that the mathematics teachers were overloaded. They had too many lessons to deliver in a week and some of them had too many activities to do at their respective schools. Some of the mathematics teachers were committed to other duties which made them too busy to assist their mathematics students, as expected. Some had too many lessons which left them with little time to plan and effectively deliver their lesson in ways that benefited all their students. The researcher also observed that some of the classes taught by the teachers who took part in this study were too large for the teachers to consider the learning style of each of the students in the classes.

Shortage of required learning materials also impeded on the teachers' utilisation of their knowledge of students' learning styles. Teachers at most of the schools chosen for this study, especially those in the rural areas, did not have adequate learning materials to use as teaching tools. The data obtained in this study indicated that the student to textbooks ratio at most of the schools used in this study were too high. Apart from having inadequate learning materials at school, the financial backgrounds of some of the students also affected their teachers. The teachers who took part in this study reported that they expected their students to continue practising even outside school hours. However, the students did not have extra learning materials to use when they were out of school.

The findings of this study also led to the conclusion that poor time tabling also affected the teachers when they taught their students according to the students' learning styles. Some of the schools chosen for this study did not religiously follow set time tables. Events that took place at the schools encroached into the time allocated for mathematics teaching. This resulted in reduction of learning time for mathematics learners. Poor time-tabling of events at the schools also contributed to the mathematics teachers' failure to utilise their knowledge of students' learning styles as some of the events that took place at their schools disturbed their lessons resulting in them resorting to teaching strategies that allowed them to cover many topics in a short period.

This study also concluded that perceptions held by the society on mathematics had an effect on how the mathematics teachers used their knowledge of students' learning styles when teaching mathematics. Negative perceptions of mathematics as a subject, held by members of the society, resulted in lack of support from the members of the community and lack of

seriousness on the part of the teachers and the students. The negative perceptions caused laziness in students as they felt that they were not capable of producing better results.

Bad working conditions at school also had a negative impact on how the mathematics teachers utilised their students' learning styles. In this study, the teachers who took part, complained of unfavourable working conditions which they said were de-motivating them. Some of the unfavourable working conditions were caused by bad relationship among the teachers themselves.

The results of the study also pointed out to the fact that the nature and effect of the socio-economic barriers depended on the responsible authorities of the schools. Data obtained in this study revealed that overloading of teachers and shortage of learning materials were associated with government and local council owned schools. Poor time-tabling and bad working conditions were associated with church owned and those schools owned by private owners.

8.3 Recommendations

Based on the findings of this study, the researcher made the following recommendations.

8.3.1 General recommendations

The researcher recommends that mathematics teachers regularly go for in-service or self advancement courses. It was noted from the research that some of the mathematics teachers who participated in this study indicated that they had learnt about students' learning styles but they had forgotten some of the important facts about learning style models. Had it been that the teachers regularly attended some in-service courses, the teachers would have been kept reminded of the important facts. Hence mathematics teachers need to be kept up-dated by being exposed regularly to issues concerning the learning of their students.

The researcher also recommends that collaborative teaching be encouraged among mathematics teachers. Mathematics teachers should share ideas on issues which are likely to improve their teaching. Collaborative teaching opens avenues for mathematics teachers to assist each other and keep each other up-dated with current trends in teaching. Collaborative teaching can even be done by teachers at different schools. Visits can be organised by the mathematics teachers to visit their colleagues at other schools. Such visits serve to expose the teachers to different learning environments.

Mathematics workshops and panel meetings should be held in schools so as to ensure that mathematics teachers discuss and share ideas on the ways they can improve mathematics teaching. It is during such discussions that teachers reflect with each other on how best they can ensure that their teaching methods benefit each and every student under their care. Mathematics clubs and associations should also be formed by the mathematics teachers or their students as a way of improving cross pollination of ideas among the members.

The researcher recommends that mathematics teachers should teach their students according to the students' learning styles. Teacher should consider their students' learning styles when planning, delivering and evaluating mathematics lessons. If teachers disregard the learning styles of their students, they risk the existence of some mismatches between their students' learning styles and the teaching styles of the teachers. As found in this study, the mismatches cause boredom in students as they experience discomfort and prolonged failure. Teaching students according to their learning styles have many benefits to the students. One of the most important benefits is that the students enjoy learning since they learn in comfortable ways to them. Other advantages include reduction of anxiety in students and development of positive attitude in students towards mathematics learning.

