STUDENT TEACHERS' CONCEPTIONS AND EXPERIENCES OF PEDAGOGICAL PRACTICES IN MATHEMATICS EDUCATION IN TEACHER TRAINING COLLEGES IN ZIMBABWE

BY

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A Thesis submitted in fulfilment of the requirements for the degree of Doctor of Education in the School of Education, Faculty of Arts and Design at the Durban University of Technology.

OCTOBER 2021

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DEDICATION

This study is dedicated to my late husband, Vincent Elias Manyadze and my late parents, Boniface Adrian Makoni and Gladys "Chituku" Makoni nee Masuku, who were my constant sources of inspiration and determination. You instilled in me the virtues of commitment and perseverance and I know you all would have been very proud of me.

DECLARATION

The work presented in this thesis, unless specifically indicated to the contrary in the text, is my own and has not been presented for any degree work in another university.
Where use has been made of the work of others it is duly acknowledged in the text.
The Durban University of Technology certified ethical clearance for this study.

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ACKNOWLEDGEMENTS

The success of this study was possible because of the unwavering support I received from different people and I do hereby acknowledge their vital contributions. Special mention is therefore made of the following:

I would like to thank the Lord Almighty for his spiritual guidance and protection throughout the successful completion of this study and also for giving me his loyal servants, the Catholic Priests and Seminarians of the Dominican Order, who provided me with decent abode at their home in Emaphethelweni.

My supervisor, Prof Tabitha Grace Mukeredzi, I know I would not have accomplished this arduous Doctoral journey without your scholarly guidance, support, encouragement and illuminating constructive comments. I really appreciate the time and the effort you put in to make this study a success. I am also grateful to Prof Julia Preece, my co-supervisor for her input.

I want to acknowledge with thanks the student teachers and their mathematics lecturers in the four selected colleges, for their willingness to participate in this enquiry, and the time offered to share their conceptions and experiences of mathematics pedagogical practices. Their cooperation is greatly acknowledged.

I am grateful to my children: son, Tamuka Bernard and daughter, Christine Kiki, for being there for me throughout this academic journey. Last but not least, my niece, Sabelo Patricia and nephew, Tusani Dan, and my sisters (Charity, Muriel and Chiratidzo Portia) and their families for their prayers and encouragement.

ABSTRACT

Conceptions about mathematics are crucial as they are conscious formations that convey personal meanings towards mathematics. They are critical for teaching and learning and need to be addressed in teacher education. Many student teachers who enter teacher education struggle to pass the national O level mathematics examinations, sitting at least twice to gain entry into teacher training. Such experiences may shape their conceptions regarding mathematics, and consequently influence learning and teaching of mathematics when they qualify as teachers. This study sought to understand student teachers' conceptions of and experiences during mathematics pedagogical practices in mathematics education in teacher training. It was those student teachers who struggled to pass O level mathematics to gain entry into teacher training colleges in Zimbabwe who were investigated in this study.

This qualitative study was located in the interpretive paradigm, and adopted a multiple-site case design where data were generated from 40 student teachers and four lecturers. Sampling of participants involved convenience and purposive selection for student teachers and self-selection for lecturers. A questionnaire served as the springboard to determine the number of sittings for purposive sampling of the student teachers and data were generated through focus group discussions, individual face-to-face interviews and lecture observations. Data analysis employed manual, eight-step open coding. Theoretical frameworks: Conceptions about mathematics (Dionne 1984) and Socio-constructivist theory (Vygotsky 1978; Kim 2001) guided the study.

Findings showed that the student teachers held traditionalistic conceptions about mathematics, but conceived interactive, student-centred pedagogies as crucial during mathematics pedagogical practices. However, student teachers across the four colleges explored were only exposed to the lecture method where there was no student engagement during mathematics pedagogical practices, and only experienced interactive strategies in research.

Drawing on the conceptions theory, I argue that student teachers were exposed to traditionalist classrooms (Dionne 1984) where they passively received mathematical knowledge during pedagogical practices. Findings also revealed that these student teachers who struggled to pass mathematics at O level were exposed more to pedagogical knowledge than to mathematics

content knowledge which they needed. Private colleges were grossly structurally and materially under-resourced and students did not experience use of technology during lectures.

The student teachers explored, who struggled to pass O level mathematics to enter teacher education still struggled with the subject in teacher training. Their conceptions and prior experiences strongly influenced their cognitive and behavioural engagement during mathematics pedagogical practices. They feared mathematics and only studied it because they had to, given that primary school teachers were required to teach all curriculum subjects to the primary school child. The student teachers viewed mathematics as a difficult subject, meant for 'a select few'.

The study recommends bridging programmes for student teachers who struggled to pass mathematics at O level to enter teacher education, and adoption of constructivist pedagogies with active 'noisy' classrooms in mathematics education, contrary to the dominant lecture method. The study further recommends provision of adequate physical and material resources in private colleges to ensure student comfort, and enhance learning effectiveness and engagement, during mathematics pedagogical practices.

In relation to the theoretical framework (Dionne 1984) my argument is that the framework provides a useful generic, analytical tool for thinking through conceptions about mathematics in pedagogical practices in mathematics education. However, on its own it does not provide a complete lens to make sense of the variations in students teachers' learning experiences. The thesis therefore argues for an additive model to Dionne's conceptions theory that may expand the framework and deepen its applicability specifically, in trying to understand issues around student teacher conceptions and experiences during pedagogical practices in mathematics education. The thesis therefore suggests the need for more studies, drawing on the framework and developing it to determine its applicability beyond this particular inquiry.

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LIST OF ABBREVIATIONS

A Level	Advanced Level
ATP	Attachment Teaching Practice
AU	African Union
BSCED	Bachelor of Science Education
CK	Content Knowledge
DE	Department of Education
DTE	Department of Teacher Education
DUT	Durban University of Technology
ECD	Early Childhood Development
EFA	Education for All
FGD	Focus Group Discussion
FFI	Face-to-face Interviews
GPK	General Pedagogical Practices
HOD	Head of Department
IREC	Institutional Research Ethics Committee
ITE	Initial Teacher Education
MDGs	Millennium Development Goals
MHTESTD	Ministry of Higher Tertiary Education Science and Technology Development
NCTM	National Council of Teachers of Mathematics
O Level	Ordinary Level
TP	Teaching Practice
TOE	Theory of Education
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
PSA	Professional Studies Syllabus A
PSB	Professional Studies Syllabus B
PTH	Primary Teacher Higher
PTL	Primary Teacher Lower
SDGs	Sustainable Development Goals

ST	Student Teacher
UNESCO	United Nations Educational Scientific and Cultural Organisation
UZ	University of Zimbabwe
VP	Vice Principal
WCEFA	World Conference on Education for All
ZIMSEC	Zimbabwe Schools Examination Council
ZINTEC	Zimbabwe Integrated National Teacher Education Course
ZMEC	Zimbabwe Ministry of Education and Culture
ZPD	Zone of Proximal Development

CHAPTER 1

SETTING THE SCENE

1.1 Introduction

This chapter sets the scene for the study by providing the vital preliminary contextual information and articulating the problem. This study sought to understand student teachers' conceptions and experiences of mathematics pedagogical practices in mathematics education in selected primary teachers' training colleges in Zimbabwe. According to Brown (2004: 303), conceptions are the "more general mental structures, encompassing meanings, beliefs, concepts, propositions, rules, mental images, preferences and the like". Conceptions are therefore formed consciously and they convey personal meanings. In this regard those entering teacher education programmes also carry with them diverse conceptions and experiences about mathematics and mathematics pedagogies emanating from their past mathematics learning experiences. Therefore, studying student teachers' conceptions and experiences of pedagogical practices in mathematics education was vital as conceptions influence mathematics education learning in college and mathematics teaching in primary schools when the student teachers graduate. This is consistent with literature (Maciejewski and Merchant 2016) observations that students' mathematics-related conceptions are the explicitly or implicitly held subjective beliefs students hold to be true and that have influence in their mathematical learning, teaching and problem solving. From these views, conceptions influence mathematical learning behaviour. Reviewed literature (Skoumious and Skoumpourdi 2021) also shows that teachers' conceptions of teaching affect their teaching practices and their students' learning. However, Hansen (2014) provides some evidence that these conceptions may shift through coaching and application of learner focused teacher practices. The study sought to understand student teachers' conceptions and experiences during mathematics pedagogical practices. Given the paucity of research on this phenomenon of student teacher conceptions and experiences during mathematics pedagogical practices in teacher education, this study will contribute knowledge in this area. The target were the student teachers who struggled to pass O level mathematics to gain entry into teacher education with a view to addressing their conceptions. Research shows that students' prior learning experiences, conceptions and learning approaches underpin and drive the quality of their current and future learning and outcomes (Mukeredzi 2015; Vettori, Vezzani, Bigozzi and Pinto 2020). At national level, findings from this study will inform policy decisions, and discussions on student teacher training generally, the group explored in particular, regarding the needed support during teacher education.

Following this introduction, I define the focus and purpose of the study, which is followed by personal context and motivation, axiological assumptions and the rationale behind the study. A detailed background of the study is then provided to contextualise the current study within the policy and historical frameworks. Teacher education history from pre to post-independent Zimbabwe is also provided. The major and sub-research questions for the study are then dealt with. An overview of the theoretical frameworks and methodology, definition of terms and thesis organization are outlined to conclude the chapter.

1.2 Focus and purpose of the study

The focus of this case study was on understanding the conceptions and experiences of student teachers who wrote O level (Grade 11) mathematics examinations more than once in order to enter teacher education. At the time of this study, entry into teacher education in Zimbabwe did not consider the number of attempts made by a candidate in order to pass mathematics or any other subject, as long as they had a pass at Grade C level or better (Garwe 2014). In addition, on entering teacher education, such students were exposed to the same mathematics pedagogical practices as those students who had passed the mathematics O level national examination at first sitting. Again, the students who struggled were not exposed to any special pedagogical treatment or consideration, as no extra mathematics tuition or bridging courses in the subject were offered. It was against this background that I sought to understand the conceptions and experiences of pedagogical practices in mathematics education of the student teachers who wrote O level mathematics more than once, and how that influenced their learning in selected teacher training colleges. I wanted to go ‘under their skins’ and hear their stories concerning their conceptions and experiences during mathematics pedagogical practices (Mukeredzi 2009) and how these aspects influenced their learning. This is given that teachers’ conceptions of mathematics influence their assumptions and choices of mathematical concepts, methodologies and presentation of the subject during instruction (Budiarto 2019).

As a mathematics teacher educator, an in-depth understanding of the conceptions about and experiences of pedagogical practices in mathematics education in college, of students who struggled to pass O level mathematics was vital. These students, due to their former struggles in mathematics, often elected to specialise in curriculum subjects other than mathematics, but were compelled to study the general course Mathematics Education. Mathematics education lectures in primary school teachers’ colleges in Zimbabwe at the time of the study included the methods course where student teachers were exposed to the pedagogical strategies of teaching primary school mathematics, including the primary school mathematics content that these students were going to teach during Teaching Practice (TP) and on course completion.

The purpose of the study was therefore to understand the conceptions of and experiences in mathematics education during training in college of those student teachers who struggled to pass O level mathematics. In this study the terms, student teacher, student and pre-service teacher are used interchangeably.

Through experience as a mathematics teacher educator, during mathematics pedagogical practices many student teachers seemingly have problems understanding mathematical concepts, symbols and algorithms. Surveyed literature (Yuanita, Ibrahim and Isnawati 2018) points out that if such students are able to operate these processes at all, they cannot tell what they are doing, why they are doing it, and they also fail to understand the meaning of the mathematical symbolism. Given my specialisation and interest in the mathematics curriculum, I felt obliged to develop competent mathematics teachers. To achieve this, I needed an in-depth understanding of the conceptions of and experiences during mathematics pedagogical practices of the teachers that I was training, with a view to addressing those conceptions. Reviewed literature (Vorholter, Kaiser and Ferri 2014) indicates that conceptions and experiences in mathematics can limit the improvement of teacher's content knowledge, classroom practices and student learning if they are not addressed.

1.3 Personal context and motivation

My interest in mathematics started when my now late mother told me about her own school experiences, where she was the best arithmetic student in her class. So this inspired me to be a good mathematician like my mom, MaMlondiza (pseudonym) (may her dear soul continue to rest in eternal peace) and as the saying goes, "like mother like daughter". I started working extra hard in mathematics to match my mother's ability. My interest was further nurtured by my Grade 6 and 7 teacher, Mr Mapungus (pseudonym). This teacher was passionate about mathematics, and most of the time when we engaged in mathematics exercises and tests I always got the highest mark. I made lots of friends who needed assistance and became a "peer teacher" in the boarding school residences. I could not understand how my peers got wrong answers as I always wanted them, especially girls, to venture into mathematics. I was always fascinated by mathematics and always had feelings of achievement after solving difficult mathematics problems. In high school, all except my mathematics teacher at this Roman Catholic girls' secondary school were Catholic nuns. This teacher would write complicated problems and ask me to make sense of them and explain them to the class. This daily occurrence developed in me an inquisitive mind and an interest in numerical investigation, and consequently I worked extra hard during free and study periods in preparation for the next lesson. This again increased my performance in mathematics. My peers conceived mathematics as a very difficult subject and I would wonder what their conceptions were based on.

For teacher training at Gweru Teachers' College the choice of mathematics specialisation was made by my mother. During college holidays I taught mathematics to primary and secondary school children, including my siblings, and always wondered why they struggled with mathematics. As a teacher I wanted my students, particularly girls and including my daughters, Kundanane and Christianne (pseudonyms), to be mathematicians and ended up offering free mathematics lessons. Notwithstanding, many learners failed O level mathematics and would write and re-write in order to enter formal professions and wipe away conceptions that mathematics was a hindrance for further academic pursuits.

When I joined teacher education as a teacher educator more than 15 years ago, observing many students entering teacher training after many sittings of O level mathematics national examination always made me wonder how they conceived and experienced mathematics during pedagogical practices in mathematics education in the college, given their earlier struggles with the subject. This influenced me to undertake research exploring pre-service teachers' conceptions and experiences.

1.4 Axiological assumptions

Axiological assumptions refer to the role of values. Values are those things that one believes to be very important in the way one lives and one works. Literature (Taber 2013; Tomar 2014) indicates that values are basic and fundamental beliefs that guide or motivate attitudes or actions. Thus, axiological assumptions are the basic values and biases that I brought into my research. Therefore, in this study my subjective values, intuition, and biases were important as they played a role in the socialising, generation and interpretation of the data on conceptions and experiences. Since axiology is the study of values or, more adequately, theory on the nature of value, I therefore acknowledge the value-laden nature of generated data and also report my own values and biases (Creswell 2014; Taber 2013).

As I generated data through focus group discussions, face-to-face interviews and lecture observations, my presence was evident in the interpretation and presentation of the data. My perceptions of conceptions and experiences during mathematics pedagogical practices were shaped by my experiences as a mathematics educator at one primary teachers' college. The participants who took part in this study were part of the population in the primary teachers' college where I worked and had interacted with some of these students in my college. Therefore, the role and contextual understanding enhanced my awareness and sensitivity to the challenges, conceptions and experiences of the student teachers who struggled to pass mathematics, thereby helping me in working with them in this study.

Due to my previous experiences in teacher education, I brought certain biases to my study. I in some way understood the conceptions and experiences of those students who struggled to pass O level mathematics. However, there is a need to declare upfront that my study was conducted with these students and their mathematics lecturers in their natural settings, in their different teachers' colleges. In spite of all the efforts to bring in objectivity during data generation and analysis, my biases may have contributed in shaping my views and understanding of the generated data and the way I interpreted it. I embarked on this study with the notion that student teachers who had struggled to pass mathematics held particular conceptions about mathematics which would bring about negative or positive experiences during mathematics pedagogical practices.

This was apparently a significant expectation that was taken for granted, but I cross-examined them on how they conceived mathematics as a subject and how they experienced pedagogical practices in mathematics. Given this, the values of the participants were explored and analysed through their previous experiences to establish how those conceptions and experiences influenced their learning during mathematics pedagogical practices as aspiring primary school mathematics teachers. Having declared my axiological assumptions in advance, the rationale for the study is presented in the next section.

1.5 Rationale

As participants in this study were primary school student teachers, as has been alluded to above, who were being prepared for teaching all primary school curriculum subjects, including mathematics - a subject which they took many years to pass, questions regarding their conceptions and experiences in mathematics education pedagogical practices needed to be answered, given that primary school education is meant to lay the foundations for later learning. Surveyed literature (Ebrahim, Verbeek and Mashiya 2012; Gipps, Hargreaves and McCallum

2015) indicates that primary school teachers should lay a solid foundation for later learning in all subjects including mathematics for the primary school child, despite their prior struggles. Foundations for later school learning success are laid in the early school years of a child's education (Verbeek 2014). Further, elementary school education is often referred to as the *'starting gate'*, implying that it is the threshold of a long career in the educational journey that has profound implications for the life course. This is supported by reviewed literature (Vedenpaa and Lonka 2014) which indicates that it is important to explore student teachers' conceptions and experiences of learning mathematics in teacher education if we intend to develop and foster improvements in mathematics learning environments in schools.

Further, a teacher's conceptions and experiences can act as an interface between curriculum theories and practice (Azis 2015), thus understanding the student teachers' conceptions and experiences of mathematics pedagogical practices cannot be overemphasised. Mukeredzi (2015) and Maciejewski (2016) concur that conceptions and experiences gained when one is a learner are carried to one's classroom, given that teachers' professional knowledge, beliefs and actions are significantly informed and shaped by their own prior school learning experiences. These conceptions and experiences may therefore be easily transmitted to the learner in the classroom, considering that conceptions and experiences are key to classroom practice and learner achievement as they influence teachers' pedagogic approaches and choice of materials, content, and learner activities (Chai, Koh and Tsai 2013; Mukeredzi 2013). It was therefore critical that teacher educators became aware of the student teachers' conceptions and experiences, in order to try to alter those conceptions through their pedagogical practices and equip them (student teachers) with the appropriate mathematical content and pedagogies while in college.

Surveyed literature (Li and Schoenfeld 2019; Suurtamm 2020) indicates that an understanding of the conceptions and experiences of student teachers may assist teacher educators in modifying negative conceptions to more positive ones, given that student teachers often enter teacher education with conceptions developed through their own learning. The study therefore sought to understand those conceptions, with a view to addressing them. Literature further (Carse 2015) indicates that teacher education programmes are being challenged as they have never been challenged before to prepare prospective mathematics teachers in ways that will enhance the teaching and learning of mathematics for the 21st Century. As teachers are considered as change agents in any education system, there was a need to investigate student teachers' conceptions and experiences of pedagogical practices in mathematics education, with a view to enhancing their skills and possibly influencing a change in their conceptions.

Studies (Gutierrez-Braojos 2015) have been conducted on secondary school and university students' general conceptions about learning mathematics. Research results empirically demonstrate a direct relationship between learning conceptions and academic outcomes in the secondary sector. However, college student teachers' conceptions and experiences of mathematics education pedagogical practices have apparently not been adequately addressed. Further, there seems to be no research on the conceptions and experiences of mathematics pedagogical practices of those student teachers who struggled to pass O level mathematics. This study therefore sought to contribute to teacher education discourses broadly, but in particular to the conceptions and experiences of college student teachers of mathematics pedagogical practices in mathematics teacher education, for those student teachers who struggled to pass the subject. Literature (Lampert 2010; Vettori 2018) further indicates that teacher educators need to "give learners reason" by respecting and understanding their prior conceptions, experiences and understandings. The assumption is that during pedagogical practices these prior conceptions, experiences and understandings serve as foundation on which to build bridges to new understandings. Thus, findings from this study will hopefully inform the discussions and decisions of professionals, academics and policy makers regarding the conceptions and experiences during the mathematics pedagogical practices of student teachers who enter teacher education subsequent to struggling with mathematics at O level.