Teaching strategies and activities should be tactfully planned and be varied to ensure that all students despite their learning styles benefit from the instructions given by the teachers. Using the same strategy over and over again makes some students passive. Only those who enjoy the strategies used will be active. Both group discussions and individual tasks are equally important in mathematics teaching. This is because some students prefer discussing with their peers while others prefer working as individuals.

Mathematics students should be allowed to use their creativity, imaginations and innovations when they learn mathematics. Learning styles that promote such activities are preferred by some mathematics students. The data obtained in the study indicated that mathematics teachers rarely consider giving their students such learning activities.

The researcher also recommends that the mathematics teachers themselves be aware of their own learning styles. Such awareness ensures that the teachers' learning styles do not dominate their teaching styles at the expense of the students' learning styles.

In order to effectively utilise students' learning styles, the researcher recommends that mathematics should not be taught in isolation. Mathematics learning should be integrated

with other learning areas. By integrating mathematics with other learning areas, the teachers utilise the skills and experiences brought by students from the other learning areas. Integration of mathematics with other learning areas is also a way of applying mathematics concepts to real life situations.

Mathematics teachers should always create free and fair learning environments in their classrooms. For mathematics teachers to successfully teach their students according to the students' learning styles, student friendly environments should be created by the teachers. Students should always be free to seek assistance from the teachers. The teachers on the other hand should be open for discussions with their students whenever need arises. Friendly learning environments assist in reducing unfavourable behaviours by the students. Students sometimes misbehave or absent themselves from school because teachers fail to create conducive environments for free and fair learning.

Mathematics classes should always be kept reasonably small, in terms of number of students in the classes and the mathematics teachers should not be overloaded. As found in the study, large classes and overloading made it difficult for the mathematics teachers to attend to the needs of all their students. Teaching according to students' learning styles is a learner-centred approach to teaching hence it is largely determined by the students' attributes. The approach demands that the teachers know the learning habits of each and every student under their care and plan instruction that suit the needs of the students.

The researcher also recommends that school responsible authorities and other stakeholders should make sure that learning materials required by mathematics students are available for the students and their teachers to use. The results of this study revealed that one of the barriers that affected the mathematics teachers when they were teaching mathematics was shortage of learning materials. The teachers themselves are encouraged to improvise when learning materials are in short supply, for instance, teachers can make use of their cell phones in cases where computers or calculator are required.

Consideration of students' learning styles should be made when crafting syllabi and policies to be used by teachers and students. Thorough research on the suitability of the content to the intended students is necessary. Most importantly, mathematics teachers should not be left behind in the planning stages of the curriculum. They should be consulted. Consulting teachers helps to ensure that the policies are properly crafted for the benefit of all students.

8.3.2 Recommendations for further studies

The researcher recommends that the following further studies be done in future:

i. A replication of this study in different settings. The researcher found it important for the study to be done in other settings so that the results of this study can be compared with the results from other environments. It serves to establish if the results of this study were affected by the environments in which the study was done.

ii. A study to establish the general proportions of learning styles displayed by students in a normal mathematics class. In my opinion as the researcher, it is important for mathematics teachers to know the learning style of the majority of students in their classes. The information is important to mathematics teachers for planning purposes. For instance when looking for teaching aids to use in a lesson the teacher should have a rough idea of how many students prefer which type of materials.

iii. A study on the relationship between learning styles and performance of the students. As the researcher I felt it very important in future to investigate whether learning styles of the students affect the performance of the students. It should be established if students with particular learning styles perform better than students with other learning areas.

iv. A study to establish if factors like gender and age affect the learning styles of the students. As the researcher, I find it very important for teachers, especially mathematics teachers, to investigate if learning styles differ on the basis of the gender or age of the learner. It is important to find out if girls have different learning styles from boys and to find out if the learning style of an individual change as the individual grows or becomes older.

8.4 Chapter summary

This chapter presented conclusions and recommendations made by the researcher from the study. The chapter started by giving the conclusions that were made by the researcher from the results that were obtained from this study. It then proceeded to present the recommendations that were made by the researcher.