1.6 Key research question

This study sought to explore the conceptions and experiences of pedagogical practices of student teachers during mathematics education in teacher training, given that many student teachers wrote and re-wrote the national O level mathematics examination to enable them to gain entry into teacher training. Thus, the study sought to answer the key question: *What are the student teachers' conceptions and experiences of pedagogical practices in mathematics education in selected teacher training colleges in Zimbabwe?*

To address the key research question, the following subsidiary questions had to be answered:

1.6.1 Sub research questions

1. How do student teachers conceive pedagogical practices in mathematics education?
2. What are the student teachers' experiences of pedagogical practices in mathematics education?
3. In what ways do the student teachers' conceptions and experiences influence their learning in mathematics education?

1.7 Background of the study

The background of the study is discussed in three sections: global context, regional context and national context.

Globally, the world education policy agenda has been closely monitored by the World Bank (Vetterlein 2012; Mundy and Verger 2015) because its main objective is to ensure quality education for all, regardless of nationality. The main focus of the World Bank was apparently the material dimension of the education systems: school infrastructure, textbooks and material assets for workshops and laboratories. However, surveyed literature (Wong 2012; Mundy and Verger 2015) points out that the World Bank later diversified to include the results of children's learning. The World Bank also views quality education for all as predictable through the efforts of the teacher (Teixeira 2017). Reviewed literature (Barber and Mourshed 2007: 4) points out that: "the quality of an education system cannot exceed the quality of its teachers". Since the World Bank plays a pivotal role in the education of children, they also advocate for quality teacher preparation.

At the World Education Forum in Incheon (Republic of Korea) in May 2015, the global education community, under UNESCO, framed priorities for a common Education Agenda within Sustainable Development Goals (SDGs) for 15 years. Participants in the Forum pushed for the Education Sustainable Development Goal (SDG) (SDG 4), aiming to "*Ensure inclusive and equitable quality education and [to] promote life-long learning opportunities for all*" (Education 2030 Framework for Action 21). In order to achieve this goal, all the participants agreed that all effective learning at any level was through the role teachers played in education. They therefore made a commitment to *"ensure that teachers and educators are empowered, adequately recruited, well-trained, professionally qualified, motivated and supported within well-resourced, efficient and effectively governed systems"* (Education 2030 Framework for Action 21; Yoshida 2020). Teacher quality is therefore considered as a key factor in the achievement of SDG 4 and quality teachers will only be produced by quality teacher education programmes. Teacher education processes therefore need to be interrogated and studied to obtain theoretical understandings among others, of student teachers' conceptions and experiences during mathematics pedagogical practices, with a view to influencing on-going policy discussions and decisions to enhance teacher education quality. A quality teacher education programme produces a quality teacher, which is the most important school-related factor influencing student achievement. This is consistent with surveyed literature (Darling-Hammond 2020) which reports that measures of teacher preparation and certification are by far the strongest correlates of student achievement in reading and mathematics. Since the production of a quality mathematics teacher is often viewed as a priority, this may be promoted by understanding the conceptions and experiences in mathematics education of these students who struggled to pass O level mathematics.

At a regional level, Africa faces developmental challenges which have adversely affected the socio-economic well-being of its people and stifled growth (Otara 2012; Ozoemena 2017). Literature surveyed (Yiu and Saner 2014) indicates that these challenges have been summarised within the Millennium Development Goals (MDGs), and one of the main objectives of the MDGs is to achieve universal primary education. Ahenkan and Osei-Kojo (2014) also confirmed that there is encouraging progress towards the attainment of the MDGs, with gains recorded in education. Thus, amongst other sectors in Africa, higher education has been identified as having an important role to play in meeting the MDGs. This is in concurrence with Cloete, Bailey and Maasen (2011) and Bloom, Canning, Chan and Luca (2014) who indicate that higher education has been identified and recognised as a significant player in facilitating Africa's quality development process. Centrality of higher education in the achievement of MDGs was also emphasised at the 1992 United Nations Conference on Environment and Sustainable Development in Rio de Janeiro (Fitzgerald, Bruns, Sonka, Furco, and Swanson 2012). Given the critical contribution and the role higher education can play in achieving MDGs, African universities and colleges are therefore faced with a great challenge.

In taking the lead, the African Union (AU) has initiated programmes and policies to revitalise higher education in Africa to contribute to the continent's development (Molla and Cuthbert 2018). This has been done through expansion of the sector in terms of the diversity of institutions, academic programmes, rapid growth in enrolments, and the development of quality assurance frameworks due to Education for All (EFA). Many African countries have embraced Education for All (EFA) targets, and there is growing recognition of the need to improve the quality of basic education (Mukeredzi 2021). This therefore calls for reform in teacher education in the region as a whole. EFA and the MDGs have generated commitments to greatly improve access to education (Bloom, Canning, Chan and Luca 2014).

Some African countries have achieved access to education, but quality remains a challenge (Chataika, Mckenzie, Swart and Lyner-Cleophas 2012). It is argued that the teacher is a key element in the achievement of MDGs (Kaur and Singh 2014). With the education system churning out semi-illiterate graduates, the teacher is to blame (Majoni 2014). This further heightens teacher quality as a key factor in the achievement of MDGs and a quality teacher can only be produced by a quality teacher education programme (Report on Achieving MDGs in Africa 2013). Consequently, teacher education needs to be investigated with a view to reorienting and improving in ways that promote quality education and enhance the achievement of MDGs. The African National Policy on Education (1986) expects a lot from the teachers, since it boldly opines, "No people can rise above the level of its teachers" (Barber and Mourshed

2007: 4) The National Policy further states that the ‘status of the teacher reflects the socio-cultural ethos of a society’ (Bourn 2015). This implies that teacher preparation needs to fulfill the expectations listed in the national policy. This justifies the relevance of academic work on conceptions and experiences in mathematics education in light of achievement of the Regional MDGs.

At a national level, mathematics is regarded as an indispensable subject as it enables nurturing of certain qualities such as the power of reasoning, creativity, abstract or spatial thinking, critical thinking, problem-solving and effective mathematics communication (Zimbabwe Ministry of Education and Culture (ZMEC) Circular No. 2 of 2005; Legner 2013). Consequently, in Zimbabwe, a pass with grade C or better in O level mathematics is a pre-requisite for entry into Zimbabwean teacher education and all other formal professions. However, for entry into the ZMEC at the time of this study, the number of exam sittings candidates had to obtain a pass were overlooked (ZMEC Circular No. 2 of 2001; ZMEC Circular No. 12 of 2005; Chinamasa, Dzinotizeyi and Sithole 2012; Maregedze, Chinamasa, and Hlenga 2012). Literature (Nyaumwe 2006; Mupa 2015) points out that many aspiring student teachers struggle to pass mathematics at O level, consequently sitting many times to obtain a pass. Mathematics is therefore viewed as a setback to those O level graduates who want to pursue formal professional fields like teaching, where mathematics is a pre-requisite (Kuneka and Chinamasa 2012; Nuamah 2020).

Notwithstanding, mathematics is seen as a means of producing scientifically literate citizenry (Oliver and Adkins 2020). Surveyed literature (Maregedze, Chinamasa and Hlenga 2012) indicates that O level graduates make several attempts at writing the national mathematics examinations to obtain a passing grade in the subject which, as alluded to above, is at Grade C or anything better. Many manage to get a passing grade in mathematics after two or more attempts, like the student teachers who participated in this study. Literature reviewed (Gafoor and Kurukkan 2015) indicates that high rates of school failure are followed by grade repetition, which has become a distinctive characteristic of many secondary school systems even in developed countries. It is therefore through this mathematical struggle experience that student teachers develop conceptions about mathematics. Reviewed literature (Rattan, Good and Dweck

2012; Darling-Hammond 2020) points out that these conceptions and experiences of learning, teaching, and subject matter formed during an individual's early learning provide a basis for understanding, interpreting and assessing any later learning that they may encounter.

The Zimbabwe Primary School Teacher Education Programme has two major areas and student teachers choose one of them: Early Childhood Development (ECD) and the General Course. The ECD specialists train to teach from Grade R to Grade 3. The General Course specialists will teach Grades 4 to 7. Both categories are required to choose an academic subject from all the primary school curriculum subjects, and on course completion they graduate with teaching diplomas. However, very few student teachers choose to take mathematics.

An analysis of the Zimbabwe teacher education curricula indicates that the primary school teacher education programme during the time of this study generally had four major components. First, was the Professional Studies Syllabus A (PSA). This component, which was a co-module, covered techniques of teaching all Primary School subjects and included – principles and strategies of teaching, classroom control, management, and organisation that transcended content knowledge. Second, was another co-module - Theory of Education (TOE), which was a foundational course which exposed the pre-service teachers to the foundational and fundamental principles and knowledge of teaching, including child development theories and their application in the classroom. TOE promoted student teacher understanding of the foundations of education (Higgs 2013). Third, was Teaching Practice (TP), which was viewed as an important *course where student teachers* had the chance to learn teaching through teaching and trying out what they had learnt in college in a real *learning* classroom environment teaching real pupils, in this case for twenty months. All student teachers had to take and pass the TP module. Fourth, was the Professional Studies Syllabus B (PSB) or subject methodology course. This was again a co-module studied by all students in the general course, where students were exposed to the teaching of mathematics: general pedagogical knowledge (GPK or PK); mathematical content knowledge (CK) which they were going to teach in the primary schools; and pedagogical content knowledge (PCK) which exposed them to the specific methods of teaching mathematics. Therefore, the three knowledge domains discussed above constituted the knowledge that the students were expected to acquire during mathematics PSB lectures or mathematics pedagogical practices. It was student teachers' conceptions and experiences in the mathematics PSB or mathematics pedagogical practices that the study sought to understand. This was supported by consulted literature (Muyengwa 2013; Lucenario, Yangco and Espinosa 2016) which indicates that the student teacher should be competent in subject knowledge, application, class management, and assessment and recording of pupils' progress.

Formal mathematics learning in Zimbabwe starts from Grade 1 through all primary school grades to high school. The first national mathematics examination is taken in Grade 7 under the Zimbabwe Schools Examination Council Examining Board (ZIMSEC 1983). The Grade 7 graduate then proceeds to Form 1 (Grade 8), where secondary school mathematics concepts are built onto primary school mathematics concepts previously gained. After the first four years of secondary education, students sit for an O level national examination (equivalent to Grade 11). As mathematics is one of the pre-requisites for any further studies (Zimbabwe Education Secretary's Circular Minute Number 2 of 2001; Rach and Heinze 2017), failing to obtain a Grade C or anything better at O level means that such students have to re-write. In 2015 and 2016 a national mathematics pass rate of 22.38% and 27.86% respectively was recorded (ZIMSEC 2016). As such, many O level school leavers were left with no option except to write and re-write mathematics to gain entry into teacher education or other formal professions. As a result of such experiences, students would develop conceptions about mathematics.

Thus, the researcher sought to develop an in-depth understanding of such conceptions and experiences. Literature surveyed (Carse 2015; Bourn 2016) reveals that since teachers have the most direct, sustained contact with students and considerable control over what is taught and the climate for learning, understanding student teachers' knowledge, conceptions, experiences, skills and dispositions is a critical step in improving student achievement. This calls for a focus on the quality of teacher education by governments generally, and the teacher education institutions in particular.

1.8 Zimbabwean historical and policy context on education

Education before independence in Zimbabwe, then Southern Rhodesia, was classified and provided on racial lines and was designed to engender white supremacy by under-educating the black child to protect the white compatriot from competition in professional, managerial, administrative and other capitalist roles (Mukeredzi 2013). The schools were divided into three categories: Group A schools were for the whites, and received full funding, Groups B and C were for the coloured and black children and received partial and no funding respectively (Tarusikirwa 2016). Few black children got access to education in mission schools (Gomba 2017).

The structure of the primary school education was such that children started with Sub A. The information that I recorded in my researcher diary from a discussion I held with some old Zimbabweans who went through the Sub system indicates that Sub A was equivalent to Grade 1. The next grade was Sub B (Grade 2), then Standard 1(Grade 3) up to Standard 6 (Grade 8) (Researcher Diary 8 May 2020). Before independence few black people had access to education because of the bottleneck system of education that was being exercised (Shizha and Kariwo 2011). These bottlenecks which were existent only in the African education system between grades and between primary and secondary school did not exist in European schools. Bottlenecks started at a very early stage, as even Sub A and Sub B had to be passed before going on to Standard 1 (Grade 3) (Ndlovu 2013; Gomba 2017). Surveyed literature (Maravanyika 1990; Tarusikirwa and Mafa 2013) indicates that to proceed to secondary school education after Grade Seven, only 12.5 % of the primary school leavers would pass and be allowed to proceed, 37.5% were expected to register in vocational secondary schools, and the rest (50%) were not accounted for in terms of formal education. The bottlenecks were placed at the time the students took national examinations. At all of these national examination points, the cut off point for the pass mark was calculated based on the candidates' performance to ensure that the above progression percentages were maintained (Tarusikirwa 2016).

Generally black children received minimal education which channeled them to practical courses in agriculture, carpentry, building, sewing and cookery which would take them into blue collar jobs - mainly manual work to reduce competition for white collar jobs reserved for their white compatriots (Mukeredzi 2009; 2013). Consequently, most black children attended the popularly known F2 schools which offered technical subjects and the F1 schools, the academic streams, were for the white children in order to prepare them for the white-collar jobs (Gomba 2017). Gomba further notes that the F2 learners would also be taught commercial arithmetic which comprised of home budgeting in preparation for work in the white man's kitchen. The F2 system had two exit levels: Grade 9 and Grade 11 and students sat for the Zimbabwe National Examinations at Grade 9 and Grade 11 (Zvobgo 2007; Chikozho and Chisaka 2014). There were a few black children who attended F1 schools, having squeezed through the bottleneck and sat for Cambridge examinations alongside their white counterparts. However, the dual education system was discontinued on attainment of independence in 1980 and all bottlenecks were removed (Mapako, Mareva, Gonye and Gamira 2012).

1.8.1 Teacher education during the pre-independence era

Before independence in Zimbabwe, graduates from Standards 3, 4, 5 and 6 (Grades 5 -8) discussed above would be recruited into teaching and attended teacher training through mixed mode delivery where they would teach during the school term, and attend teacher training during the school holidays (Tarusikirwa 2016). These in-service teachers studied for a Primary Teacher Lower Course (PTL) certificate. The training structure was, however, later changed into full-time teacher training. During this period teacher training which resided in missionary institutions, was mostly for Africans to teach in the black missionary primary schools, and teacher training duration was two years with periods of practicum (Tarusikirwa 2016). In some cases, according to Tarusikirwa, Certification was granted for good performance, without having attended any teacher development programme or written any examinations.

Missionary organisations undertook teacher training to promote evangelisation and develop African converts in schools (Bone 1970; Siyakwazi 2014). Literature surveyed (Bone 1970;

Tarusikirwa 2016) highlights that the missionary school teacher training model was run by clergy Principals who had no leadership and management training, therefore it was chaotic and it desperately needed redemption and planning for order and control. The two-year teacher training model was later amended and missionaries adopted a three-year teacher training model following Standard 3 (which is equivalent to Grade 5) (Hadfield Commission Report 1925; Siyakwazi 1980). The model had a uniform examination prescribed by the Department of Education (DE) and School Inspectors conducted the examinations. According to the Hadfield Commission Report (1925), the three-year course comprised of subjects related to theory and practice of teaching, reading from the Bible and industrial work (Tarusikirwa 2016).

From 1956 when the Hillside Teachers' College was established, the government got involved in teacher education, and introduced government primary teacher training colleges to complement the mission colleges (Colclough, Löfstedt, Manduvi-Moyo, Maravanyika and Ngwata 1990). During that time two secondary teachers' training colleges were also opened: the one for white students was popularly known as "The Teachers' College" in Bulawayo, which is now Hillside Teachers' College, and the other for the black students was called the Gwelo (now Gweru) Teachers' College. The new teacher training colleges became affiliated to the then University of Rhodesia, now the University of Zimbabwe (UZ). Siyakwazi and Siyakwazi (2012) posit that teacher quality was emphasised and colleges had to apply for Associateship with the University of Rhodesia to ensure quality primary and secondary school teacher training. It was the UZ which ensured the quality of the training programmes through assessment of the course content and Teaching Practice.

The two-year Primary Teacher Higher Course (PTH) general teacher training model was replaced by another two-year teacher training programme, the T4 and Primary Teacher Lower Course (PTL), which was meant to prepare Foundation Phase or Early Childhood teachers (Annual Report of the Secretary for African Education 1968). A few years later, a three-year teacher training, (T3) model replaced the PTH general course. The entry qualification into the T3 model was a Cambridge School Certificate, to improve teacher quality (Rhodesia Government Education Policy 1966).

1.8.2 Education provision after independence

After independence, the new Zimbabwean government introduced basic primary education which was free and compulsory to enable all children to attend school (Education Act 1994). This led to an enormous increase of student numbers in the schools. This is supported by reviewed literature (Zvacek 1989; Mukeredzi 2013) which reflects that Zimbabwe after independence was now in a position to offer educational opportunities to all of its citizens, regardless of colour. The Education Act (1994) came into being in order to enable Zimbabwe to attain the Education for All (EFA) goals determined and agreed upon at the World Conference on Education for All (WCEFA) held in Jomtien, Thailand (1990) and that was also re-affirmed in Dakar, Senegal (2000). This increase in student population called for the need for more teachers. Unfortunately, these radical changes brought about by a new political philosophy could not immediately be assimilated in the newly independent Zimbabwe (Mukeredzi 2013). Many schools were opened, both primary and secondary (secondary schools popularly known as Upper Tops or rural day secondary schools) in places that never had any schools before. Primary schools were opened within walking distance from the homes of the young primary school children (Shizha and Kariwo 2011). This rapid increase in the number of pupils enrolled in both primary and secondary schools resulted in severe shortage of teachers.

Reviewed literature (Maravanyika 1990; Tarusikirwa 2016) indicates that the government started engaging expatriate teachers from other countries, as well as retired and untrained teachers, including O and A level graduates to teach. Some of them did not have full O level certificates (no five O level passes) and in some instances, not even a pass in Mathematics and English.

However, notwithstanding the impediments and bottlenecks in the African education system discussed above, the system of education which was modelled by the British provided good quality education (Mukeredzi 2009; 2013). Thu,s given this situation, the education system remained intact following independence. In other words, on attaining independence, other than expansion and massification to address EFA requirements, the British model of education remained relatively un-dismantled. However, there was an urgent need to train more teachers to address the severe teacher shortage.

1.8.3 Teacher education in post-independence Zimbabwe

The current Zimbabwe Teacher Education structure reflects a paradigm shift from the colonial teacher education structure before independence. On attaining independence Zimbabwe embarked on a massive expansion of educational provision at all levels, including the higher education sector (Mukeredzi 2009; 2013). This brought about massive changes in the country's educational priorities and offered equal educational opportunities to all of its citizens, regardless of colour or race across the entire education system (Shizha and Kariwo 2011).

The severe shortage of qualified teachers led to a review of teacher education preparation programmes. Surveyed literature (Chiromo 1999) indicates that there was a review of the models of teacher preparation to alleviate the acute shortage of qualified teachers emanating from the phenomenal expansion in education. The massification of the education system led to phenomenal expansion of teacher education, from five teachers' colleges before independence to seventeen teachers' colleges that offered various three-year programmes after independence (Education System Zimbabwe 2019). This, as Chiromo (1999) notes, led to the birth of different teacher training models, namely: the Zimbabwe Integrated Teacher Education Course (ZINTEC) 2-5-2 Model; the 5-7-9 Model; the Two-year In Two-year Out Model, the Attachment Teaching Practice (ATP) Model and the 1-1-1 Model. These models are discussed in turn in the next section.

1.9 The ZINTEC model 2-5-2

To supply teachers in the new primary schools established due to massification and the free and compulsory primary education that had been introduced, the ZINTEC Model was launched in

1981 (Mukeredzi 2009; 2013). The model was launched to complement and run parallel to the conventional three-year training models that existed before independence and were expanded during massification. The ZINTEC was a three-year programme and was also referred to as the 2-5-2 Model which meant that student teachers spent the initial two terms (eight months) at college, five terms (twenty months) on TP, and the final two terms (eight months) back at college. A term in Zimbabwe at the time of this study was four months long.

1.10 The 5-7-9 model

This model was adopted in 1981 and effected in 1982 by some teachers' colleges as a modification of the then three-year conventional model that had been running before independence, and also ran concurrently with the ZINTEC 2-5-2 Model (Maguraushe 2015). The 5-7-9 Model, allowed student teachers to go on TP during the fifth, seventh and ninth terms of their three-year programme. This was a three-year programme where students spent a total of twenty-four months in college and twelve months on TP (Zvacek 1989; Chiromo 1999). Given that this was during massification of education to address EFA, the model allowed colleges to enrol more student teachers as facilities meant for three-year groups were now available for two-year only groups in any given term. This programme proved to be cumbersome and difficult for the individual teachers' colleges to administer (Siyakwazi 2014) and so it was abandoned and a new four-year programme, the 2-year in 2-year out programme was introduced.

1.11 Two-year in two-year out model

The two-year in two-year out programme (Tarusikirwa 2016) was a four-year teacher training programme where in the first and third years, students were residential in college and in the second and fourth years they were on TP. This programme was introduced in 1982 and it was commonly referred to as the two-year in two-year out model. I trained as a mathematics teacher through this model of teacher education. During TP the student teacher took full responsibility for the class (es) allocated to him/her, thus helping in reducing teacher demand. This was supported by reviewed literature (Siyakwazi 2014) which indicates that TP was a full-time commitment and was used as a way to put teachers into classrooms in order to accommodate the rapid expansion of the student population. The Teacher Education Review Committee Report (1986) shows that this model was abandoned in the early 1990s since both students and college lecturers conceived that the fourth year where students were on TP was a wasted year as they could operate as qualified teachers and not student teachers. This argument resulted in the change of this programme back to a three-year programme.

1.12 The three-year attachment teaching practice (ATP) model

The ATP model was introduced in the mid-1990s to enable students who were deployed for TP to be attached to qualified and experienced teachers who would help and provide guidance in the students' practice teaching. Reviewed literature (Mapolisa and Tshabalala 2014) indicates that the attachment was launched so that the student teacher could be offered guidance on various methodologies and general issues concerning their own learning as well as the teaching and learning of learners. An outstanding feature in this model was that students did not have teaching loads of their own. Classroom TP supervision was done by lecturers and mentors while external examination was carried out by the UZ's Department of Teacher Education (DTE) as the associate quality assurance and control centre. The DTE is a department at the UZ and is the custodian of teacher education in the country. Its programmes are anchored on quality assurance, supervision and monitoring, teaching and research (Maravanyika 1990; Garwe 2014). Since all (primary and secondary) teachers' colleges were expected to maintain high standards in order to produce quality teachers they were affiliated to the DTE and it was the diploma awarding institution.

1.13 The 1-1-1 programme

From 1998, teacher education reverted to a three-year programme (Tarusikirwa 2016). The 1-1-1 programme allowed student teachers to be in college in their first and third years and out on TP in the second year as full-time teachers. This model is popularly known as the "Sandwich" Model of teacher education (Tarusikirwa 2016) because the TP year was sandwiched between the two years of residential college courses. The model exposed the students to more time in college than on TP. Musingafi, Mapuranga, Chiwanza and Zebron (2015) remark that this conventional mode of training placed emphasis on trainee teachers acquiring the requisite theory and skills before they were deployed to teach. All these models of Teacher Education had to be adopted in order to increase the teacher population rapidly.

In 2003, teacher education reverted to the 2-5-2 model which was instituted by the then Minister of Higher Education (Murerwa 2004). In Zimbabwe at the time of this study, all the primary teacher's training colleges were using the ZINTEC or the 2-5-2 Model in order to curb the teacher shortages due to brain drain. All the teacher education models discussed above were implemented in a bid to provide professionally qualified teachers who would enhance the quality in the Zimbabwean education system and enhance children's learning achievements (Hamre 2014).

Having provided in detail the history of both basic and teacher education in Zimbabwe from the colonial era through post-independence to the time of the study, the next section provides an overview of the two theoretical frameworks which I used as lenses in my study. It was the students studying in this 2-5-2 Model, who had struggled to pass O level mathematics to gain entry into teacher education, who were targeted in this study.

1.14 Overview of the theoretical frameworks

The study was guided by two theoretical frameworks: conceptions about mathematics (Dionne 1984; Li and Schoenfeld 2019), and socio-constructivism (Vygotsky 1978; Kim 2001; Vintere 2018). The two theoretical frameworks complemented and supported one another as the shortcomings of one were filled in by strengths of the other, thereby enabling a more nuanced understanding and picture of the reality under exploration (Mukeredzi 2013). The theoretical frameworks also provided for theory triangulation.

Conceptions about mathematics (Dionne 1984; Li and Schoenfeld 2019) were used to understand the different conceptions about mathematics held by the student teachers. Dionne spells out three different conceptions: traditionalists, formalists and constructivists. The traditionalists conceive mathematics as comprising of rules and formulae to be memorised, and that mathematics is a set of unrelated rules and facts with no relation to everyday life. The traditionalist teacher plays the role of instructor and dispenser of knowledge in the classroom. Learners in such classrooms are passive knowledge recipients - empty vessels to be filled by the knowledgeable teacher. The formalist conceives mathematical knowledge as logical and full of rigorous proofs and definitions, with strict mathematical language. The formalist teacher assumes the role of an explainer. The third conception, the constructivist according to Dionne (1984), conceives mathematics as dynamic with new discoveries of mathematical knowledge from experimentation and application. They also conceive reality as constructed socially through interactions with knowledgeable others. The constructivist teacher plays the role of learning facilitator.

The socio-constructivist theory (Vygotsky 1978; Kim 2001) views the teacher as one who handles the student with care as the sole beneficiary and central to every learning situation. This social learning theory emphasises the importance of context and culture in understanding what happens in society with regard to knowledge construction. Socio-constructivist proponents conceive reality as socially constructed through human activity and the teacher as a knowledgeable other who facilitates learning. In the context of this study, students who struggled to pass O level mathematics benefitted from knowledgeable others – lecturers and peers, and also from the context. The lecturer scaffolds student teacher learning so that they move and operate within the Zone of Proximal Development (ZPD) (Vygotsky 1978). Kim (2001) argues that while knowledge and learning reside with the student and not the teacher or lecturer, it is not purely located at their psychological level but occurs by interaction with others and the context. Constructivists recognise that experience and context have an important role in learning and in the process, language plays a key role in knowledge acquisition (Dewey 1938; Kim 2001; Vintere 2018).

The study used two theoretical frameworks to explore the conceptions and experiences of student teachers during mathematics pedagogical practices. I needed Dionne's theory to understand the type of conceptions held by these students who struggled to pass O level mathematics. Dionne's theory was relevant as I needed a theory to help me understand the conceptions of students who struggled to learn mathematics during mathematics pedagogical practices. On the other hand, Vygotsky's theory helped me by focusing on the appropriate pedagogical practices these student teachers experienced and were expected to experience during mathematics education. These helped address any conceptions they may have held and experiences they may have gone through.

1.15 Overview of the methodological approach

Research paradigm: My study was situated in the interpretive paradigm to help me generate and understand subjective data on the conceptions and experiences of pedagogical practices in mathematics education of student teachers who struggled to pass O level mathematics. Taber (2013) indicates that an interpretivist assumes that reality is constructed inter-subjectively through the meanings and understandings developed socially and experientially.

Research approach: As I wanted to generate and interpret subjective data about conceptions and experiences of pedagogical practices in mathematics education, a qualitative approach was deemed appropriate. As qualitative research is holistic and strives to record the multiple interpretations of intentions and meanings given to situations, experiences and events (Cohen, Manion and Morrison 2013) by participants, I decided to use this approach to understand the conceptions and experiences of pedagogical practices in mathematics education.

Research design: I used the multiple-site case study design where four research sites (primary teachers' colleges) were studied to explore in-depth conceptions and experiences of pedagogical practices in mathematics education. The four research sites explored comprised two government and two missionary colleges. The multiple-site case study design enabled capturing rich descriptive contexts of the conceptions and experiences in mathematics education from different sites, thereby strengthening the findings. This was consistent with reviewed literature (Kennedy

2016) which indicates that a multiple-site case study design enables the researcher to make replications in data generation across sites. Though the multiple-case study results cannot be generalised, the purpose of my study was not to generalise but to have in-depth understanding of conceptions and experiences of students during mathematics pedagogical practices.

Population: All non-specialist student teachers and mathematics education lecturers in the four selected teachers' colleges studied constituted the population of my study. The common characteristic among the student teachers and lecturers used in this study was that the students were not specialising in mathematics and the mathematics lecturers were teaching the mathematics education course.

Sample: A purposive sample used in this study was a smaller group or subset of the total population such that the knowledge gained in the study would be transferable to the total population under study (Spangler, Liu and Hill 2012). The participants were 40 students who had written mathematics more than once and 4 mathematics education lecturers in the 4 selected Primary Teachers' Colleges in Zimbabwe. A convenient sample was used as a springboard for purposive sampling for the study. The sampled participants were deemed to possess vital information on student teachers' conceptions and experiences in mathematics pedagogical practices in mathematics education. The lecturers, on the other hand, were self-selected.

Data generation procedure: I employed questionnaires to generate biographic data and also to enable purposive sampling. Given that I needed to generate subjective data aligned with the philosophical orientation, research design and approach, data to answer the research questions was generated through eight focus group discussions (two per college); and twenty face-to-face interviews (five per college) with students, complemented by four face-to-face interviews and four lecture observations of the lecturers teaching.

Data analysis: After identifying the codes through open coding, I clustered them into categories after which I then examined, modified and clustered the categories to form themes. This coding helped me in reducing lots of data on conceptions and experiences during pedagogical practices into smaller chunks of meaningful data.

Trustworthiness and rigour: Trustworthiness is achieved through the following four components: credibility, transferability, dependability and confirmability. In this qualitative study I ensured rigour and trustworthiness by addressing these aspects of trustworthiness.

Ethical considerations: The research was carried out with careful consideration and adherence to ethical practices which included doing good and avoiding harm, obtaining informed consent, guaranteeing participants absence of risk or harm, ensuring privacy, ensuring anonymity, and maintaining confidentiality (Cohen, Manion and Morrison 2013).
Before conducting the study, I obtained ethical clearance from DUT's Institutional Research and Ethics Committee (IREC), and also consent from the Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD) (hereinafter referred to as the Ministry) and the Principals of the four selected primary school teachers' training colleges. For each gatekeeper a detailed letter was provided which contained comprehensive information about the study and how data was to be generated, reported and stored, including the issues of anonymity and confidentiality. I sought consent from my participants, both students and lecturers, and clearly explained the study and assured participants that they were free to leave the study at any time without prejudice to them and also that pseudonyms would be used for reporting the findings. More detail on ethical issues is articulated in Chapter Four, my methodology chapter. Definitions of terms will be dealt with next.

1.16 Definition of terms

Conception: This is any idea, understanding, viewpoint or perception. Conceptions may also be defined as specific meanings or understandings attached to phenomena which are claimed to mediate a viewpoint (Craig 2013). In this study the conceptions explored were around the pedagogical practices in mathematics education.
Content knowledge: This is knowledge, understanding, skills and dispositions that students learn and teachers teach. Shulman (1987) defines content knowledge as the knowledge teachers have of the subject matter they are teaching, in this case mathematics. Literature surveyed (Chapman 2013) indicates that teachers with strong content knowledge may teach in a more dynamic and interesting way.
College: A college in this study refers to an institution of higher learning. Merriam-Webster (2003) defines a college as an educational institution or establishment, in particular one providing higher education or specialized professional or vocational training. This study was

focused on primary school teacher training colleges where student teachers were enrolled in these institutions of higher learning.

Distance education: Distance education refers to any form of instruction not occurring in a traditional, face-to-face mode. Keegan (2013) also defines distance education as a physical separation of the teacher and the learner.

Experience An experience is an event or occurrence which leaves an impression on someone. *Experience* can also be referred to as past events, knowledge, and feelings that make up someone's character or life. Mukeredzi (2020) defines experience as an act of doing which does not require a teacher, and is not merely hearing other people talking about experiencing something. Rather it is about engaging in the diverse roles of being a student. In this study in particular, understanding student teachers' experiences during mathematics pedagogical practices was the main objective, that is, what they went through during mathematics education.

Lecturer: A person who gives lectures, especially as a teacher in higher education and in this context he/she was a teacher educator in a teachers' college. They are those teachers in higher education who are formally involved in pre-service and in-service teacher education (Snoek, Swennen and van der Klink 2011)

Mentee: Someone who has identified a specific personal or professional goal and who believes that the guidance and help of a mentor can help them achieve their goal. A mentee is therefore advised, counseled and trained by a mentor in his/her career. Reviewed literature (Jones 2013) points out that a mentee is a dedicated student who seeks to grow personally, develop professionally, and successfully in order to achieve academic goals with the support of a peer mentor.

Mentor: A qualified teacher who is involved in the professional development of students, in this case student teachers. Surveyed literature (Morris-Williams and Grant 2012) indicates that a mentor is a qualified classroom practitioner who assumes the role of being a guide, supervisor, counselor, overseer, coach, teacher, model, supporter, critic, collaborator, helper, sponsor, instructor, co-participant, advisor, promoter, assessor and gate-keeper to the teacher under training.

Pedagogy: It is the art or science of being a teacher or teaching methodology. According to Anderson and Dron (2011), pedagogy is any conscious activity by one person designed to enhance the learning of another. Alexander (2003:3) defined pedagogy as the act of teaching together with its attendant discourse. This definition brings in the aspect of social interaction between learners and teachers thus suggesting that pedagogy requires discourse. Therefore, pedagogy involves the teaching methods and pupil organisation.

Pedagogical: Methods and strategies of instruction. These strategies are selected practices according to a teacher's conceptions, putting into consideration the needs of the learner and the demands of the task. With reference to this study, the pedagogical practices were aligned to the constructivist model which supports student-centered activities, active learning and support of multiple student learning styles, as spelt out by Dionne's theory (1984) on conceptions about mathematics.

Practice: The practicing of a profession. The practice is a repeated exercise in order to acquire professional skills and in the case of this study the skills will be teacher related (Lampert 2010**)**.

Profession: An occupation, trade, craft or activity in which one has professed expertise in a particular area or job, especially one requiring a high level of skill or training (Saks 2012). The student teachers in this study were being trained so that they would become teachers by profession.

Student teacher: A prospective teacher undergoing training in a teachers' college. A student teacher observes classroom instruction and undergoes closely supervised teaching in a primary or secondary school as part of the training. A student teacher or pre-service teacher is a student who has been enrolled in a teacher preparation program who must successfully complete degree requirements including course work and field experience before being awarded a teaching certificate or diploma (Sjolie 2014).

Teacher education: Teacher education is a programme that is related to the development of teacher proficiency and competence that will enable and empower the teacher to meet the requirements of the profession and face the challenges therein. Teacher education refers to the whole range of activities that constitute preparation for, and improvement of, members of the teaching profession (Illingworth 2012). It includes pre-service education for those students who have not had teaching experience and in-service education for those who are actually engaged in teaching.

Teachers college: An institution of higher education in which individuals are trained to become teachers. It is a school which was created to train high school graduates to be teachers. These colleges have a curriculum specifically for training teachers (Darling-Hammond 2000).

Teacher education: It is a programme in a teacher training institution through which the students are trained. In the context of this study the teacher education programme prepares pre-service students to teach in primary schools. The teacher education programme exposes students to theory and practices as well as principles of effective teaching through field work and coursework (Flores 2016).

Teaching practice: Teaching practice is a period of teaching in a school under supervision, carried out by a person who is training to become a teacher as part of his or her training. Student teachers view teaching practice as an important component in their training because it exposes them to the actual teaching and learning environment in which they can contextualise their theoretical knowledge gained during training (Nicolini 2012) and learn how to teach, engaging with actual learners in a real classroom. Teaching practice is therefore a form of work-integrated learning that is described as a period of time when students are working in schools to receive specific in-service training in order to apply theory to practice.

Teacher quality: Is what a teacher knows and is able to do in relation to the tasks of teaching. Reviewed literature (Perez 2013) indicates that teacher quality refers to the characteristics that teachers possess and teaching quality refers to what teachers do in the classroom to foster student learning. Teacher qualities can be acquired through teacher professional preparation and teacher knowledge.

Teacher training: Refers to policies, procedures and processes aimed at empowering teachers with the knowledge, abilities and attitudes in an integrated way necessary for the development of their profession (Harris and Sass 2011). Teacher training therefore implies giving prospective teachers subject matter, pedagogical knowledge and pedagogical content knowledge so that they can facilitate the learning of their students. Teacher training therefore corresponds to learning real-life classroom skills.

1.17 Conclusion and thesis outline

Chapter One – Background of the study: In this chapter I presented the background to the study on student teachers' conceptions and experiences of pedagogical practices in mathematics education. I discussed the focus and purpose of the study and the rationale, followed by the research questions. I then contextualised the study by discussing the global, regional and national contexts of teacher education. Following this I discussed teacher education in Zimbabwe before and after independence, encompassing the different teacher training models. An overview of the two theoretical frameworks underpinning my study was also provided as well as the methodological approach. Key terms were defined and a brief structure of the thesis outlined.

Chapter Two - Literature Review: Relevant literature focusing on my study on conceptions and experiences of pedagogical practices in mathematics education was reviewed. The related literature was discussed under the themes extracted from the research questions. Reviewed related literature was extracted from international, regional and national contexts.

Chapter Three - Theoretical frameworks: In this study I employed two theoretical frameworks: conceptions about mathematics and socio-constructivism. Chapter Three traces their historical development, discusses their principles and application, as well as weaknesses and how these are addressed in the study.

Chapter Four - Research methodology and design: In Chapter Four, I outlined the research paradigm, research design, research approach, and the research methods that I used to generate data to address the research questions. I also discussed the data analysis, trustworthiness, ethical considerations and the limitations of the study.

Chapter Five - Research sites: Chapter Five focused on the discussion of the four teachers' colleges used in the study. This included the location of the colleges, the historical background information of the colleges and their governance, first enrolment and statistics of the current enrolment, their visions, missions, goals, core values and their mottos.

Chapter Six - Data presentation and interpretation for research question one: In this chapter a presentation and an analysis of the qualitative data with respect to question one about student teachers' conceptions of pedagogical practices in mathematics education was presented. The main findings answering this question were that though student teachers held traditional conceptions of learning mathematics, they conceived interaction during lectures as vital for concept mastery, but they were not exposed to such pedagogical practices.

Chapter Seven - Data presentation and interpretation for research question two: Qualitative data was presented and analysed in answer to the second research question about student teachers' experiences of pedagogical practices in mathematics education. Findings revealed that students who struggled to pass mathematics experienced the lecture method as the only mode of instruction, which did not promote interaction. On the contrary, the participants expected to experience an in-depth mathematics understanding. Non-government colleges studied were inadequately resourced and therefore student teachers experienced limited use of technology and inadequate infrastructure.