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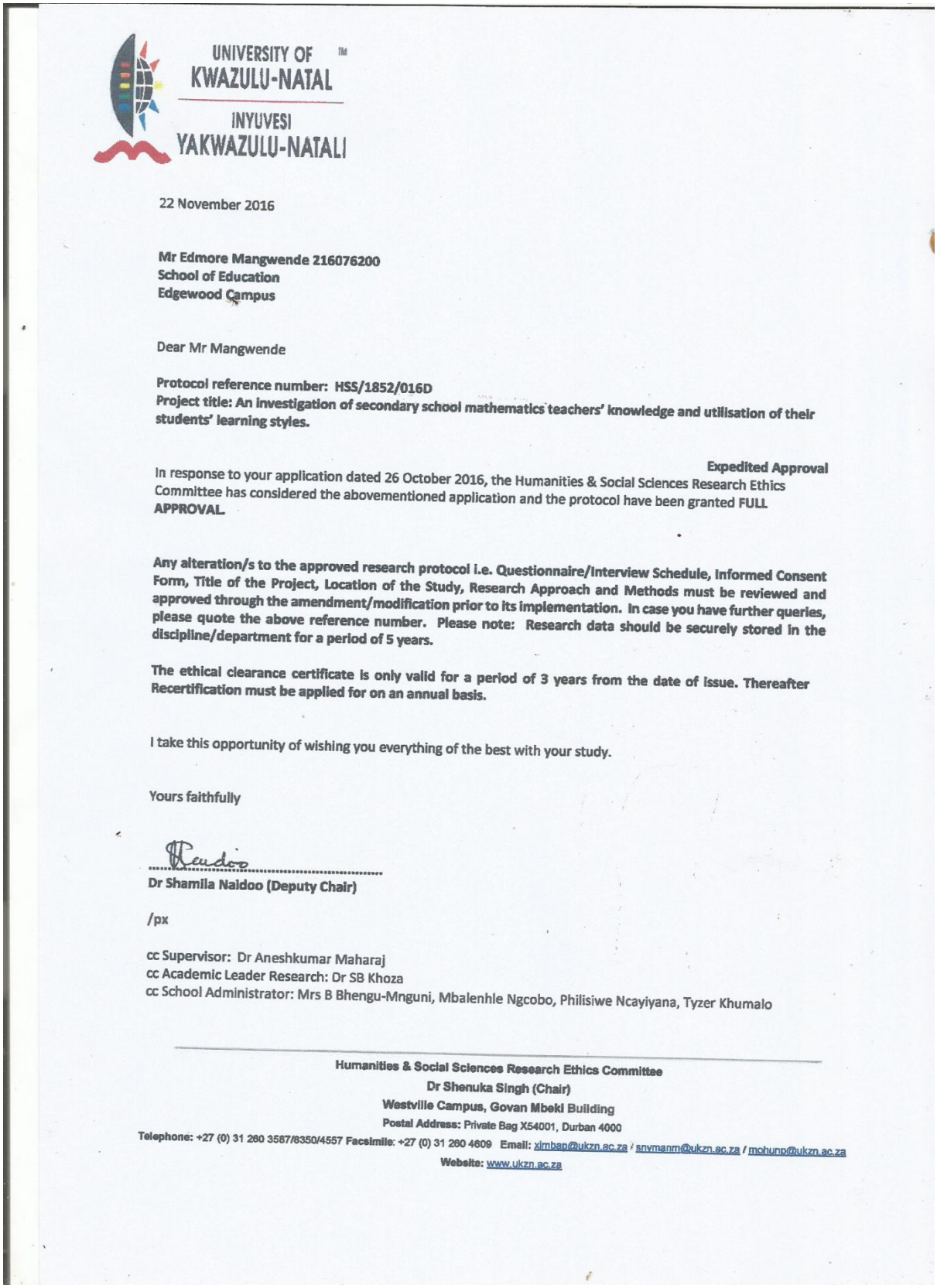
APPENDICES

Appendix 1: Ethical clearance



UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

22 November 2016

Mr Edmore Mangwende 216076200
School of Education
Edgewood Campus

Dear Mr Mangwende

Protocol reference number: HSS/1852/016D
Project title: An investigation of secondary school mathematics teachers' knowledge and utilisation of their students' learning styles.