Chapter Eight - Data presentation and interpretation for research question three: In Chapter Eight, I presented and analysed the research findings for question three on the influence of student teachers' conceptions and experiences of their earning during mathematics pedagogical practices. From the findings, student teachers' conceptions and experiences resulted in them struggling with mathematics at college and brought about fear of the subject, when they had to study the subject in college.

Chapter Nine - Discussions, conclusions and synthesis: The chapter presented a detailed discussion of the research and the main findings, organised according to the research questions. I also presented recommendations, which were followed by methodological reflections on the study. There followed a review of the study, the contributions of the study, and its limitations. Finally, conclusions were discussed.

Having set the scene for this study in Chapter One, the next chapter will review related literature on conceptions and experiences during mathematics pedagogical practices.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The previous chapter introduced the study and provided the focus, rationale, research questions and background for the study. That chapter also gave a historical background of the developments in teacher education in Zimbabwe before and after independence. This chapter reviews the relevant literature on the conceptions and experiences of student teachers in mathematics education during mathematics pedagogical practices. Through an exploration of 40 student teachers and four mathematics lecturers in four selected teacher training colleges in Zimbabwe, the study sought to understand conceptions and experiences during mathematics pedagogical practices of the student teachers who had struggled to pass mathematics O level (equivalent to Grade 11) national examinations before gaining entry into teacher education.

This review of literature provides an opportunity to identify gaps that exist, to illustrate how my study can contribute. A preliminary literature survey identified theoretical and methodological gaps in current research. Most of the studies in the extant literature generally used only one theoretical framework; however, my study employs two theories (conceptions about mathematics [Dionne 1984] and socio-constructivism [Vygotsky 1978; Kim 2001] to understand student teachers' conceptions and experiences during mathematics pedagogical practices.

Methodologically extant literature revealed that most of the studies were large surveys that employed quantitative and mixed methods approaches where random probability-sampling designs had been employed to draw out large samples across the education systems (primary, high school, teachers and lecturers). Very few qualitative studies exist in literature. The current study which was qualitative, employed non-probability sampling designs to sample out 40 student teachers who had struggled to pass mathematics and 4 of their mathematics lecturers, and it was conducted in four research sites. There appears to be a dearth of literature on conceptions and experiences of student teachers in teacher training colleges who struggled with mathematics to gain entry into teacher education.

This chapter helps develop a deeper understanding of student teachers' conceptions and experiences during mathematics pedagogical practices and how these aspects influence the learning and teaching of mathematics, hence the need to review related literature.

The review of literature also helps contextualise and locate my study within existing literature. A literature review in any field is essential as it offers a comprehensive overview and recapitulation on the given scholarship from past to present, giving the reader a sense of focus as to which direction the new research is headed in (Kim 2018). Thus, a review of the literature indicated a need for additional research similar to the current study on pre-service teachers who had struggled to pass mathematics.

The chapter therefore discusses academic work relating to the conceptions and experiences of students during mathematics pedagogical practices drawing on global, regional and national debates. First, the chapter defines the concept of conceptions. Second, the chapter discusses literature on the different conceptions held by student teachers in teacher education with regards to mathematics. Third, the student teachers' experiences of pedagogical practices in mathematics education are evaluated. Fourth, the chapter then examines how students' conceptions and experiences influence their learning during mathematics pedagogical practices.

2.2 What are conceptions?

Conceptions can be conceived as guiding principles which people (student teachers) hold to be true, that serve as lenses through which their new experiences can be understood. When an individual conceives something as true, they are likely to experience situations that support that conception. Conceptions therefore include the totality of all the person's ideas and beliefs concerning something. Conceptions can be formed in the mind and believed by a person or group of people. This is supported by literature (Russell 2012; Barrett 2017) which purports that conceptions are thoughts and beliefs about a phenomenon, and that these exist in the mind. Thus, in the current study conceptions about mathematics would therefore be those thoughts, beliefs and views that student teachers who struggled to pass mathematics held in their minds about mathematics. Conceptions about mathematics are therefore dispositions or mentalities about mathematics, and Bar-Tal (2012) indicates that these are tendencies or beliefs to exhibit a frequent, conscious and voluntary behavior directed towards learning a mathematics subject. This therefore means that students may also hold conceptions about how they believe mathematics should be learnt and taught. Thus, conceptions in this study were viewed as the thoughts, beliefs and views about mathematics and mathematics learning and teaching.

Subramaniam (2013) defines conceptions as specific meanings attached to phenomena, which then mediate an individual's response to situations involving those phenomena. This therefore implies that the student teachers who struggled to pass mathematics were likely to have their specific meanings about mathematics and during mathematics pedagogical practices would expect to experience the mathematics lectures according to their conceptions. Further literature reviewed (Alt 2018) indicates that student teachers' conceptions about teaching and learning can be defined as beliefs held by student teachers about their preferred ways of teaching and learning. In other words, a conception in simple terms is something that someone believes to be true, for example when a student teacher conceives mathematics to be a subject about rules and formulae, the student will only master the rules and formulae without bothering about how they are derived and applied. The student therefore conceives that by regurgitating these mathematical formulas, this will help him or her to be a mathematics expert.
Jacobs, van Luijk, van der Vleuten, Kusurkar, Croiset and Scheele (2016) indicate that how student teachers learn in a classroom is governed by what they conceive, and these conceptions act as a filter through which instructional experiences, learning and learning decisions are made. This implies that conceptions affect classroom learning activities, given that individuals tend to act in ways that they believe. Literature (Parker, Maor and Herrington 2013) concurs that student teachers possess a vast array of complex conceptions and experiences about pedagogical issues. Given that the students in this study struggled to pass mathematics and came from different academic backgrounds, this could also imply that they could have been taught by different teachers who had different conceptions about mathematics, who in turn passed such conceptions

on to them. Given that a conception is a mental structure, it therefore includes a person's beliefs and presuppositions which are implicit.

This schema of concepts is developed from theoretical studies and from interactions with society and the world, and they can undergo changes (Moors 2017). Thus, if these students who struggled with mathematics in order to enter into teacher education held negative conceptions, they could change them into more positive conceptions during pedagogical practices. Moors (2017) further alludes to the fact that conceptions can be changed through a process of reflection which enables a person to construct and reconstruct their mental structures in order to gain professional knowledge. According to Moors one can change a previously held conception through reconstruction, which then leads to the adoption of a new conception different from the initial one. Conceptions can be deduced from practice and practice can derive from conceptions (Moors 2017). This implies that one's actions are a true reflection of his/her conceptions. Conceptions can be expected to influence one's practice and vice versa, only if this is accompanied by reflective analysis of the relations between conception and action. This is supported by literature (Rowland, Thwaites and Jared 2015) which indicates that according to the constructivist approach, all conceptions are potentially modifiable, and restructuring is often catalysed by the exposure of inconsistencies.

Conceptions are subjective as they offer a personal view of something by an individual, and they are many and complex (Siswono 2010). Thus, according to this definition conceptions related to mathematics are those beliefs held by an individual about mathematics. Khalid, Hashmi and Javed (2021), show that teachers' conceptions about teaching and learning are belief-driven and form significant relationships among student teachers' epistemological beliefs and teaching and learning. The conceptions about mathematics are generally caused by what one believes and this can then be reflected in one's learning, teaching or decisions about the subject of mathematics. Such conceptions of mathematics are often shaped by the environment within which the student teachers previously learnt mathematics (prior mathematics learning experiences), and in turn affect the manner in which these students engage in mathematics. It is possible that due to the struggle to pass mathematics that they went through, participants in my study could probably have acquired different conceptions through their struggles. Given that these conceptions and dispositions influence student learning in a mathematics classroom, developing a better understanding of student teachers' conceptions and experiences during mathematics pedagogical practices through a critical evaluation of existing literature was vital. After defining conceptions, the next section discusses literature on the conceptions of mathematics.

2.3 Conceptions of pedagogical practices in mathematics education

A critical analysis of global studies on conceptions about mathematics will be discussed in this section. Addressing the type of conceptions that student teachers hold, the studies conducted by Kaminski (1999) in Australia; Salout, Behzadi, Shahvarani and Manuchehri (2013) in Tehran; Lim (2016) in Pennsylvania; Pa and Osman (2015) in Malaysia; Ng and Dindyal (2016) in Singapore; Andrews and Hatch (2013) in the United Kingdom; and Genc and Erbas (2019) in Turkey suggest that students hold traditionalist conceptions about mathematics. Students who hold traditionalist conceptions about mathematics conceive that mathematics should be learnt through repetitive means in order to pass. The traditionalists conceive mathematics as involving computation and that its main goal is to obtain a correct answer during the teaching/learning process (Berry 2014). The teacher who holds such traditionalist conceptions, according to Dionne (1984), takes the role of instructor when teaching mathematics and students are treated as empty vessels and passive recipients of mathematical knowledge.

Kaminski (1999) studied the conceptions about mathematics held by six second year university student teachers and generated data through semi-structured, individual interviews. Kaminski's qualitative study discovered that student teachers' conceptions about mathematics were that mathematics learning is about finding correct, exact solutions to mathematics problems through manipulation of symbols and memorised rules and formulae. Kaminski (1999) further revealed that some student teachers used memorisation and rote learning approaches, and there was little participation in the construction of mathematical knowledge. Such student teachers' conceptions are strongly aligned to the traditionalist conceptions about mathematics (Dionne 1984).

Traditional learning/teaching conceptions portray teacher-centered pedagogies where knowledge is transmitted from the teacher as the sole source to students as passive recipients (Souleles 2017). Matthews, Lodge and Bosanquet (2014) indicate that attitudes to mathematics are important in learning endeavours in this discipline, and for the student teachers in Kaminski's study the existence of a direct relationship between mathematics beliefs and mathematics teaching practice is also revealed (Thompson 1992; Mutwarasibo 2013). This is supported by Donche and Van Petegem (2011) who indicate that approaches to teaching, on the other hand, are the way in which conceptions or beliefs are put into practice. While Kaminski's (1999) study is different from mine, in terms of sample size and research setting, Kaminski's study relates to the current study as it employed individual interviews to generate data. Drawing on Kaminski's study which discovered traditionalist conceptions held by student teachers, my study also tried to establish the nature of the conceptions held by the participants who struggled to pass mathematics.

While Kaminski's (1999) students revealed conceptions related to learning mathematics, students studied by Salout et al. (2013) in Tehran revealed conceptions about mathematics related to everyday life. Their study, which was conducted on 780 high school girls from different schools, used random multi-step cluster sampling where data was generated through a questionnaire with a five-point Likert scale and a few open-ended questions. However, in my study the questionnaire was only used as a spring board for purposive sampling and data was generated through focus group discussions, face-to-face interviews and lecture observations. Salout et al.'s (2013) quantitative study which used the scales of Cronbach's Alpha as a data analysis tool revealed that students did not understand the relationship or application of mathematics in real life situations, which suggested traditionalistic conceptions about mathematics. Given that participants in my study enrolled for teacher training after struggling to pass the O level mathematics examination, my study also wanted to establish whether participants also held similar traditionalist conceptions about mathematics, where the subject was detached from everyday life. According to Dionne (1984), the traditionalist conception dissociates itself from life outside the mathematics classroom; the teaching of mathematics is confined to the four walls of the classroom.

Though Salout et al. (2013) used multiple sites as in the current study to generate data; their study was on high school girls and not on a heterogeneous group of student teachers in primary school teachers' colleges, where my study was located. The questionnaire was the only data generation tool used in the Tehranian study, however, whereas I adopted a multi-modal approach and triangulated my data by employing the focus group discussion, face-to-face interviews with both students and lecturers, and also observed lectures.

While Kaminski in Australia and Salout et al. in Tehran studied conceptions about mathematics and how the subject was related to everyday life, Lim (2016) in Pennsylvania also wanted to understand the applicability of mathematics to students in that state. Lim's study of 38 high school learners and 2 teachers from 2 research settings used 4 data generation methods: interviews, teacher/ researcher meeting notes and recordings, class observations and artifacts from the class sessions. Each of the participants was interviewed twice and all except four participants did not give consent to be audio recorded. Lim (2016) transcribed the generated data and data analysis was done through iterative data coding to identify themes through the use of a framework by Westheimer and Kahne.

Results from Lim's (2016) qualitative study revealed learners' conceptions of mathematics as related to a limited perspective of the role of mathematics in the world, such as in applications involving money, daily tasks and careers. Lim further established that those learners from the two settings he used in his study expressed that the mathematics learnt in school primarily served a credentialing role. By conceiving mathematics as bearing a limited role in the world outside the classroom, learners portrayed traditionalistic conceptions about the subject. Dionne (1987); Schoenfeld (2016); Berrett and Carter (2018) and Yang, Leung and Zhang (2019) indicate that such traditionalist conceptions related to rote learning, reproduction of facts and failing to give meaning to the regurgitated facts results in the learnt mathematics having no link to everyday life. This is supported by Waldrop (2015) and Willacy and Calder (2017) who indicate that the aesthetic value of mathematics is not in the memorisation of facts or routine mathematics, but in conceptual understanding creating an awareness of the practical value of the subject. Engaging in rote learning of mathematics is traditionalistic in nature and does not create students' creative thinking (Thompson 1996; Golafshani 2013). The results in the studies discussed above provided pointers to look out for in the present study. Lim's study had only one theoretical framework: Westheimer and Kahne's framework, whereas my study employed two theoretical frameworks (conceptions about mathematics by Dionne [1984] and socio-constructivism by Vygotsky [1978] as the lenses for the study.

In another study, Pa and Osman (2015) in Malaysia investigated Actuarial Science students' conceptions of the learning of mathematics, images of learning mathematics, metaphors for the learning of mathematics, and the use of mathematics in daily life. This was a case study of five students enrolled in the Diploma Actuarial Science programme. Data for this research was video recorded to capture accurate data (Rosenthal 2016) during the interview. Other data sources were notes and sketches. Data analysis was done using a thematic analysis. The conceptions revealed were that the structure of mathematics is a formal discipline which uses symbols. Such findings pointed to traditionalism where mathematics is conceived as a systematic subject with rules, symbols and formulae to be mastered (Dionne 1984). The relevance of this to my study related to it being a qualitative case study, however, whether or not students in this study who struggled to pass mathematics would conceive it as a systematic subject with rules and formulae to be memorised needed to be established.

Ng and Dindyal (2016) in Singapore focused on the conceptions of high school teachers regarding the use of examples when teaching mathematics. The Singaporean study found that examples and homework tasks were intended to cover the syllabus and prepare learners for examinations by repeating examples done in class in the homework given. This repetitive approach to learning and teaching of mathematics suggested traditionalistic conceptions (Dionne 1984). Literature (Lai and Murray 2012) indicates that instead of repetitive teaching, teachers should craft and use examples that allow them to attend to common errors and misconceptions, thus increasing students' exposure to mathematical knowledge and thereby adopting constructivist conceptions. A purposeful sample of 121 secondary teachers with at least 5 consecutive years of experience from 24 schools responded to 3 open-ended questions. While

Ng and Dindyal (2016) studied high school teachers, my study used primary school student teachers and mathematics lecturers in order to understand the conceptions in mathematics education, including the use of examples, and this Singaporean study offered areas to look out for in my study.

Andrews and Hatch (2013) in the United Kingdom studied secondary school teachers' conceptions of, and beliefs about, mathematics and its teaching. They used a questionnaire and distributed it to all mathematics teachers in 200 secondary schools in 3 selected regions of the UK. A factor analysis employed revealed that there was a strong relationship between the conceptions held about the subject of mathematics and the teaching of mathematics. That is, if a teacher's conceptions were constructivist in nature that teacher would teach mathematics interactively, playing a facilitative role in the mathematics classroom. Literature (Campbell, Nishio, Smith, Clark, Conant, Rust, DePiper, Frank, Griffin and Choi 2014) indicates that teachers' knowledge and beliefs influence their instructional practices. Further literature (Hill, Charalambous and Chin 2019) purports that while development in mathematics rests on the teacher's knowledge, the subject matter and how they teach it, their beliefs or conceptions are also important. This therefore implies that conceptions influence teacher practice. Teachers with transmissionist conceptions believe that effective teaching is when the teacher first illustrates how a mathematical problem is worked out, and then learners solve the problem using the method presented by the teacher. This UK study was relevant to my study because it also included pedagogical practices in mathematics; however, this was a quantitative study while the current study was qualitative. Andrews and Hatch (2013) studied secondary school mathematics teachers in 200 schools, different from my study that investigated mathematics teacher educators and their mathematics student teachers in 4 primary school teachers' colleges.

While Andrews and Hatch (2013) found a strong link between mathematics conceptions and mathematics pedagogies using a quantitative study in the UK, Genc and Erbas (2019) conducted a qualitative study in Turkey of secondary mathematics teachers' conceptions of mathematics literacy and discovered that teachers' conceptions of mathematical literacy were related to their possession of mathematical knowledge and skills, problem solving, conceptual understanding and motivation during mathematics learning and teaching. The Turkish study regarded the conceptions of mathematics literacy as vital in identifying effective pedagogical practices. Data generated through semi-structured interviews with 16 in-service mathematics teachers from different types of secondary schools was transcribed and analysed using open coding. These teachers in Genc and Erbas's (2019) study portrayed multiple constructivist conceptions (Vygotsky 1978; Kim 2001) of mathematical literacy.

When constructivist conceptions about mathematics, like conceptual understanding and possession of mathematical content surface, this is a deviation from the traditionalist conceptions where facts, rules and formulae are regurgitated and reproduced without understanding. The constructivist conceptions are important in the learning of mathematics as they help instill critical thinking skills in students. This is contrary to most of the teaching and learning processes and approaches adopted in schools where the traditional lecture method is based on memorisation, leading students to thinking less critically (Othman, Salleh and Abdullah 2013; Hurst and Hurrell 2016). Genc and Erbas's (2019) study is similar to mine in that it was a qualitative study and analysed generated data using open coding. Students and lecturers participated in the current study, while Genc and Erbas used high school mathematics teachers. The current study also tried to establish the nature of the conceptions that the students who struggled with mathematics held.

In the global literature discussed above, the studies focused on conceptions about mathematics and its relationship to daily life. Participants in the studies reviewed included secondary school teachers, high school learners and undergraduate students as participants. The participants studied generally conceived mathematics as a systematic subject with no relation to everyday life, but which contained rules and formulae to be memorised. These rules and formulae had to be used in order to produce the correct answers to mathematical problems. The researchers through their results highlighted that participants had traditionalist conceptions about mathematics (Dionne 1984). Traditionalist conceptions are a barrier to meaningful mathematics learning and performance, and learners who hold such conceptions are not critical thinkers; an aspect demanded by the subject. This is supported by Fonseca and Arezes (2017), which mentions that the development of critical thinking generates improvement of mathematics achievement. Quantitative and qualitative approaches were adopted and in the quantitative studies the questionnaire was the data generation tool. The majority of the studies used qualitative approaches where the interview was the commonly used data generation tool. All except one of the studies discussed above were carried out in high schools with high school learners and teachers.