Expedited Approval

In response to your application dated 26 October 2016, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have 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

.....
Dr Shamila Naidoo (Deputy Chair)

/px

cc Supervisor: Dr Aneshkumar Maharaj
cc Academic Leader Research: Dr SB Khoza
cc School Administrator: Mrs B Bhengu-Mnguni, Mbalenhle Ngcobo, Philisiwe Ncayiyana, Tyzer Khumalo

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

Appendix 2: Permission from the Permanent Secretary of Zimbabwe's Ministry of Primary and Secondary Education

All communications should be addressed to
"The Secretary for Primary and Secondary Education"
Telephone: 799914 and 705153
Telegraphic address : "EDUCATION"
Fax: 791923

ZIMBABWE

Reference: C/426/3 Manicaland
Ministry of Primary and Secondary Education
P.O Box CY 121
Causeway
Harare

15 November 2016

Mangwende Edmore
St. No. 216076200
Vengere High School
Box 53 Rusape
Zimbabwe

RE: **PERMISSION TO CARRY OUT RESEARCH IN MAKONI DISTRICT AT VENGERE,ST JOSEPH,CHIUNDU, TSANZAGURU. MT CAMEL, RUKWEZA, HIGH,TSINDI, CHITSVA, MANONGA AND CHAMAKUMBU SECONDARY SCHOOLS : MANICALAND PROVINCE**

Reference is made to your application to carry out a research at the above mentioned school in Manicaland Province on the research title:

"MATHEMATICS TEACHERS' KNOWLEDGE AND UTILISATION OF THEIR STUDENTS' LEARNING STYLES"

Permission is hereby granted. However, you are required to liaise with the Provincial Education Director Manicaland Province, who is responsible for the schools which you want to involve in your research. You should ensure that your research work does not disrupt the normal operations of the school. You are required to seek consent of the parents/guardians of all learners who will be involved in the research.

You are required to provide a copy of your presentation and a report of what transpired to the Secretary for Primary and Secondary Education by December 2016.

MIN. OF PRY. & SEC. EDUCATION
POLICY PLANNING RESEARCH
AND DEVELOPMENT
15 NOV 2016
P.O. BOX CY 121, CAUSEWAY
ZIMBABWE

E.Chinyowa
Acting Director: Policy Planning, Research and Development
For: **SECRETARY FOR PRIMARY AND SECONDARY EDUCATION**
cc: PED – Manicaland Province

Appendix 3: Permission from Manicaland Provincial Education Director's office

Vengere High School

P.O. Box 53

Rusape

16 November 2016

The Provincial Education Director

Ministry of Primary and Secondary Education(Manicaland Province)

Mutare

Dear Sir

REF: APPLICATION FOR PERMISSION TO CARRY OUT A RESEARCH IN SCHOOLS: MAKONI DISTRICT: MANICALAND PROVINCE

I am applying for your permission to carry out a research in your schools in Makoni District in Manicaland Province. I am a PhD student with the University of Kwazulu Natal, Faculty of Humanities- college of Education (Edgewood Campus). I am carrying out a research on mathematics teachers' knowledge and utilisation of their students' learning styles. The research intends to contribute towards improved mathematics teaching by exploring possible causes of mismatches between mathematics teaching and mathematics learning. For more information contact the researcher at mangwendeeddy@gmail.com or the supervisor at maharaja32@ukzn.ac.za.

Please find attached the following document;

-a letter granting permission from the Acting Director: Policy Planning, Research and Development

Thank you

Yours faithfully

Mangwende Edmore

MINISTRY OF PRIMARY AND SECONDARY EDUCATION
DEPUTY DIRECTOR SECRETARY
16 NOV 2016
P.O. BOX 146, MUTARE
ZIMBABWE TEL: 020 60[illegible]

Granted.

Appendix 4: Permission from the Head of Chamakumbu Secondary School

The School Head

Chamakumbu Secondary School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I..MANDEYA R. ..being the School Head of CHAMAKUMBU SEC ..school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

HEAD
CHAMAKUMBU SEC SCH
BOX 340 RUSAPE
DATE 18/11/16 SIG
CELL

Appendix 5: Permission from the Head of Chiundu High School

The School Head

Chiundu High School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I.....CHIYANIKE T.....being the School Head of CHIUNDU HIGH.....school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

THE HEAD
CHIUNDU HIGH SCHOOL
18 NOV 2016
P.O. BOX 590, RUSAPE
Email: chiunduhighs@gmail.com

Appendix 6: Permission from the Head of Manonga Secondary School

The School Head

Manonga Secondary School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I PHILLIP CHIKOMWE ..... being the School Head of MANONGA SECONDARY ..... school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

THE HEAD
MANONGA SEC. SCH.
P. BAG 8079, RUSAPE
DATE: 21/11/16
SIGNATURE:

Appendix 7: Permission from the Head of Mt Camel High School

The School Head

Mt Camel High School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I...ZVINOKUAZVO TICHAFARA.....being the School Head of .MT. CARMEL HIGH SCH.....school have granted/~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