The regional studies on conceptions about mathematics were conducted in Nigeria, Botswana, Kenya, Zambia and Ethiopia. Awofala, Lawani and Oraegbunam (2020) in Nigeria, conducted a study on pre-service teachers in universities and found that teaching of mathematics was done using rule based and algorithmic dependent teacher centred pedagogies, and students ended up learning mathematics through rote memorisation which suggests traditionalist conceptions. This learning of mathematics led to patchy formations of mathematical concepts, thereby hindering their conceptual understanding of mathematical concepts. This was an indication that the pre-service teachers held traditionalist conceptions about mathematics and this led to the same pedagogical practices. The patchy formations are linked to surface learning, while the conceptual formations are deep approaches to learning mathematics (Howie and Bagnall 2013). The rule-based strategy of teaching can literally be linked to 'spoon feeding' and is traditionalistic (Dionne 1984). Literature (Noreen and Rana 2019) indicates that the traditionalist approaches, where learners balk when approached and just do as they are told, retard critical thought. Further literature (Shah and Rahat 2014; Celik 2018) indicates that the classroom environment created is conventional, and the learning abilities of the majority of the learners are restricted to only duplicating what is written on the board and they are not capable of effectively handling the data through thoughts, evaluation and investigation. Such constraints can be detrimental as they affect a learner's intellectual capability and lead to loss of interest in learning mathematics.

Whether traditionalist conceptions related to rule based and teacher centred pedagogies emerged in the current study remained to be established. The Nigerian study was carried out with 228 pre-service teachers from 5 public universities. Data was generated using a questionnaire on the conceptions of teaching and learning mathematics, and data analysis was done quantitatively using the Cronbach's Alpha. The study recommended that pre-service mathematics teachers be exposed to constructivist teaching practices in the teacher education training programme in Nigeria. Drawing on Awofala et al.'s (2020) study, my study sought to establish whether student teachers still held traditionalist conceptions related to rote learning. While the Nigerian study studied pre-service teachers like in the current study, it did not focus on those student teachers who had struggled to pass O level mathematics.

In another study, Mapolelo (2009) in Botswana studied learners' views about the nature of mathematics, the mathematics learning process and factors within the classroom that were perceived to impact upon the learning of mathematics. The study found that high school learners considered the learning and understanding of mathematics to mean being able to get correct answers. This was an indication that students held traditionalist conceptions about mathematics, where students were result oriented (Dionne 1984). Students further reported that in the majority of cases, the teaching of mathematics was lecture-oriented, implying a traditionalist environment in which they were learning mathematics. However, literature (Festus 2013; Riley, Luban, Holmes, Gore and Morgan 2017) indicates that innovative teaching methods, unlike the traditional methods, provide positive mathematical learning experiences which can enhance students' achievement in mathematics.

In the traditionalist or the conventional classroom learners are passive, contrary to the activity-based instruction advocated for by Vygotsky (1978), where the learner actively participates in the educational procedures and processes during demonstrations of 'doing' (McGrath 2011). Thus, findings offered in Mapolelo's study were pointers to the current study to establish whether students conceived the traditionalist mathematics environment. The Botswana study used a mixed method approach and generated data from senior secondary school learners through questionnaires, interviews and lesson observations. The study relates to my study in that the data generation tools (interviews and lesson observations) used to generate the data was also used in the current study. However, Mapolelo's (2009) study adopted a mixed method approach and the current study was qualitative.

While Awofala et al. (2020) in Nigeria studied the psychometric properties of the conceptions of teaching and learning by pre-service mathematics teachers, Wanjala and Simiyu (2020) in Kenya studied mathematics teachers' conceptions about problem solving. The results of the Kenyan study showed that teachers tend to hold strong conceptions about problem solving that are consistent with the instrumentalist view. This instrumentalist view by Ernest (1991) matches Dionne's (1984) traditionalist conception. The instrumentalist view treats the student as a passive recipient of mathematical information, while the teacher takes the role of an instructor. Instrumentalism is at the lowest level of Ernest's three conceptions and it involves knowledge of mathematical facts, rules and methods as separate entities. Literature (Hunter, Hunter and Restani 2018) also indicates that the instrumentalist view takes mathematics to be a collection of procedures, facts and skills, with the teacher as an instructor supporting students to master skills and processes. Therefore, mathematics teachers, in order to teach mathematics for retention, should move away from an instrumentalist view of mathematics and traditionalist teaching strategies towards developing a more problem-solving view of mathematics and mathematics teaching, which is a hands-on approach.

Wanjala and Simiyu's (2020) study used simple random and stratified sampling to select 20 teacher participants from 20 schools. Data was generated using questionnaires, interviews and classroom observations. The study was guided by three theoretical frameworks by Ernest; Anderson and Bernado. Wanjala and Simiyu (2020) analysed their data using descriptive and inferential statistics. The study recommended that adequate educational interventions should be planned and implemented in teacher education programmes in order to address these negative conceptions. This study related to my study in that it sought to understand conceptions in mathematics and it also used a theoretical framework on conceptions about mathematics. However, it was distinct in that 20 research settings were used for the study, while I only used 4 research settings. Another distinction was that while the Nigerian study sampled participants using simple random and stratified sampling, the current study used convenience and purposive sampling, as well as self-selection.

Mulendema, Ndhlovu and Mulenga (2016) in Zambia studied the perceptions and attitudes of student teachers and their cognitive-metacognitive awareness in mathematics in colleges of education and found that student teachers stated that mathematics was a difficult subject, involving and demanding a lot of commitment and effort to understand it. Students further revealed that lecturers taught them the "how" approach of solving mathematical problems, without the "when" and "why" processes of solving problems. Literature (Umugiraneza, Bansilal and North 2017) also indicates that teachers mostly focus on teacher-led instructional methods and formal assessments. However, the "when" and "why" approaches create active learners and foster student engagement and collaboration in the learning of mathematics. This is supported by literature (Luft and Dubois 2017) which suggests that learners are expected to apply their knowledge to develop new perceptions and skills and to apply mathematical reasoning to problems in order to have the capacity to participate in today's and tomorrow's economy. This, according to Dionne (1984), portrays a traditionalistic conception of mathematics where lecturers are concerned with the end product and not the process of solving mathematics problems. The current study also tried to establish whether the "how" approach employed by lecturers in the Zambian study could also be confirmed in the current study. Results from the Zambian study further revealed traditionalism when students indicated that lecturers taught them procedures of solving problems, without their participation. The current study sought to establish the types of conceptions held by these students who struggled to pass O level mathematics. The quantitative Zambian study which had a sample of 600 student teachers drawn from 2 secondary school Teachers' Colleges of Education in Zambia generated data through questionnaires. Participants were selected through a simple random sampling method. In the current study the student teachers were purposively drawn from four selected colleges, while Mulendema et al. (2016) drew their participants from secondary schools. Furthermore, the current study was qualitative and data was triangulated, unlike Mulendema et al. (2016) who used the questionnaire only for data generation purposes.

In Ethiopia, Serbessa's (2006) qualitative study confirmed that although the employment of innovative constructivist teaching and learning strategies was emphasised in the Ethiopian education policy, teachers conceived traditional lecture methods, in which they talked and learners listened, and these dominated the classrooms (Attard and Orlando 2014). The focus of this Ethiopian study was to understand the tension between traditional and modern teaching-learning approaches in 12 (6 urban and 6 rural) randomly sampled Ethiopian primary schools. The teachers engaged in transmissive modes of teaching, portraying traditionalist conceptions where they conceived themselves as sources of knowledge and treated their learners as empty vessels who did not have any prior knowledge (Vygotsky 1978; Dionne 1984; Kim 2001). The study further revealed that common obstacles and barriers to the employment of active learning in Ethiopian primary schools were the Ethiopian traditionalist ways of teaching and learning of mathematics, lack of institutional support and learning resources, teachers' lack of expertise, inappropriate curricular materials and students' lesser preference to actively participate in learning due to lack of prior experience and knowledge (Angelo and Cross 2014; Bringula, Basa, Dela Cruz and Rodrigo 2016). Teacher-dominated pedagogy, which places students in a passive role, is undesirable (Moore 2012). Government policies and implementation strategies encouraged learner centered, active pedagogy, cooperative learning and the development of critical thinking and problem-solving skills. From the government's standpoint, it sought to transform the traditionalist classrooms into constructivist classrooms where interaction came into play. Yet there was ample evidence that teacher-dominated pedagogy was the norm in the vast majority of Ethiopian primary schools. Drawing from Serbessa's (2006) study, this study also attempted to establish whether student teachers revealed traditionalist conceptions of teaching mathematics. Furthermore, my study also tried to determine conceptions about classroom-based pedagogical practices and whether conceptions and experiences affected learner learning. These aspects created pointers for the current study which also sought to investigate the influence of conceptions and experiences of students' learning. Data for the study was generated from the students and teachers. Research techniques employed were simple random sampling for selecting schools and teachers, and a purposive sampling technique for selecting students. A total of 120 teachers and 600 students were selected to fill in the questionnaires, and classroom observations were done in each school. The observation checklist was used during lesson observations to triangulate the questionnaires. While the study related to mine in that it was on pedagogical practices in mathematics, the difference was that Serbessa's (2006) study generated data from the students and qualified teachers while my study generated data from student teachers and their mathematics lecturers. Serbessa (2006), however, did not compare teacher conceptions against learner conceptions, as was done in the current study.

From the above discussion, regional studies on conceptions were conducted in universities, teachers' colleges, secondary teachers' colleges and schools. The focus was generally to establish conceptions about mathematics. Of all the studies, only one was qualitative in nature otherwise the rest were quantitative studies. Like in the global studies, the questionnaire was mostly used as the data generation tool for these quantitative studies. One of the studies was informed by three theoretical frameworks. The findings, like in the global studies, indicated that students and teachers held traditionalist conceptions about mathematics, which led to rote learning and memorisation of facts.

The national studies on conceptions about mathematics were conducted by Chauraya and Mhlolo (2008); Rudhumbu (2014); Muzangwa (2014) and Ndemo, Zindi and Mtetwa (2017) and these will be discussed below.

Chauraya and Mhlolo (2008) sought to understand in-service teachers' conceptions about mathematics problems and problem-solving approaches and found that they conceived the use of drill exercises and tasks commonly used in the mathematics textbooks as what they adopted to solve mathematical problems. The view of doing mathematics by way of using mathematics textbooks and drill is related to the traditional conception about mathematics (Dionne 1984). This view makes mathematics too formal and mathematics taught in this traditional skill of drilling does not make students learn much mathematics (Baroody and Dowker 2013). The sample in Chauraya and Mhlolo's (2013) study constituted 34 mathematics in-service teachers who provided data through a questionnaire designed to find out what they perceived to be mathematics problems and problem solving. The study by Chauraya and Mhlolo (2013) used the questionnaire to generate data, whereas in my study the questionnaire was used for the selection of student participants only and was yet to ascertain whether students conceived the traditionalist conception as drilling or use of mathematics textbooks.

While Chauraya and Mhlolo (2013) examined teacher conceptions about mathematics problems and problem-solving approaches, also in Zimbabwe, Ndemo, Zindi and Mtetwa (2017) examined in-service mathematics teachers' deductive and inductive conceptions about mathematics. The study found that in-service teachers conceived deductive teaching as appropriate in solving mathematical problems. Deductive learning is a more instructor-centred approach to mathematics learning (Al-Zu'be 2013). This finding suggested traditional conceptions. Concepts and generalisations are introduced first to learners, followed by specific examples and activities to support learning. The study found that lessons were generally conducted in lecture approaches with minimal dialogue between educators and their learners. This kind of mathematical learning and teaching is traditionalistic in nature (Dionne 1984).

Literature (Serbessa 2006; Van Dat 2016) indicates that some novel teaching approaches, such as active learning methods based on investigation, discovery, cooperative learning and simulation approaches, are more effective than concentrating on traditional approaches where teachers just apply "chalk and talk". Further literature (Boaler 2016) posits that during interactions learners make mistakes and these mistakes can present a powerful learning opportunity which teachers can take advantage of, capitalise on and provide feedback on the actions and how this can be improved, instead of focusing on the learner characteristics. This is an indication that socio-constructivism and constructivist conceptions should be considered in the teaching and learning of mathematics at all levels of mathematical learning. As well, my study tried to determine whether deductive conceptions about mathematics pedagogical practices existed. Ndemo, Zindi and Mtetwa's (2017) study was a cross-sectional survey involving 11 secondary mathematics teachers who had enrolled for an in-service mathematics education degree. The study generated data through interviews and was guided by Ausbel's learning theory and Tall's notion of a met-before. This study informed my study as it used interviews as a data generation tool and data analysis was informed by two theoretical frameworks which suggested areas to look out for in the current study.

Rudhumbu (2014) investigated teacher conceptions about the application of motivational teaching methods in the teaching of mathematics in primary schools in Zimbabwe. The study found that learners viewed the learning of mathematics as too abstract, mechanical and difficult which should be learnt by drill and practice. Drill and practice is a teaching strategy employed during mathematics teaching typified by systematic repetition of examples, practice problems and concepts. It is therefore a practice used for perfecting a skill or a mathematical algorithm. Literature (Rittle-Johnson and Schneider 2015; Meyer 2018) indicates that during drill and practice, students may be relying on recall in order to take a test or an examination, but without a deep understanding of the material. Rittle-Johnson and Schneider (2015) further point out that students may not master intended knowledge and skills through memorisation of material. In addition, memorisation can be problematic at later stages when they try to accomplish more complex tasks and learn more advanced concepts. Literature (Burroughs and Schmidt 2014) indicates that this traditionalistic conception of conceiving mathematics as difficult has been compounded by teachers' obsession with teacher-centered methods like drill and practice which inhibit students from being creative and demonstrating problem solving skills. Further findings of this study were that primary school teachers in Zimbabwean schools mostly used teacher-centered teaching methods rather than learner-centered teaching methods in their teaching of primary school mathematics and this negatively impacted their ability to motivate students to effectively learn mathematics. How such aspects could play out in the current study was also established. A sample of 150 teachers who had been randomly sampled was used. A survey questionnaire and documentary evidence were used as data generation instruments. These data generation tools were pilot tested. Data was analysed using the SPSS software. While my study was located in teachers' training colleges, Rudhumbu's (2014) quantitative study was conducted in primary schools and used documentary evidence to compliment the questionnaire data, contrary to my study which used focus group discussions, face-to-face interviews and lecture observations.

Concomitantly, Muzangwa (2014) also in Zimbabwe, studied in-service teacher conceptions about cultural aspects of the subject mathematics and found that a good number of them were aware of the significance of the role of culture on mathematics education, whilst some were not very sure how culture played a role in the field of mathematics. Thus, these teachers conceived and advocated for the use of cultural games in the teaching of mathematics. By using games in the teaching of mathematics, the teachers reflected that they held constructivist conceptions about mathematics where interaction was a norm (Vygotsky 1978; Dionne 1984; Kim 2001; Kerrigan 2018). Other literature (Orim and Ekwueme 2011) indicates that playing games encourages strategic mathematical thinking as students find different strategies for solving problems and deepen their understanding of numbers. Play moves mathematics instruction beyond rote memorisation to a more expansive understanding of the subject (Orim and Ekwueme 2011). If games can be incorporated as a teaching tool during mathematics pedagogical practices, they may be an effective and necessary intervention which will stimulate learners' interest in solving mathematical problems.

Muzangwa's (2014) study used the case study research design and was on in-service teachers' views and conceptions on the relationship of mathematics with culture. The sample comprised of 27 in-service teachers and data was generated through a questionnaire. The current study also tried to establish whether student teachers who struggled to pass mathematics would conceive indigenous games as a way of conceptualisation of mathematical concepts.

From the national studies discussed above, only one used primary school teachers practicing in schools while the other studies used in-service teachers who were furthering their studies in mathematics in the different universities in Zimbabwe. The questionnaire, like in the global and regional studies, was popularly used as the data generation tool. The focus of the studies was to understand the conceptions about mathematics and the relationship of mathematics to real life. Surveys and case studies were used in these studies. Methodically, both quantitative and qualitative methods were employed to generate and analyse the data in the national studies. Again, like in the global and regional studies, traditional conceptions surfaced in these national studies. Following is the discussion on the experiences of student teachers during mathematics pedagogical practices.

2.4 Experiences of student teachers during mathematics pedagogical practices

This section reviews global, regional and national literature on students' experiences during mathematics pedagogical practices.

From the global arena, studies on experiences during mathematics pedagogical practices were carried out in Malaysia, the United Kingdom and Turkey. Tajudin (2015) in Malaysia studied mathematics lecturers' teaching and learning practices and established that students experienced non-interactive lectures where lecturers incorporated passive teaching methods during their mathematics pedagogical practices. This was contrary to the fact that Malaysian academics had proposed various teaching practices in order to enhance mathematics teaching effectiveness in universities (Yi, Ying and Wijaya 2019). Further literature (Birhan 2018) indicated that the main issue in mathematics teaching processes was not how well a lecturer prepared his or her lesson, but how his or her students conceived the lesson and mastered the mathematics concepts therein. The current study tried to determine what kind of experiences student teachers had during mathematics pedagogical practices. Data generation employed observation of two mathematics lecturers in their natural setting and the data was analysed through content analysis focusing on related mathematics teaching and learning (Bengtsson 2016). The Malaysian study informed my study in that some participants were mathematics lecturers who were observed teaching.

In another study, Pampaka and Williams (2016) in the UK sought to understand how students experienced transmissionist teaching practices and the study revealed that students experienced a lecture method which worsened their transition from high school to university. Thematic analysis of the generated data further revealed that students had problems due to the way in which they were taught, which lacked dialogue/interaction. As the lecture method was the predominant mode of teaching, students' past academic experience had not prepared them for the fast pace of lectures and this caused problems for many students since the lecture 'conversation' often became reduced to a monologue. These lecture practices are associated with the transmissionist way of teaching mathematics, which commonly causes negative conceptions and dispositions. Further research findings indicated a lack of enjoyable experiences of university mathematics as the mathematics was of a higher level (Pfeiffer 2010; Eraslan 2013). Literature (OFSTED 2012; Foster 2013) purports that the majority of students continue to experience an uninspiring mathematics curriculum in which learning is limited to memorising and practising mathematical procedures, with little understanding of their application, purpose or underlying concepts. Furthermore (Wright 2017) also indicates that teachers should transform their classroom practice and develop teaching approaches which enhance the engagement and agency of students. This longitudinal survey by Pampaka and Williams (2016) involved five universities and was carried with five hundred and ninety-eight students who were interviewed following an open-ended semi-structured schedule throughout. Pampaka and Williams's (2016) study related to the current study, which also used an interview schedule. However, the UK based study, unlike mine, was a longitudinal study and participants were university students as opposed to the primary school student teachers in this study.

While Tajudin (2015) in Malaysia and Pampaka and Williams (2016) in the UK studied the mode of mathematics teaching in the universities, Kilic (2009) in Turkey studied how student teachers experienced the methods course and how it supported the development of pedagogical content knowledge for pre-service secondary mathematics teachers. The Turkish study found that although the pre-service teachers thought that course topics contributed to their pedagogical content knowledge, they experienced a weak application of their knowledge when they were asked to help a student who was struggling to understand particular mathematical concepts. This is supported by literature (Meagher, Edwards and Ozgun-Koca 2013) which indicates that the teacher candidates with their mathematical knowledge try to create solutions without understanding the reason for students' misconceptions. This implies that a teacher with adequate content knowledge will be able to predict the students' ways of thinking so that his or her teaching is based on mathematical conceptions and misconceptions of the students. This implies that students have a surface understanding (Biggs and Tang 2007; Dolmans, Loyens, Marcq and Gijbels 2016) of mathematics concepts, especially when they fail to impart acquired knowledge to their learners. Drawing from the Turkish study, the current study also tried to establish whether students who struggled to pass mathematics failed to impart mathematical knowledge. The data for the Turkish study was generated from six pre-service teachers through the use of interviews, observations, a questionnaire, documentary evidence and class artifacts. A pedagogical content knowledge framework guided the study and data from the university student participants was analysed thematically, whereas in my study I adopted open coding to analyse data.

Another study in the UK by Francome (2015) studied how learners experienced grouping practices and the effect on their mindsets, teachers' mindsets and teachers' beliefs and practices. The study found that learners experienced collaborative work in pairs or small groups in a typical mathematics lesson. Further findings were that learners experienced learning through their mistakes and they developed an understanding of mathematics concepts through discussion, thereby boosting their engagement (Diaz 2017). Collaboration is therefore conceived as a teaching strategy which can act as a catalyst for improving pupils' experiences in learning mathematics. Literature (Laursen, Hassi, Kogan and Weston 2014; Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt and Wenderoth 2016) posits that collaboration in the mathematics classroom engages students in activities such as reading, writing, discussion or problem solving, that promote higher-order thinking. Collaboration is an important teaching intervention, given that when students are given mathematics problems they are not familiar with, they will need to collaborate with one another to find solutions (Slavin 2014; Baloche and Brody 2017). This collaboration during mathematics lessons portrays constructivist conceptions as opposed to traditionalist experiences which are experienced during most lectures (Paris 2014). Francome (2015) generated data for the qualitative study through a questionnaire, interviews and lesson observations with 286 primary school students and 12 teachers. My qualitative study, like Francome's, used a qualitative multi-modal approach which enabled data triangulation. However, the UK study used primary school teachers and learners, whereas I used student teachers and lecturers.

From the above discussion on global literature, studies focused on students' experiences during pedagogical practices in mathematics. Participants were drawn from teachers' colleges and universities, where students and lecturers provided data through interviews, documentary evidence and observations. Findings revealed the lecture method as the dominant mode of instruction experienced by students. Furthermore, students generally experienced non-interactive pedagogical practices, which limited their acquisition of mathematics content knowledge during pedagogical practices.

The regional studies on students' experiences during mathematics pedagogical practices were carried out in Botswana, South Africa, Ghana and Ethiopia. Rudhumbu (2014) in Botswana revealed that while teachers concurred that motivational teaching strategies were effective in motivating learners to learn mathematics. The majority of these teachers did not expose their learners to experiences in motivational strategies in the teaching of mathematics. The study sought to understand the experiences of learners of motivational strategies and their effectiveness in the teaching and learning of primary school mathematics. Further, findings revealed that learners did not experience motivational strategies due to high workloads and large class sizes in schools. Motivation creates a learning environment, where students are encouraged to communicate their understandings of the task, and their ideas are valued and respected (Heich 2014). The supportive mathematical environment created by motivation helps learners to build positive dispositions towards mathematics, which is ideal for conceptual understandings of mathematics. The current study also tried to establish whether or not student teachers experienced motivational strategies during mathematics pedagogical practices. The sample in the Botswana study consisted of 200 primary school mathematics teachers selected randomly from 10 primary schools. A questionnaire with a 5-point Likert scale was used for data generation, complimented by documentary evidence in the form of schemes and plan books. Statistical analysis utilised the Statistical Package for Social Science (SPSS-X) to compute frequencies and percentages. While my study used primary school student teachers, Rudhumbu‘s study of primary school mathematics teachers was quantitative and used the Statistical Package for Social Science (SPSS-X) package.

While Rudhumbu (2014) investigated whether learners experienced motivational strategies during mathematics lessons, Bansilal (2015) in South Africa sought to understand how university students experienced technology in the mathematics classroom. The South African study found that students experienced some benefits of mathematics software related to provision of different representations, dynamic visualisation of concepts and variation in mathematical situations. Furthermore, findings indicated that students experienced use of technology more often in their own learning rather than in the classroom. Technology is effective in the mathematics classroom since mathematics is made alive through engagement and use of interactive media. This is also supported by literature (Meehan and Salmun 2016) which indicates that in technology implemented classrooms, interactive student involvement is fostered and learning becomes more fun, more enjoyable and more attractive for students. Both students and lecturers benefit from its usage and it also provides the students with an opportunity to explore and to be motivated during mathematics instruction. The mathematics classroom is transformed into a constructivist classroom where mathematics knowledge is actively acquired and shared (Vygotsky 1978; Kim 2001). The current study also sought to establish whether or not students experienced the use of technology during mathematics pedagogical practices. Bansilal's (2015) qualitative study used a sample of 52 mathematics student teachers, generated data through interviews and used Saxe's framework to analyse the data. The study recommended the provision of specialist mathematics software to expose students to such experiences and improve their learning outcomes in mathematics. While the South African study, just like the current study, was qualitative and used interviews, it was guided by one theoretical framework.

In another study, Marmah (2014) in Ghana sought to understand students' preferred mode of instruction during pedagogical practices and they revealed the lecture method as their preferred mode of instruction in mathematics lectures. While the Ghana students apparently preferred the lecture method, my study also tried to understand what participants' experiences were like regarding this lecturer exposition strategy. The lecture method which students experienced emerged as a teaching method where an instructor was the central focus of information transfer (Festus 2013; Saira 2020) and students remained as passive recipients of mathematical knowledge. In many tertiary institutions, students experience mainly the lecturer-centred lecture method and learning tends to be superficial (Durosaro and Adgoke 2011; Paris 2014; Salam, Hossain and Rahman 2015). The strategy does not provide an opportunity for the instructor to check whether the learners are intellectually involved. This descriptive study in Ghana used the questionnaire as the data generation instrument, which was administered to 197 undergraduate students. This was a quantitative study where the t-test was used for data analysis.

In Ethiopia, Alemu (2010) found that Ethiopian education policies emphasised that students should experience active mathematics learning, however, traditional lecture methods in which lecturers talked and students listened dominated most lecture rooms. The study suggested that active learning methods such as cooperative learning, inquiry-based learning, discovery learning, problem-based learning and discussion methods should have been used instead. In mathematics classrooms, during pedagogical practices cooperative learning enables the students to listen to each other and share ideas and even question one another's mathematical thinking. Students work in small groups collaboratively in order to solve a given problem or task and achieve a common goal. When classrooms achieve this balance, all students have the opportunity to learn within their Zone of Proximal Development (Vygotsky 1978). Classrooms are becoming more and more student-centered and group work oriented, thus deviating from the traditional mathematics classrooms (Fetzer and Tiedeman 2018). Findings from Alemu's (2010) study revealed that students experienced the lecture method due to lack of time and resources to implement problem-based learning, rigidity of the time table, negative lecturer attitudes, a lack of instructional materials and administrative support, and the huge amount of content to be covered. Alemu's (2010) study adopted a mixed methods approach where six universities were used and eighty-four lecturers participated in the study by completing a questionnaire, engagement in interviews and being observed.

In the regional studies discussed above the main focus was on students' experiences in mathematics lessons or lectures. The participants in these studies ranged from student teachers in colleges and universities to qualified teachers. The studies employed both qualitative and quantitative approaches and in the quantitative studies, like in other studies discussed above, the questionnaire was the dominant data generation tool. The studies found that students mainly experienced the lecture method and did not experience or acquire adequate subject content knowledge. Furthermore, the students did not experience motivational strategies during pedagogical practices. The teachers and students lamented the large class sizes and high workloads which hindered students' experiences of such practices. The studies also revealed that use of technology during pedagogical practices was limited.

In the national forum the studies which are discussed in this section were conducted by Muyengwa (2013); Sunzuma, Ndemo, Zinyeka and Zezekwa (2012) and Makamure (2018). Makamure (2018) found that course structures, teaching methods and teachers' attitudes were contributory factors to the lack of student motivation during mathematics pedagogical practices, which limited their experiences. Bol, Campbell, Perez and Yen (2016) showed that negative attitudes were the result of frequent and repeated failures or problems when dealing with mathematical tasks and these negative attitudes could become relatively permanent and affect student motivation. Further literature reviewed (Manalu 2014) indicates that students who have a positive attitude towards mathematics learning have a tendency to obtain satisfactory mathematics performance. Makamure's (2018) study further revealed that students did not experience process-oriented approaches during mathematics pedagogical practices and most lessons were text book driven. The textbook approach of mathematics teaching is traditionalistic since it is rule based and procedural and hinders the conceptual understanding of mathematics concepts. This is supported by literature (Corkin, Coleman and Ekmekci 2019) which indicates that another potential barrier to reform in mathematics teaching is the current emphasis on textbooks for mathematics lessons. Furthermore, Knipping and Reid (2015) posit that such practice undermines teachers' professional judgment regarding appropriate mathematical methodology as traditional texts embody transfer-of-information, drill and practice approaches to instruction. In the current study, whether the students who struggled to pass O level mathematics experienced process-based approaches during mathematics pedagogical practices also had to be confirmed. Makamure's (2018) qualitative study generated data from high school learners and teachers through focus group discussions and observation. The study was informed by the self-determination theory (SDT) and recommended that for meaningful mathematics learning the students needed to experience high levels of motivation (Davis, Kelley, Kim, Tang and Hicks 2016; Hegedus 2017; Holmes 2018). This study on high school learners and teachers offered pointers to my study, which used lecturers and student teachers.

Muyengwa's (2013) case study focused on the experiences during mathematics pedagogical practices of third year student teachers at a primary teachers' college. Findings indicated that although the pre-service mathematics programme enabled students to experience foundations in subject knowledge, more could be done to improve the teaching methods, provision of resources and exposure to more subject knowledge. Subject content knowledge is one of Shulman's (1987) knowledge domains vital for every teacher, as it is the knowledge that a teacher should teach that learners should learn. However, literature (Lee, Capraro and Capraro 2018) indicates that the majority of these mathematics teachers lack substantial subject matter knowledge. Further reviewed literature (Johannsdottir 2013) also confirms that prospective teachers have difficulties evaluating alternative solution methods for difficult topics. One crucial attribute of a constructivist teacher is based on a strong hold of content and pedagogical content knowledge for effective mathematics teaching (Udoh 2012). Therefore, during mathematics pedagogical practices the pre-service teachers should develop the constructivist approach to teaching mathematics. This is in line with Marshall, Smart and Alston (2017)'s position statement which indicates that teachers regardless of grade level should promote inquiry-based instruction and provide classroom environments and experiences that facilitate proper learning of science subjects.

These findings offered pointers to the current study to establish whether pre-service teachers experienced adequate content knowledge during mathematics pedagogical practices. Data in Muyengwa's (2013) study was generated from 278 students using a 5-point Likert scale questionnaire and data analysis was done using a mixed method approach. As this study investigated student teachers' experiences during mathematics pedagogical practices, there was something for me to learn, however, Muyengwa's (2013) study used a mixed method approach based on a questionnaire as the only source or data generation instrument and as such lacked triangulation.

While Muyengwa (2013) studied the experiences of primary school student teachers during mathematics pedagogical practices, Sunzuma, Ndemo, Zinyeka and Zezekwa (2012) studied factors that hindered learners' experiences of learner-centred methods in mathematics pedagogical practices in secondary schools. Sunzuma et al. found that in-service students should experience student-centred approaches to learning mathematics for them to be highly motivated. In-service students were qualified teachers who were enrolled in colleges and universities to upgrade their professional knowledge, skills and competence in the teaching profession. Therefore, in-service teacher training encompasses all activities and sets of training required for quality improvement and professional development of teachers (Egert, Fukkink and Eckhardt 2018). Literature (Akhtar, Ali and Din 2011) shows that in-service training includes all those activities which are designed for professional development and skill building of school teachers, essential for professional improvement of teachers as it keeps the teachers abreast of the latest information. However, the teachers in Sunzuma et al.'s (2013) study revealed constraints related to examination assessment, time factors, class sizes, lack of resources and teachers' subject content which hindered the students' experiences in such strategies. The survey generated data through questionnaires and interviews with 15 in-service mathematics students.

In the above national studies on student teachers' experiences of pedagogical practices, studies were generally conducted in teachers' colleges and in universities. The focus was on pedagogical practices and qualitative, quantitative and mixed approaches were adopted. Again, like in the other studies already discussed above, the questionnaire was the most popular data generation tool. Like in the global and regional studies, students' experiences during pedagogical practices were generally related to lecture methods and these students also experienced inadequate mathematics content knowledge learning. The next section discusses the influence of conceptions and experiences on student learning during mathematics pedagogical practices.

2.5 The influence of conceptions and experiences on student teacher mathematics learning

The effects of conceptions and experiences on student learning are discussed in the following section. Global studies on the influences of conceptions and experiences on the learning and teaching of mathematics were carried out in Australia, India and Japan. Murphy (2017) in Australia found that in order to succeed in mathematics, students needed to view mathematics as a discipline that had an essential application to their lives. The Australian study focused on the relationship of conceptions of mathematics and the students' performance using their grades. This research finding suggested that conceptions have an impact on performance, since successful mathematics performance is associated with the conceptual understanding of mathematics concepts (Orhun 2013). Murphy's (2017) survey used a randomly selected sample of 291 students and a 5-point Likert scale questionnaire which had been pilot tested to generate data. Analysis of the data was done quantitatively using SPSS and two assumptions for chi-square tests were considered. The current study also tried to establish how conceptions and experiences influenced students' learning. The Australian study, however, was a quantitative survey while the current multi-site case study used 40 student teachers and their mathematics lecturers.

Karimi and Venkatesan (2009) in India sought to understand the relationship between mathematics anxieties and mathematics learning and performance in high school learners. The study established that mathematics anxiety and negative conceptions about mathematics had a significant negative correlation with mathematics performance. Learners generally conceive mathematics as a boring and disengaging subject. They hate mathematics, and also try to avoid it (Colgan 2014). Thus, negative conceptions about mathematics create anxiety, which leads to poor performance in mathematics. Literature (Lyons and Beilock 2012) indicates that mathematics anxiety is characterised by feelings of tension, apprehension, negative beliefs and fear about performing mathematics. Further literature (Chinn 2014) indicates that mathematics can also be conceived as a frustrating subject for many children who have problems with computation and application, and their anxiety then leads to fear of mathematics and poor performance. To confirm that conceptions and experiences have an impact on performance, Fu and Chin (2017) add that mathematics can also be a very interesting and fun provoking subject for some learners and they can really enjoy their learning. Their sample comprised 284 (144 males and 140 females) 10th grade high school learners. Data generated through a questionnaire was analysed quantitatively using the Pearson correlation analysis and the two independent samples T-test. The current study also explored ways in which conceptions and experiences influenced student teachers' mathematics learning and teaching during mathematics pedagogical practices. My study however was qualitative as opposed to the quantitative Indian survey which investigated high school learners.

Gravoso, Pasa and Mori (2002) in Japan found that students' prior learning experiences, learning conceptions, and learning approaches influence their learning outcomes. Students' conceptions of learning as the absorption of information indicate that such experiences either result in a conception of learning as the intake of information or the use of surface learning approaches which hinder performance. So many students, like the students in the current study, may suffer from mathematics phobia due to several negative prior mathematics experiences and conceptions. Literature further indicates that students' prior learning experiences shape their learning conceptions and predispose them to using certain learning approaches which affects their performance (Nelson 2011; Yilmaz and Sahin 2011). Such negative conceptions and experiences towards mathematics could cause suffering and it can be difficult to shift from a mindset of failure to a more positive attitude. Literature (Kunwar and Sharma 2020) shows that if teachers as well as the parents deal with the mathematics phobia in students early by adopting different pedagogical strategies, this may shift their conceptions into positive mind sets. This can help them overcome the negative conceptions by controlling their anxiety, improving their mathematics skills and developing their positive attitudes towards mathematics. Data in the Japanese study was generated from 119 college students using a questionnaire that contained a 4-option Likert-type scale on prior learning experiences, conceptions, approaches and effects. The quantitative study used factor analysis to obtain the measures for prior learning experiences, learning conceptions and learning approaches. This study, notwithstanding its quantitative approach and use of a questionnaire, related to my study as it focused on the effects of conceptions and experiences on students' learning outcomes.

The global literature discussed above addressing the influence of conceptions and experiences on students' learning of mathematics showed that these aspects have an effect on performance during mathematics pedagogical practices. Negative conceptions about mathematics lead to poor mathematics performance and likewise, if they align themselves with positive conceptions and experiences they perform fairly well. The global studies adopted a quantitative approach, used a questionnaire to generate data and were based on high school learners and college students.

Studies on the effects of conceptions and experiences on students' learning were also carried out in the region; in Kenya, South Africa and in Tanzania. Wasike, Ndurumo and Kisulu (2013) in Kenya, from studying the impact of conception on female learners' performance in mathematics within secondary schools, established that female students had negative conceptions towards mathematics and most of these learners with negative conceptions performed poorly in the subject. This may therefore be an indication that conceptions, whether positive or negative, have an effect on performance. If the participants in the study had positive conceptions this would probably improve their performance in mathematics (Bol, Campbell, Perez and Yen 2016). Nicolaidou and Philippou (2003) showed that negative attitudes or conceptions are a result of frequent and repeated failures or problems when dealing with mathematical tasks, and these negative attitudes or conceptions may become relatively permanent. Further literature (Mato and De La Torre 2010) on secondary school learners also showed that those students with better academic performance have more positive attitudes or conceptions regarding mathematics than those with poorer academic performance. However, literature (Pohl 2016) also indicates that improving the negative conceptions of students towards mathematics helps to unlock their ability in performance. The Kenyan study was guided by the constructivism analytical framework of gender performance. The 240 female participants were selected by the stratified random sampling method and provided data through a questionnaire. Descriptive statistics was used to analyse the generated data. This study closely relates to the current study which also sought to understand the influence of conceptions on student teachers' learning during mathematics pedagogical practices. The use of the constructivist theory also provided pointers to the current study, although my study maintained a gender balance.

Wambui (2018) in Kenya found that the performance in mathematics among the female learners was attitudinal and their attitudes determined their performance in mathematics. The aim of the study was to understand whether conceptions and attitudes influenced the performance of girls in mathematics. The students we teach bring with them their own previous and personal learning experiences, some of which may have negative influences on their conceptions of learning and attitudes to study (Cai, Liu, Yang and Liang 2019). Wambui (2018) employed the descriptive survey method and used ten schools which were randomly selected. A questionnaire was used as the data generation tool and it was distributed to teachers and learners in the selected schools, and the District Education Officer (DEO) who was interviewed also provided documentary evidence on performance for the selected schools. Data analysis used both qualitative and quantitative techniques. The attitudinal aspects were also examined in the current study where multiple data generation methods enabled methodological triangulation.

Also, in Kenya, Mbugua, Kibet, Muthaa and Nkonke (2012) studied factors influencing performance in mathematics and established that negative attitudes and conceptions by teachers and learners and learners' retrogressive practices influenced the performance during mathematics pedagogical practices. These research findings therefore imply that conceptions affect learners' learning. Retrogressive practices are deep-rooted practices that are traditional in nature and may be difficult to change as learners may adhere to these practices, thinking that they are proper. Thus, literature (Ashwin and Trigwell 2012) purports that students' perceptions of the learning environment play a pivotal role in fostering student learning outcomes. The Kenyan study had 1876 high school learners, 132 mathematics teachers and 9 head teachers. The data was generated through three questionnaires: for learners, teachers and head teachers. Analysis of the data was done through the use of descriptive statistics. Though the study relates to the current as it explores the effects of conceptions and experiences in mathematics learning, it is distinct in that Mbugua et al.'s (2012) study investigated high school learners and not primary teachers' colleges using three questionnaires to generate data.