THE HEAD
MT. CARMEL HIGH SCHOOL
18 NOV 2016
P.O. BOX 112
HEADLANDS

Appendix 8: Permission from the Head of St Joseph High School

The School Head

St Joseph's High School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I....CHIOME.....RICHARD.....being the School Head of .....ST. JOSEPH'S HIGH...school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

THE HEAD
ST JOSEPH'S HIGH SCHOOL
18 NOV 2016
P BAG 8007, RUSAPE
SIGN

Date Stamp

Appendix 9: Permission from the Head of Rukweza high School

The School Head

Rukweza High School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I..MURAWU JOHN.....being the School Head of RUKWEZA HIGH.....school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

THE HEAD
RUKWEZA GOVT HIGH SCHOOL
18 NOV 2016
P. O. BOX
TEL
SIGNATURE

Appendix 10: Permission from the Head of Sanzaguru High School

The School Head

Tsanzaguru High School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I....MUGUTI CHRISTOPHER.....being the School Head of .....SANZAGURU HIGH.....school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

Appendix 11: Permission from the Head of Tsindi Secondary School

The School Head

Tsindi Secondary School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I. MADZIKATIRE LENOS F. ..... being the School Head of TSINDI SEC ..... school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

THE HEAD
TSINDI SECONDARY SCHOOL
21 NOV 2016
P. BAG 8113, RUSAPE
Email: tsindisec@gmail.com

Appendix 12: Permission from the Heads of Vengere High School

The School Head

Vengere High School

REF: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH AT YOUR SCHOOL

My name is Mangwende Edmore, a PhD student at KwaZulu-Natal University. I am asking for permission to carry out a research at your school. I intend to carry out interviews with mathematics teachers. The research also involves observing teachers teach and analysing their lesson plans. An interview session with a teacher is expected to take twenty minutes. The purpose of the interview is to obtain data from Mathematics teachers on their knowledge and utilization of their students' learning styles. The information obtained shall be kept confidential and shall be used only for the purpose of this research study. For further enquiries on this research feel free to contact me on +263772667359 or email me at mangwendeeddy@gmail.com. You can also contact my supervisor at maharaja32@ukzn.ac.za.

I will be grateful if you register your decision by signing in the space below.

Declaration by the School Head

I....MANGWENDE.....E.....being the School Head of ..VENGERE.....HIGH...school have granted/ ~~not granted~~ permission to carry out a research at my school.(delete the inappropriate)

Signature of School Head .....

Date Stamp

THE HEADMASTER
VENGERE HIGH SCHOOL
2016 -11- 18
P.O. BOX 53, RUSAPE
TEL. 0225 205 2500

Appendix 13: Participants' consent form

Full title of the thesis

An investigation of secondary school mathematics teachers' knowledge and utilisation of their students' learning styles

Name of researcher: Mangwende Edmore

Contact address: 268 Tait Avenue, Rusape, Zimbabwe

Cell number: +263772667359

Email address: mangwendeeddy@gmail.com

Name of supervisor: Dr Maharaj Aneshkumar

Supervisor's email address: maharaja32@ac.za

Please tick the appropriate box

I confirm that the purpose of the study has been explained to me.

Yes ☐ No ☐

I confirm that I had an opportunity to ask questions and I received satisfactory answers.

Yes ☐ No ☐

I understand that participation in this research is voluntary. Yes ☐ No ☐

I understand that I am free to withdraw at any time without giving reasons. Yes ☐ No ☐

I understand that disguised names shall be used in the research for confidentiality purposes. Yes ☐ No ☐

I agree to the interviews and observations on this research study being video or audio recorded. Yes ☐ No ☐

I agree to take part in this research Yes ☐ No ☐

Signature of participant … ……Date……

Signature of researcher …..……Date……

Appendix 14: Participants' information sheet

PARTICIPANT INFORMATION SHEET

1.0 Introduction

You are being invited to take part in a research study. It is important that you understand why the research is being done and what it involves before you decide to take part in the research. Please read through the following information. If you find anything not so clear, or if you would like more information, please feel free to contact the researcher or his supervisor. You are free to take part in the research if you decide to do so. Your consent should be shown by filling in a provided consent form.

2.0 Title of the research:

An investigation of mathematics teacher's knowledge and utilisation of their students' learning styles.