In another study carried out in South Africa, Mutodi and Ngirande (2014) sought to understand the influence of learner conceptions on performance in mathematics. Factors such as strengths and weaknesses in mathematics, teacher support/learning material, family background and support, interest in mathematics, difficulties or challenges in doing mathematics, self-confidence and myths and beliefs about mathematics were identified as constructs of the conceptions that influenced learner performance. Findings also revealed that learners conceived that difficulties in mathematics were obstacles, and attributed failure to their own lack of inherited mathematical ability. The conceptions the learners revealed related to inheriting mathematical ability from their parents is a pointer to the traditionalistic conceptions (Dionne 1984) about mathematics. Kaahwa (2012) found that most of the participants he studied did not get enough support from their parents or guardians when they were doing mathematics homework because the parents or guardians also found mathematics difficult for them. The fact that students failed to get parental assistance when working out mathematics homework points to inherited mathematical ability. Such traditionalistic conceptions (Lerman 1983; Dionne 1984) indicate that students label the subject as a subject for the selected few who are born talented. Thus, when learners experience difficulties or challenges when learning mathematics this may lead to the conception that mathematics is difficult, and this subsequently has a bearing on their learning and performance in mathematics. The quantitative study used a questionnaire to generate data from 124 high school learners who had been randomly selected. While Mutodi and Ngiranda (2014) studied high school learners so their study had a different context from mine, and they adopted a quantitative approach, the purpose of their study resembled mine.

In Tanzania Mazana, Montero and Casmir (2019) found that learners' learning and performance in mathematics was affected by factors which included attitude towards the subject, teachers' instructional practices and the school environment. The study investigated learners' attitudes towards learning mathematics, why they disliked mathematics, and the relationship between attitude and performance. An attitude is a set of beliefs, emotions and behaviors toward a particular object, event, thing or person. Attitudes are born through one's own experiences in life. One consequence of a negative attitude towards mathematics is that this leads to avoidance of mathematics-related activities, thus reducing opportunities for practice and performance (Erturan and Jansen 2015; Ganley and McGraw 2016). The Tanzanian study was informed by two theoretical frameworks: the ABC model and Walberg's theory of productivity. The study used a mixed method approach to analyse the data generated from 419 primary school learners, 318 secondary school learners, and 132 college students from 17 schools and 6 colleges, using a survey. While the Tanzanian study used two theoretical frameworks and adopted a mixed method approach, the study pointed me towards some factors which influenced learners' learning in mathematics pedagogical practices which I had to look for during my study.

The regional studies discussed above which researched the factors influencing mathematics performance revealed that conceptions/beliefs and experiences were powerful influencers of students' learning in mathematics pedagogical practices. Participants in these studies comprised of primary and high school learners, college students, mathematics teachers and school heads, and in three of the studies the only participants were girls. Mixed and quantitative approaches were used and like in most of the previously discussed studies, the questionnaire was the only data generation tool used in these regional studies. Random sampling was the popular sampling technique employed as they were mainly large-scale surveys.

At the national level the studies reviewed were carried out by Denhere (2015); Kufakunesu (2015); Gudyanga, Mandizvidza and Gudyanga (2016) and Wadesango and Dhliwayo (2017). Denhere (2015) established that negative traditional beliefs, conceptions or philosophies and embarrassing mathematical experiences including hostile learning environments were the causes of anxiety and fear of mathematics, which in turn triggered poor performance in mathematics. The aim of the study was to understand the possible causes of anxiety among learners in the learning of mathematics. Mathematical anxiety refers to feelings of tension which interfere with the manipulation of numbers and working out mathematical problems (Chang and Beilock 2016; Yamani, Almala, Elbedour, Woodson and Reed 2018). Literature (Maloney, Ansari and Fugelsang 2011; Maloney and Beilock 2012; Ganley and Lubienski 2016) indicates that mathematics anxiety has a negative impact on mathematics performance, and poor performance in mathematics increases anxiety. From these findings it is clear that conceptions and experiences affect students' learning. Concomitantly, my study sought to determine whether conceptions and experiences influenced the mathematics learning of student teachers who struggled to pass mathematics and whether such students experienced fear and anxiety during mathematics pedagogical practices. Denhere (2015) indicated that learning mathematics also created anti-mathematics feelings or anxious experiences among learners engaging in further studies in mathematics. Denhere further alluded to the fear of failure, which resulted in mathematics indifference among learners. Denhere (2015) elicited data by interviewing three high school learners, whereas my study explored college students.

Gudyanga, Mandizvidza and Gudyanga (2016) focused on the influence of perceptions on the participation of Ordinary Level rural female students in mathematics. Findings revealed that rural female students conceived mathematics as a difficult subject; masculine and irrelevant to their future aspirations. Further, research findings indicated that female students' participation in mathematics was highly influenced by their conceptions towards the subject; hence they struggled to learn it during pedagogical practices. Many girls struggled to articulate the purpose of mathematics, and to define what is meant by being a mathematician (Foley 2016). Further literature reviewed (Schleepen and Van Mier 2016) also indicated that girls who struggled with mathematics at times got confused about both understanding the concepts and the meaningfulness of mathematics. The negative conceptions resulted in the development of female students' struggles with and fear of the subject. Therefore, the traditionalistic conceptions about mathematics affect mathematics learning and lead to struggle and/or a fear of mathematics. The current study tried to ascertain whether the students who struggled to pass O level mathematics struggled to learn or feared further studies in mathematics at college. The qualitative study was located in the interpretive paradigm, and 18 female learners and 6 teachers from 3 secondary schools were purposively selected to participate. Lesson observations and semi-structured question-type interviews were used as the data generation tools. The use of an interpretive, qualitative approach, purposive sampling and the use of observations and interviews resembled the current study, albeit that my study used 40 student teachers and 4 mathematics lecturers. Another departure from my study was that Gudyanga et al. (2016) only used female students.

Wadesango and Dhliwayo (2017) found that teaching methods and negative attitudes or conceptions by learners of both sexes were some of the causes of poor performance by students at O level mathematics. This was supported by literature (Michael 2015) which purported that poor teaching environments, poor management of mathematics departments, inadequate self-practice and students' poor backgrounds in mathematics were some of the factors which contributed to poor performance. Wadesango and Dhliwayo's (2017) study focus was on the causes of poor performance in mathematics at O level. The current study which used student teachers who struggled to pass O level mathematics also tried establish whether teaching methods and negative attitudes and conceptions influenced mathematics learning during pedagogical practices. The descriptive research design was employed by Wadesango and Dhliwayo's (2017) and ten O level teachers and their HODs participated in their study. A questionnaire was used as a data generation tool. This study differed from mine in terms of the research approach, data generation instrument and a focus on O level learners, teachers and HODs. However, the study was relevant as its focus was O level mathematics, which participants in my study struggled to pass.

In another national study, Kufakunesu (2015) sought to understand the influence of irrational beliefs on adolescent secondary school learners' mathematics achievement in Zimbabwe and found that learners' irrational thoughts about mathematics correlated negatively with their mathematics achievement. Irrational thoughts are the negative thoughts, conceptions and beliefs that can hinder someone from achieving his/her goals. In terms of research findings, this implies that the irrational thoughts towards mathematics affect the learners' achievements in the subject. Irrational thoughts lead to panic, helplessness, paralysis and mental dis-organisation when students are required to solve a mathematical problems (Wu, Barth, Amin, Malcarne and Menon 2012). According to Dionne (1984), irrational thoughts are aligned to the traditional conceptions about mathematics. My study tried to establish whether the irrational or traditional conceptions and experiences influenced mathematics learning. A questionnaire was administered to 306 high school learners and this quantitative study was informed by Ellis and Tang's theory. Kufakunesu's (2015) study, which was carried out in Zimbabwe like my study was, related to mine because it sought to understand whether irrational thoughts (conceptions) had an influence on students' learning. However, the questionnaire was used as the only data generation tool from high school learners, whereas my study adopted multiple instruments to generate and triangulate data from primary school college students.

National studies established the influence of conceptions and experiences on students' learning and provided evidence that these aspects indeed influenced learning during pedagogical practices. Furthermore, the studies established that anxiety in learners led to fear and struggle during mathematics pedagogical practices (Chinn 2012). The national studies drew their participants from high school (female) learners, high school teachers and HODs. Both qualitative and quantitative approaches were adopted and the questionnaire and interview were used as data generation tools. These studies found that the way students conceived and experienced mathematics also affected their learning during mathematics pedagogical practices.

2.6 Chapter summary

Globally, regionally and nationally the quantitative and qualitative studies reviewed suggested that participants held traditionalist conceptions about mathematics. Furthermore, the questionnaire was the most popular data generation tool and data was generated through questionnaires, while the qualitative approaches employed interviews and mainly drew participants from high schools. The regional studies were mostly quantitative. Nationally, the surveys and case studies which were adopted did not investigate pre-service students but rather primary school learners and in-service teachers.

In answer to the first research question on conceptions about mathematics, literature examined revealed that college and university students and high school learners hold traditionalist conceptions about mathematics. This type of conception is not process based; rather the student uses rote means of acquiring mathematics concepts and in the end no conceptual understanding is achieved (Schoenfeld 2016; Yang, Leung and Zhang 2019). This traditionalist conception conceives mathematics as an accumulation of facts, rules and skills to be used in the pursuance of some external end. Furthermore, mathematics is conceived as a set of unrelated but utilitarian rules and facts (Dionne 1984; Ernest 1988; Berrett and Carter 2018).

With regards to the second research question, literature reviewed on how students experienced their pedagogical practices revealed that global studies drew participants from colleges and universities. All the studies on experiences were qualitative and used documentary evidence, interviews and observations to generate data. Globally, studies discussed indicated that students experienced non-interactive strategies of learning mathematics and the most commonly experienced strategy was the lecture method. Further findings revealed inadequate subject content knowledge during pedagogical practices. If the students are equipped with adequate subject knowledge while at college, this will help them to become effective teachers when they qualify. The content knowledge helps the teacher to respond to students' mathematics misconceptions productively and effectively (Wheeldon 2017). Regional studies reviewed, like in the global studies, also suggested that the lecture method was the primary method of instruction during mathematics pedagogical practices. Consequently, students did not experience interactive approaches to learning mathematics due to class sizes and high workloads, as well as the fact that technology was not used during pedagogical practices due to the lack of such resources. National literature reviewed on students' experiences during pedagogical practices suggested that the students' experiences during pedagogical practices were generally linked to the lecture methods and assessments due to time factors, teachers' attitudes, a lack of resources and the fact that students were not exposed to adequate mathematics content knowledge. The national studies, which were conducted in colleges and universities, adopted qualitative, quantitative and mixed methods approaches and data generation was generally through questionnaires.

In relation to the third research question on the influence of conceptions and experiences on learning during mathematics pedagogical practices, global studies suggested that conceptions and experiences influence students' performance. Older memories were found likely to be more persistent and powerful than new experiences (Mohyuddin and Khalil 2016). All the studies discussed adopted quantitative approaches, the questionnaire was the common data generation tool, and participants were drawn from high schools and colleges.

Like the global studies, the regional studies reviewed drew their participants from schools and colleges. Findings from these studies which generally used girls suggested that factors that influenced learner performance were conceptions/beliefs and experiences. The regional studies adopted mixed and quantitative approaches and, like in most of the global studies, the questionnaire was the popular data generation tool. In all the regional studies reviewed random sampling was adopted. In the national studies reviewed, high school female learners, high school teachers and HODs revealed that conceptions and experiences influenced students' learning. In addition, the studies revealed that the students became anxious, which led to struggles in mathematics and fear of the subject during mathematics pedagogical practices. The national studies reviewed adopted both qualitative and quantitative approaches and the questionnaire and interview were used to generate data. Thus, the conceptions and experiences influenced students' performance during mathematics pedagogical practices.

From the discussion of the different relevant literature reviewed, it appears that no academic work had been carried out investigating conceptions and experiences during pedagogical practices of the student teachers who struggled to pass O level mathematics. This study will therefore contribute to this gap. The next chapter describes the two theoretical frameworks underpinning my study: conceptions about mathematics (Dionne 1984) and socio-constructivism (Vygotsky 1978; Kim 2001).

CHAPTER 3

THEORETICAL FRAMEWORKS

3.1 Introduction

The previous chapter discussed reviewed literature related to the study. The purpose of this chapter is to discuss the two theoretical frameworks underpinning this study: conceptions about mathematics (Dionne 1984; Li and Schoenfeld 2019) and socio-constructivism (Vygotsky 1978; Kim 2001). The study sought to address the major research question: What are the student teachers' conceptions and experiences of pedagogical practices in mathematics education in teachers' training colleges? These two theoretical frameworks helped me to understand and explain student teachers' conceptions and experiences during mathematics pedagogical practices. This was supported by reviewed literature (Osanloo and Grant 2016), which indicates that a theor etical framework is a group of related ideas that provide guidance to a research project as a ready-made map for the study for data generation and analysis. Furthermore, Krainovich-Miller (2017) relates the role of the theoretical framework to that of a travel plan that guides a traveler to a particular destination. The two theoretical frameworks were relevant to my study as I wanted to understand student teachers' conceptions and experiences during mathematics pedagogical practices.

I combined the two theories, conceptions about mathematics (Dionne 1984; Li and Schoenfeld 2019) and socio-constructivism (Vygotsky 1978; Kim 2001) as they were complimentary to each other. Dionne's (1984) theory was useful for unpacking and understanding the types of conceptions about learning of mathematics held by the student teachers who struggled to pass mathematics. Vygotsky's socio-constructivist theory (1978) enabled understanding and an explanation of how student teachers experienced pedagogical practices in mathematics education during teacher training. Thus, the two theoretical frameworks guided data generation and analysis, providing the vital lens through which the findings could be viewed.

Reviewed literature (Imenda 2014; Collins and Stockton 2018) points out that a research without a theoretical framework makes it difficult for readers to establish the academic position to the researcher's declarations. The use of these two theoretical frameworks also provided for theory triangulation, thereby enhancing the credibility and rigour in my research. Given that I wanted to interrogate the phenomenon from different perspectives, the two theoretical frameworks were vital for that purpose. Related literature (Turner, Cardinal and Burton 2017) indicates that use of more than one theoretical framework deepens the essence of the research and accentuates the reasons why a research topic is worth studying.

The chapter begins by discussing the theory on conceptions about mathematics under three sections: historical development, the key ideas or principles forwarded by the authorities, including their application in my study, and lastly a critique of the theory. This is followed by a discussion on socio-constructivist theory which is discussed under similar sections: historical development, principles and application, and critique. A chapter summary ties up the chapter.

3.2 Conceptions about mathematics

A conception in this study refers to something that a student believes to be true. These beliefs that students hold to be true can be mental representations about the world around them. In this particular case they relate to students' conceptions or beliefs about pedagogical practices in mathematics education and mathematics as a subject. Surveyed literature (Jacobs, van Luijk, van der Vleuten, Kusurkar, Croiset and Scheele 2016) indicate that conceptions influence mathematical behaviour since these are general notions or mental structures encompassing beliefs, understandings, meanings, concepts, propositions, rules, mental images and preferences. The student teachers in this study wrote mathematics more than once and they may have been taught mathematics by teachers with different conceptions and notions about mathematics, thus it is also possible that some of the conceptions that student teachers held might have been transmitted to them during mathematics interactions. This is supported by reviewed literature (García-Carmona, Criado and Cruz-Guzmán 2018), which indicates that prospective teachers hold beliefs or conceptions about mathematics based on their own experiences as learners of mathematics.

3.3 Historical development of conceptions about mathematics theory (Dionne 1984)

Different researchers made significant developments in understanding the types of conceptions that students generally have about mathematics, mathematics learning and mathematics learners, and each researcher came up with different names for these conceptions (Acharya 2017). The different proponents of conceptions theory are discussed in the next section, starting with Skemp (1978), followed by Lerman (1983), Dionne (1984), Ernest (1988) and finally Torner and Grigutsch (1994). However, the study used Dionne (1984) because his conceptions theory included constructivist conceptions which complemented Vygotsky's socio-constructivist theory. While Dionne's constructivist conceptions cover aspects of learners' engagement and learner centrality in their learning, Vygotsky's (1978) socio-constructivist theory was able to fill up the gaps, bringing other constructivist aspects like ZPD, knowledgeable other and scaffolding. However, where it was necessary I also had to draw on other authors in the presentation and analysis of data.

3.3.1 Skemp (1978)

Skemp (1978) proposed two conceptions of mathematics during mathematics classroom practices which he named: instructional and relational. According to Skemp, the instrumental conception of mathematics is that it is a set of "fixed" plans for performing mathematical tasks; a fixed step-by-step procedure. This type of conception suggests that a student is given a mathematical rule or formula to apply and manipulate. The student who holds such a conception does not consider why the formula works or how the formula has been derived. The student merely applies a series of steps without knowing why they are being applied in that way, or what they mean, which portrays a situation of using rules without reasons. Instrumental teaching affords temporary success to the student and necessitates memorisation of facts. On the other hand, the relational conception of mathematics is characterised by the possession of conceptual structures that enable the teacher/pupil to construct several plans for performing a given task. The student who holds the relational conception can use already acquired mathematical knowledge and can easily adjust and apply it to a new mathematical concept which is to be learnt. Students who are taught relationally are more likely to remember the procedures because they will have truly understood why the procedures work, and are more likely to retain their understanding for longer, more likely to connect new learning with previous learning, and are less likely to make careless mistakes. Therefore, according to Skemp understanding mathematics is relational understanding. Skemp (1978) defines relational understanding of mathematics as knowledge that enables the student to construct several plans for solving mathematical problems and tasks. Thus, the student conceptually understands the mathematical rules and the reasons for using them. The student who is engaged in this relational approach is afforded an opportunity to explore, thereby developing confidence in mathematics while the teacher monitors their progress. For example, in the context of this study, when learning the concept of differentiation, student teachers learn the rules of finding derivatives of different functions and they also have and understanding of when to use each rule and the meaning of a particular derivative. Such a student teacher, when learning a more abstract concept like integration, will connect it to differentiation and will understand that integration is the reverse of differentiation. Furthermore, a student can derive a formula for the area of a triangle and then use it in the calculations for area. It would appear from Skemp's (1978) contribution on conceptions about mathematics that there are two types of students: those who conceive mathematics as a subject that should be approached the instrumental way, and those who conceive it as a subject to be taught relationally.

3.3.2 Lerman (1983)

Lerman (1983), like Skemp, also identified two alternative conceptions of the nature of mathematics and he called them the absolutist and fallibilist conceptions. Literature surveyed (Lerman 1983; Ernest 1988; Murphy 2017) suggests that conceptions range from viewing mathematics as a static, procedure-driven body of facts and formulas, to a dynamic domain of knowledge based on sense-making and pattern-seeking. According to Lerman (1983), the absolutist conception of mathematics views mathematics as a body of knowledge whose truths appear to be necessary and certain. Lerman (1983) further indicates that absolutists hold that mathematics is almost independent of humankind. In other words, this absolutist conception suggests that mathematics has no relationship to everyday human life. Mathematics is therefore learnt for its utilitarian purpose, as conceived by the students in this study who struggled with the subject, in order to gain entry into teacher education. Absolutism does not allow for the questioning of basic mathematical principles or the means by which the principles were derived. According to Lerman (1983), the pedagogical styles of the absolutist conception reveal the role of the teacher as authoritarian and the pupil as a passive and empty vessel. This absolutist conception of treating students as passive recipients portrays what takes place in many mathematics lecture rooms where the mathematics lecturer provides notes and the students take down the notes instead of listening for understanding.