3.0 Purpose of the study

The main aim of this study is to explore mathematics teachers' knowledge and utilization of their students' learning styles. It also determines barriers that impinge on full utilization of the students' learning styles. It goes further to explore possible remedies to the barriers. The researcher is doing the research in order to fulfil the requirements of a PhD degree in Mathematics Education at the University of Kwazulu Natal.

4.0 Participation in the research

Participation in the research is voluntary. Participants have a right to choose to participate or not. However the researcher will be grateful if you decide to participate in this research since your contribution is of much importance to the success of the research study.

5.0 Confidentiality

Information obtained from participants shall be kept confidential. Disguised names will be used in the research so as to protect the rights of those who take part. Video and the audio tapes taken during data collection will be destroyed by burning. This shall be done in consultation with the University of Kwa-Zulu Natal after a required period set by the university.

6.0 Time required to participate

Data will be collected using face to face interviews, lesson observations and document analysis. An interview session with a teacher will take approximately thirty minutes. Thirty-minute lessons shall be observed while the teachers teach. Video and audio tapes may be used in capturing the proceedings during lesson observations.

7.0 Report back

The results of the study shall be published. The research final report is expected to be ready by December 2019.

8.0 Risks associated with the research

The researcher shall try not to infringe the rights of the participants. Permission was sought from the gate keepers. These include the Permanent Secretary of the Ministry of Primary and Secondary Education and the school heads. Ethical clearance was sought from the University of Kwazulu Natal. No-one will be exposed to physical danger during the research study.

9.0 Questions and further information

Should you have any questions concerning the research, feel free to contact the researcher or his supervisor on the details given below. Further information can also be obtained from the researcher or his supervisor.

10.0 Contact Details

Name of Researcher: Mangwende Edmore

School: Education

Faculty: Humanities

Campus: Edgewood

Email: mangwendeeddy@gmail.com

Cell: +263772667359

Physical Address: 268 Tait Avenue, Rusape, Zimbabwe.

Name of Supervisor: Prof Maharaj Aneshkumar

Supervisor's email: maharaja32@ukzn.ac.za

HSSREC RO contact name: Ms Ximba Phumelele

HSSREC RO email: XIMBAP@ukzn.ac.za

11.0 Conclusion

Thank you for reading the information sheet. I will be grateful if you take your time to participate in the research.

Appendix 15: Observation guide

Teacher' coded name:

Topic/ Concept taught:

Lesson objective:

Level taught:

Period of the lesson in minutes:

Teaching aids used:

Teaching method used:

Activities done by the students:

Activities done by the teacher:

Notes on student-student interaction:

Notes on teacher-students interaction:

Notes on teaching resources availability:

Observable possible barriers to effective teaching:

Appendix 16: Document analysis guide

Teacher's coded name:

Level taught:

Name of document analysed

Teaching methods planned/used:

Individual tasks for students:

Group tasks for students:

Activities done by the teacher:

Teaching aids used by the teacher:

Assessment techniques employed by the teacher:

Estimated time for students' activities:

Appendix17: Interview guide for phase 1 of the study

Interview guide

1. What do you understand by the term ‘students’ learning styles’?

2. How did you come to know about these learning styles? Did you ever receive any training on how to teach students according to their learning styles?

3. What do you think brings in the differences in the learning styles of your students?

4. How do you utilise your knowledge of students’ learning style when you teach mathematics?

5. What are your views on the strategy of teaching students according to their learning styles in teaching mathematics?

Appendix 18: Interview guide for phase 2 of the study

Interview guide

1. What are the teaching strategies you use when you teach functions?

2. What are the teaching aids or teaching tools that you use when you teach functions?

3. Can you give examples of how you use the teaching aids when teaching concepts under functions?

4. How do you assess your students' progress when you teach functions?

5. What else do you need to share concerning the teaching strategies and teaching aids you use when teaching functions?

Appendix 19: Interview guide for phase 3 of the study

Interview guide

1. What are the teacher related barriers that affect your effective use of your knowledge of your students' learning styles in mathematics teaching? How do they impact on your use of your knowledge of students' learning styles?

2. What are the student related barriers that affect your effective use of your knowledge of your students' learning styles in mathematics teaching? How do they affect the use of your knowledge of students' learning styles?

3. What are the curriculum related barriers that affect your effective use of your knowledge of your students' learning styles in mathematics teaching? How do they impede on your use of your knowledge of students' learning styles?

4. What are the socio-economic barriers that affect your effective use of your knowledge of your students' learning styles in mathematics teaching? How do they impinge on your use of your knowledge of students' learning styles?

5. What are the other barriers that affect your effective use of your knowledge of your students' learning styles in mathematics teaching? Explain how they affect your use of your knowledge of students' learning styles.

Appendix 20: Editor's certificate

30 November 2019

2116 Magamba Rusape

Zimbabwe

makuvasae@gmail.com

To whom it may concern

REF: THESIS EDITOR'S CERTIFICATE

Name of student: Mangwende Edmore (216076200)

Title of thesis: An investigation of secondary school mathematics teachers' knowledge and utilisation of their students' learning styles

The abovementioned thesis submitted for the Degree of Doctor of Philosophy in Mathematics Education was proofread by me for grammar, spellings, punctuation and typing errors. As I proofread the document, I made sure that the student's style of writing was maintained.

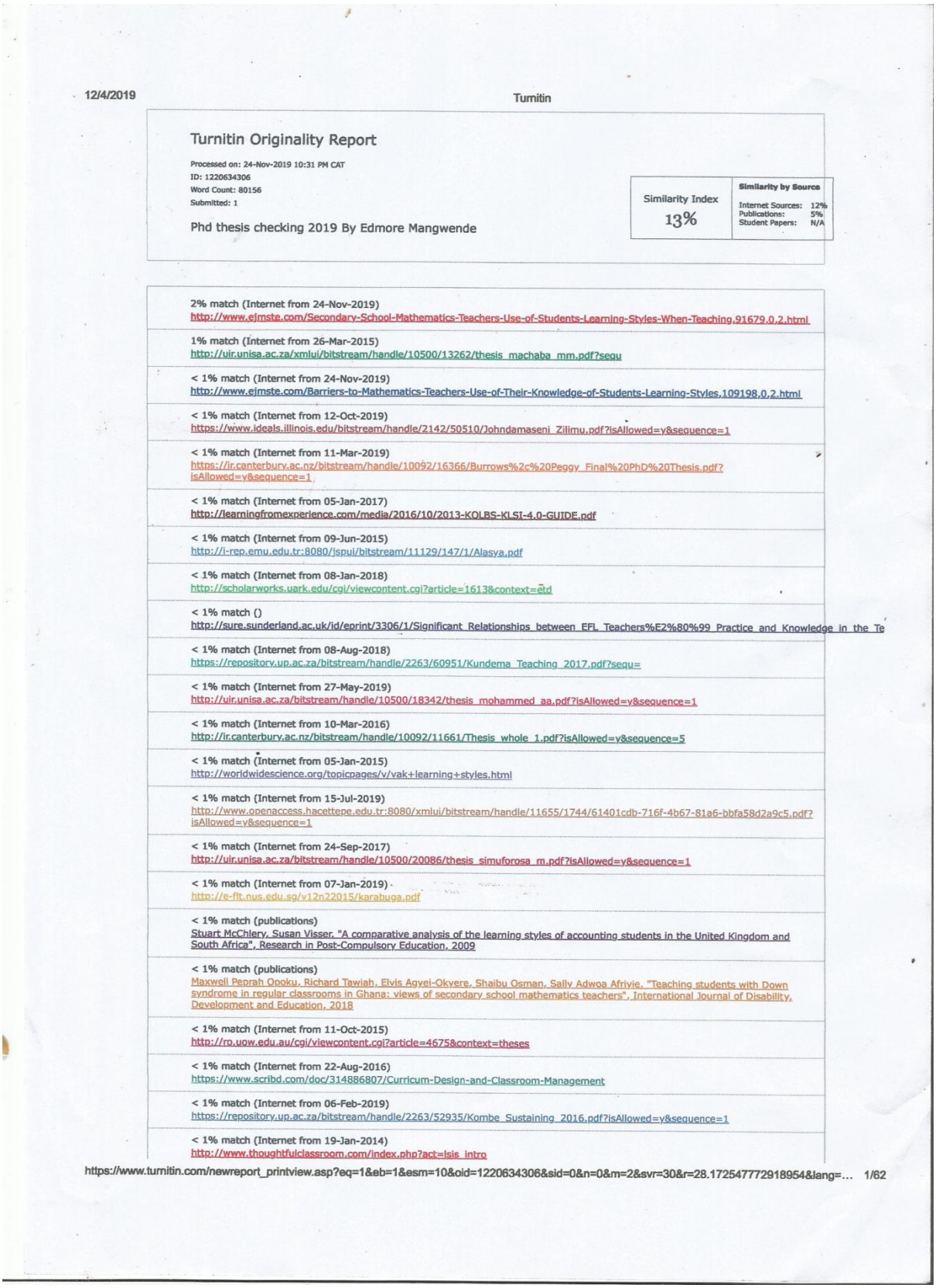
The changes that I suggested may be accepted or not at the student's or his supervisor's discretion.

Makuvasa

Makuvasa Eunice

+263776330108

Appendix 21: Turnitin report



12/4/2019 Turnitin

Turnitin Originality Report

Processed on: 24-Nov-2019 10:31 PM CAT
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Word Count: 80156
Submitted: 1

Phd thesis checking 2019 By Edmore Mangwende

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Stuart McChlery, Susan Visser. "A comparative analysis of the learning styles of accounting students in the United Kingdom and South Africa", Research in Post-Compulsory Education, 2009

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Maxwell Peprah Opoku, Richard Tawiah, Elvis Agyei-Okyere, Shaibu Osman, Sally Adwoa Afriyie. "Teaching students with Down syndrome in regular classrooms in Ghana: views of secondary school mathematics teachers", International Journal of Disability, Development and Education, 2018

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Appendix 22: Published paper 1

EURASIA Journal of Mathematics, Science and Technology Education - Decision on Manuscript ID EURASIA-2017-0707.R2

Inbox X

Lianghuo Fan <onbehalfof@manuscriptcentral.com> Sat, May 5, 2018, 11

to me

05-May-2018

Dear Mr. Mangwende:

It is a pleasure to accept your manuscript entitled "Secondary School Mathematics Teachers' Use of Students' Learning Styles When Teaching Functions: A Case of Zimbabwean Schools" in its current form for publication in the EURASIA Journal of Mathematics, Science and Technology Education. The comments of the reviewer(s) who reviewed your manuscript are included at the foot of this letter.

Thank you for your fine contribution. On behalf of the Editors of the EURASIA Journal of Mathematics, Science and Technology Education, we look forward to your continued contributions to the Journal.

Sincerely,
Prof. Lianghuo Fan
Editor-in-Chief, EURASIA Journal of Mathematics, Science and Technology Education
L.Fan@southampton.ac.uk

Appendix 23: Published paper 2

Your article has been published

Inbox x

Modestum Limited 8:23 AM (12 hou

to me, Aneshkumar

Dear Dr. Mangwende,

We would like to inform you that your article has been published in EJMSTE:
http://www.ejmste.com/Barriers-to-Mathematics-Teachers-Use-of-Their-Knowledge-of-Students-Learning-Styles,109198,0,2.html
Thank you for publishing with us. We are looking forward to your future publications.
Best regards,
The Printing Office of Modestum Publications
http://www.modestum.co.uk

Eurasia Journal of Mathematics, Science and Technology Education 8:30 AM (12 h
<kontakt@editorialsystem.com>

to me

Dear Dr. Edmore Mangwende,
We would like to inform that manuscript Barriers to Mathematics Teachers' Use of Their Knowledge of Students' Learning Styles in Mathematics Teaching: A Case of Secondary Schools in Zimbabwe. (EJMSTE-01287-2019-02) has been indexed in CrossRef.
Assigned DOI: 10.29333/ejmste/109198
Link: https://doi.org/10.29333/ejmste/109198
Article view:
https://www.editorialsystem.com/ejmste/article/157878/view/

Editorial Office of Eurasia Journal of Mathematics, Science and Technology Education

Appendix 24: Paper under peer review

New manuscript received by Editorial Office (EJMSTE-01623-2019-01)

Inbox x

Eurasia Journal of Mathematics, Science and Technology Education <kontakt@editorialsystem.com> 12:15 PM (2 minutes ago)

to me

Dear Dr. Edmore Mangwende,

Thank you for your manuscript: Mathematics Teachers' Views on Teaching Students According To Learning Styles: A Case Study of Secondary School Teachers in Zimbabwe. The following number has been assigned to it: EJMSTE-01623-2019-01.

The manuscript will be checked by Editors and then sent to the Reviewers.
You will be informed by email about any further decisions on this article.

Thank you for submitting your work to our journal.

Kindest regards,
Chun-Yen CHANG & Milan KUBIATKO
Co-Editors-in-Chief
Eurasia Journal of Mathematics, Science and Technology Education

Editorial System is available here: https://www.editorialsystem.com/ejmste/