The fallibilist conception was developed and may have been developed as a reaction to absolutism. Fallibilism is a conception which views mathematics as a product of a social process. According to this conception of mathematical knowledge, its concepts and proofs are open to revision (Lakatos 1976; Tanswell 2017). Literature surveyed (Popper in Ernest 1991) indicates that knowledge is fallible. Fallibilism values how numerical information is truly made through casual investigative interactions involving trial and error methods while the teacher plays the facilitative role. They also take cognisance of the diversity of the learners during mathematics learning. The contrast with the absolutist conception is therefore that absolutism philosophy focuses on the reproduction of mathematical facts without reasoning, describing or understanding why, while the fallibilist stand point is underpinned by the human practice of mathematics. Skemp and Lerman's contributions on the conceptions of mathematics are also supported by reviewed literature (Felbrich, Kaiser and Schmotz 2014), which establishes that conceptions on the nature of mathematics can be grouped in a dichotomic conception as static-oriented (absolutist) and dynamic-oriented (fallible). The static conception includes formalism-related orientation and the rigid scheme-related orientation, where mathematics is conceived as an exact, axiomatic science and as a collection of terms, procedures and formulas, respectively. In other words, this dynamic view includes process-related orientation and application-related orientation, where mathematics is conceived as a science that involves problem-solving and the discovery of structure and regularities. The dynamic view of mathematics is that all mathematics teaching and learning does not exist in a vacuum but rather belongs to the people.

This therefore means that during mathematics pedagogical practices, mathematics should be treated as a highly organised social activity, while acknowledging the existence of divergent abilities of students. In the context of this study, in the mathematics lecture room there is always a mixed bag of student teachers. Those who sat and passed the O level mathematics examination in one sitting and proceeded to do A level mathematics before joining teacher education, others who sat for and passed O level mathematics in one sitting and joined teacher education, and then those who struggled to pass O level mathematics. Thus, the lecturer should use pedagogical strategies that promote collaborative engagement in diversity.

3.3.3 Ernest (1988)

Another proponent of conceptions theories is Ernest. Ernest (1988), like Dionne, identified three similar conceptions of mathematics. First, the instrumentalist conception that mathematics is an accumulation of facts, rules and skills to be used in the pursuance of some external end. Thus, mathematics is viewed as a set of unrelated but utilitarian rules and facts. This type of conception matches those of Skemp (instrumental), Lerman (absolutist) and Dionne's traditionalist conceptions. Second, is the Platonist view of mathematics as a static but unified body of knowledge. Skemp and Lerman do not have this type of conception, however Dionne's second conception- formalist - is similar to Ernest's Platonist conception. In this conception, mathematics is discovered, not created. Third, is the problem-solving view of mathematics as a dynamic, continually expanding field of human creation and invention, and a cultural product. In other words, mathematics is a process of enquiry and coming to know, not a finished product, because its results remain open to revision and modification (Lerman 1983; Ernest 1992; Dede and Uysal 2012).

Ernest viewed these philosophies hierarchically, with the instrumentalist philosophy representing the lowest level on the hierarchy. Ernest, like Dionne, also placed mathematics teachers into three categories, namely: instructors, explainers and facilitators. The instructor, according to Ernest, holds an instrumentalist conception and considers mathematics as an accumulation of facts, rules and skills to be used in the mathematics learning process. The instructor's role as a teacher or lecturer is to make students master skills with the correct performance. The Platonist teacher or lecturer is an explainer who conceives that his/her task is to make students conceptually understand mathematics and his/her students should conceive it as a unified body of truth. The Platonist lecturer, like the formalist (Dionne), will teach mathematics as a structured, unchanging body of knowledge. The lecturer just transmits the mathematical knowledge to be mastered by the student teacher. When lecturing, the Platonist lecturer conceives that mathematical formulae and proofs cannot be invented since they already exist. Unlike the Platonist, in the mathematics classroom during mathematics pedagogical practices, student teachers' learning should involve active engagement while the lecturer facilitates and guides to ensure effective students' mathematics learning for retention (Skilling 2014).

According to reviewed literature (Hiebert 2013), both the instructor and the explainer fall within the absolutist conception of mathematics. According to Garegae (2016), the two conceptions of mathematics, the instrumentalist and the Platonist, and their approaches to mathematics teaching have dominated mathematics classrooms and have failed to make mathematics a student-friendly subject. Instrumentalism and Platonism are more aligned to direct instruction – lecture-centred strategies and teacher-centered exposition approaches of mathematics teaching. Literature reviewed (Ampadu 2012) shows that little attention is given to helping students to conceptually develop mathematics concepts and as such, students fail to connect the mathematics they study with the outside world. Further surveyed literature by Grady (2018) supports this when they indicate that with this kind of teaching strategy, students are bound to conceive mathematics as a subject that does not make sense.

The third category of teacher according to Ernest (1988) is the facilitator, which relates to the constructivist conception (Dionne) and fallibilist (Lerman) and relational (Skemp) conceptions where mathematics is conceived as a dynamic, continually expanding field of human creation and invention, and thus a process of enquiry. Therefore, the facilitator's (teacher/lecturer) role, according to Ernest (1988), is to make students confident problem posers and problem solvers as this facilitative process enhances their understanding. Knowledge, according to the constructivist conception, should move from teacher or lecturer to student, from student to student, and even from student to teacher or lecturer. Such a teacher or lecturer deviates from the traditionalistic approaches of teaching mathematics and views learning as collaborative, creative and related to human situations (Ernest 1988; Kwon and Ryang 2019). The messages communicated to students about mathematics and its nature greatly influence the students' thinking and affect the way they grow to conceive mathematics and its role in the world, given that what teachers do or do not do draws on their early learning experiences (Mukeredzi 2015). In the context of this study, if these students were exposed to traditionalistic ways of learning mathematics during pedagogical practices, they will in turn adopt such conceptions when they qualify and will in turn pass them on to their own learners when they enter the classroom as teachers. Likewise, if they were exposed to constructivist approaches they will in turn become constructivist mathematics teachers, who will in turn pass on constructivist mathematics learning to their learners.

This is supported by Thompson (1992) who purports that a student teachers' conceptions of what mathematics is and, in particular, how it should be taught are tacitly formed by the way they were taught mathematics in their pre- and during college mathematics pedagogical practices. Thus, a teacher's conceptions are very influential to their students. It appears that this could have been the case with the student teachers in my study who struggled to pass mathematics, since their pass in mathematics was through memorisation and writing and re-writing mathematics.

3.3.4 Torner and Grigutsch (1994)

Torner and Grigutsch (1994), like Dionne and Ernest, proposed three categories of conceptions about mathematics: the conception of mathematics as a toolbox, a system and as a process. In the toolbox conception, Torner and Grigutsch (1994) indicated that mathematics was conceived as a set of rules, formulae, skills and procedures, while mathematical activity was deemed to involve calculating using rules, procedures and formulae. The toolbox aspect of mathematics, like the instructional (Skemp), absolutist (Lerman), traditionalist (Dionne) and instrumentalist (Ernest) aspects, was conceived as containing a collection of isolated techniques necessary for solving problems (Pehkonen 2004). This was supported by reviewed literature (Craig 2013) which indicated that students with a toolbox conception conceived mathematics as manipulation with numbers, or a collection of isolated techniques, or a fragmented body of knowledge whose main goal was to get a correct answer. Students who held the toolbox conception, according to Torner and Grigutsch (1994), did not believe that mathematics beyond basic mathematics was useful to everyday life. Student teachers who struggled to pass mathematics would seemingly hold similar conceptions about mathematics due to what they went through as mathematics students.

In the system view, like the formalist one by Dionne and the instrumentalist one by Ernest, mathematics was characterised by logic, rigorous proofs, exact definitions, and a precise mathematical language. In addition, doing mathematics consisted of accurate proofs as well as the use of precise and rigorous language. The lecturers who held such conceptions like the traditionalist lecturers would just dispense mathematical content while the students passively received this knowledge, for example in a dictation. Finally, in the process view, mathematics was considered as a constructive process where relations between different notions and sentences played an important role. Surveyed literature (Wood 2012) suggests that mathematical activities involve creative steps, such as generating rules and formulae, thereby inventing or reinventing the mathematics purported by Skemp (1978), Lerman (1983), Dionne (1984) and Ernest (1988). The process view, according to Torner and Grigutsch (1994), engages students in discovery activities of deriving mathematical formulae, rather than just spoon feeding the student teachers with formulae. Thus, Torner and Grigutsch (1994) imply that during mathematics pedagogical practices students who struggle with mathematics, such as those who have sat for the subject more than once, should be given lots of practice and afforded opportunities to find solutions and methods of working out some mathematics problems.

3.3.5 Dionne (1984)

Unlike his predecessors, Dionne (1984) came up and defined three conceptions about mathematics: traditionalist, formalist, and constructivist conceptions. This study used Dionne's theory on conceptions about mathematics as he appears to be the first proponent who came up with three different types of conceptions about mathematics. The first type of conception about mathematics is the traditionalist one, which is sometimes called the "absorption theory" (Fosnot 2013). The traditionalists (like Lerman's absolutist conception) believe that children are passive learners who store memorised knowledge. Related literature (Kitchenham 2011) indicates that Paul Freire likened traditional education to the "banking" method of learning, whereby the teacher deposits information into those students whom the teacher deems worthy of receiving the gift of knowledge. The problem with this kind of education is that students become dependent on the teacher or lecturer whom they see as the 'knower', and they are the 'passive recipients' of the knowledge. If this knowledge is uncritically questioned, it remains at a superficial level. A learner who can reproduce notes in an examination will do very well but will not retain the mathematical knowledge for a long time. Learning is done by repetitive means, resulting in rote learning and memorisation. The traditionalist will find it difficult to relate mathematics to everyday life and as far as this belief is concerned, mathematics is confined to the four walls of the classroom (Kahembe and Jackson 2020). No deeper understanding of the subject is sought. The traditionalist, according to Dionne (1984), fails to give meaning to calculated answers, for example one can calculate the Spearman's correlation coefficient but cannot give meaning to the numerical value. Surveyed literature (Willum Johansen and Misfeldt 2016) indicates that with relation to the traditionalist conception "knowing" mathematics means being skilful and efficient in performing procedures and manipulating symbols without necessarily understanding what they represent. This therefore, means that mathematics is a subject which has formulae, rules and algorithms and memorising and reproducing them is not enough; a deeper understanding of when to apply them and why they should be applied in that mathematical problem is vital.

The traditionalist believes that mathematics is an accumulation of facts, rules and skills to be used for further mathematical advancement (Amirali and Halai 2010). Mathematics is, therefore, treated as a set of unrelated rules and facts. Mathematics is conceived to be an authoritarian discipline governed by rules, formulae and textbooks (Blanco, Guerrero Barona and Caballero Carrasco 2013). The student teacher with traditionalist conceptions views those who excel in mathematics as having genes for the subject of mathematics. In other words, according to this conception the subject is meant for only a selected few who attempt to pursue it further. The traditionalists believe that mathematics is all about computation, taking orders and instructions from the mathematics textbooks (Lerman 1983). This direct and deductive mathematical approach to mathematics teaching causes anxiety and fear in students and they tend to avoid studying mathematics (Gresham and Burleigh 2019). Further literature reviewed (Chen and Brown 2018) indicates that students develop the wrong conceptions about mathematics as most conceptions have a very strong negative effect on their learning of the subject.

The second type of conception, according to Dionne (1984), is the formalist conception. According to the formalists, the relationship between mathematics and everyday life is weak. The formalists believe that mathematics is a static but unified body of knowledge. Dionne (1984) indicates that formalists also believe that mathematics is logical and consists of rigorous proofs, definitions and precise mathematics language. In the classroom the formalist teacher takes the role of an explainer who conceives that the learner must be a good recipient of these explanations. During mathematics pedagogical practices mathematics should be presented as being open to investigation and discussion; in other words, it should be a socially constructed discipline. The mathematics lecturer should encourage discussion and dialogue and allow the students, particularly those in this study who struggled to pass O level mathematics, to generate and test their own theories while he/she corrects misconceptions that surface, if any. Both formalism and traditionalist conceptions create passive receptive students during mathematics pedagogical practices.

Dionne's third and last conception is the constructivist conception. According to Dionne (1984), the constructivist educator is child-centred and the student teacher assumes the role of an active explorer. Students engage in collaborative learning, engaging in some mathematical activities and through the guidance of their lecturer, they come up with some mathematical solutions to given mathematical problems. Mathematics learning is such that the learner is the beneficiary of all learning activities. Learning should be experienced by the student, practicing the mathematics problems as an alternative to rote knowledge and the strict one-way teaching of mathematics where the teacher is the knower. The student teachers who struggle to learn should not be treated as passive recipients of mathematical knowledge, but should rather be afforded an opportunity to participate and make contributions during mathematics pedagogical practices. This is in line with surveyed literature (Ernest 1991; Pitsoe and Maila 2012) which indicates that the constructivist teacher or lecturer wants his/her pupils to think and act, rather than merely repeating what the lecturer has said, and teaching and learning should be student-centred. Constructivists believe that students should construct their own understanding of mathematical ideas by means of mental activities or through interaction with the physical world (Dangel 2011). The constructivists also believe that mathematical knowledge should not be passively but actively acquired.

Knowledge acquired using the constructivist approach is actively constructed by the individual learner (Erath, Prediger, Quasthoff and Heller 2018). The teacher or lecturer in this case believes that experiences that will enable children to discover relationships and construct meaning must be provided for. According to the constructivists, mathematical rules and formulae are generated (Toner and Grigutsch 1994). For example, instead of the students who struggled to learn being given the formula for the area of a triangle, the lecturer creates an atmosphere where the student teachers can explore, with the guidance of the lecturer as facilitator, how to come up with a formula for the perimeter of a circle. The student teacher when actively involved retains the newly found knowledge. The constructivist teacher uses the hands-on approach and mathematics concepts are constructed and conceived through practice, by working out mathematics problems. Mathematical knowledge is believed to be dynamic, that is, it is a continuous process of development. The constructivists also believe that mathematics is a culture which is value laden (Ernest 2007). In the context of this study, the student teacher comes to the lecture with some valuable mathematical concepts (prior knowledge) and the lecturer or teacher should make use of that knowledge.

The lecturers should therefore not assume that the student teacher who comes into their lecture room comes empty handed and has no prior knowledge. They should not just add new knowledge but should test assumed knowledge, thereby creating interaction. The lecturers should not teach new knowledge in isolation but rather relate it to prior knowledge. The constructivist lecturer assumes the role of a facilitator and by creating appropriate mathematical situations makes the student an active participant during mathematics pedagogical practices. The learner must be afforded an opportunity to explore in order to find patterns, and relationships in mathematics. Mathematics, according to the constructivist, is the study of patterns or sets of connected ideas, unlike dictation and note taking that generally dominates mathematics education lectures.

Ernest (1996 sec. 2, para. 4) describes the constructivist mathematics classroom as, "... warm, human, personal, intuitive, active, collaborative, creative, investigational, cultural, and historical, living, and related to human situations, enjoyable, full of joy, wonder, and beauty". Mathematics is conceived as a human invention which is created in an active manner where learners interact and enjoy, thereby appreciating the aesthetic value of mathematics. In a classroom where a teacher holds a constructivist philosophy they do not present a finished product but mentor the students with carefully planned activities which facilitate knowledge construction and mathematical learning. Student teachers during mathematics pedagogical practices need to construct their own understanding of each and every mathematical concept, thus the major role of teaching is not to explain, lecture or transfer mathematical knowledge, but to create environments that foster necessary mental mathematical constructions by students. The constructivist lecturer follows through the process of the learner's work giving part marks, unlike traditionalist teachers whose focus is on the answer, the product. Some answers may be correct but coming from a wrong working. The constructivist is concerned about the process (method) not the product (answer), since a correct method signifies conceptual understanding and therefore knowledge can be retained and applied in other related learning situations.

As already alluded to, Dionne (1984) came up with three different types of conceptions, unlike Skemp (1978) and Lerman (1983) who had two conceptions each, so for this particular study I chose to use Dionne's theory as one of the theoretical frameworks given that I wanted to understand student teachers' conceptions of pedagogical practices in mathematics education. However, I will also draw on the other theorists discussed above who contributed to conceptions in the discussion of my findings. A summary of the conceptions by their proponents is reflected in Table 3.1 below:

Table 3.1: Summary on conceptions about the nature of mathematics

Proponent/ Conception	**Skemp (1978)**	**Lerman (1983)**	**Dionne (1984)**	**Ernest (1988)**	**Torner and Grigutsch (1994)**
1	Instructional	Absolutist	Traditionalist	Instrumentalist	Toolbox
2			Formalist	Platonist	System
3	Relational	Fallibilist	Constructivist	Problem solving	Process

Source: Researcher (2021)

Once the student teacher was aligned to a certain conception about mathematics this would also influence the way he/she approached mathematics learning and teaching. In view of the discussion above, the authors' ideas provided lenses to explore the conceptions about mathematics held by the student teachers who struggled to pass mathematics in order to gain, entry into teacher training.

3.4 Critique of conceptions about mathematics theory

Dionne's (1984) theory is criticised for having three conceptions instead of just two. Literature surveyed (Felbrich, Kaiser and Schmotz 2014), unlike Dionne's three conceptions about mathematics (traditionalist, formalist and constructivist conceptions), established that conceptions on the nature of mathematics could be grouped into two: static-oriented and dynamic-oriented conceptions. In other words, traditionalist and formalist would constitute the static while the constructivist would fall into the dynamic category. This was also further confirmed by Petocz, Reid, Wood, Smith, Mather, Harding, Engelbrecht, Houston, Hillel and Perrett (2007) who also clearly suggested that conceptions about mathematics could be categorised into two main groupings: fragmented conceptions and cohesive conceptions, since traditionalism and formalism constituted transmission of mathematical knowledge rather than the interactive constructivist conception which emphasised learners' construction of their meaning. This would seemingly imply that there was no need for a third conception, given that the first (traditionalist) and second conceptions (formalist) were closely aligned and so could be integrated into one. I used conceptions about mathematics according to Dionne because I wanted to verify whether the three conceptions as propounded by Dionne existed in the students who had struggled to pass O level mathematics. As already been alluded to, I used Dionne because his third conception – the constructivist conception about mathematics aligned with Vygotsky's constructivist theory.

Another major constraint related to conceptions about mathematics is the diversity of the students' backgrounds and experiences in relation to mathematics. Students hold different conceptions about mathematics and it may be difficult for the lecturer to effectively handle that diversity in the classroom by employing student-centred constructivist approaches. As such lecturers adopt knowledge-centred exposition strategies to learning mathematics. While the teaching of mathematics requires a paradigm shift from a traditionalist perspective to a constructivist perspective as a necessity, another constraint emanates from the conceptions held by the teachers or lecturers themselves. Unless the instructors hold constructivist conceptions about mathematics as opposed to the traditional conceptions where they see the subject as a domain of the selected few, shifts in their paradigms may not be achieved. Surveyed literature (Koc and Koybasi 2016) indicates that some insights have been offered to make mathematics teacher educators assist prospective teachers to change their conceptions about mathematics in order to align those conceptions with current perspectives of mathematics education, however significant change continues to be a challenge for many teachers. However, according to Beswick and Dole (2008) some student teachers who hold traditionalist conceptions may not feel comfortable learning mathematics the constructivist way. Furthermore, reviewed literature (Prince and Felder 2007.) indicates that some students may not enjoy this constructivist approach of interactive learning since they may fail to construct meaning and build appropriate knowledge and end up copying from their more gifted peers.

On the contrary, despite the criticisms leveled against conceptions theory above, literature reviewed (Wood 2012) indicates that although there are different types of conceptions about mathematics, these different conceptions about mathematics can be applicable at different stages of mathematics teaching and learning. In other words, a lecturer can combine different conceptions and strategies during mathematics pedagogical practices to help students understand the mathematical content. This therefore suggests that though the students may hold the different conceptions about mathematics, their different learning styles may be catered for during mathematics pedagogical practices by adopting what Wood (2012) indicated above.

The types of conceptions discussed above often form the foundations on which student teachers eventually develop their own conceptions and build their practice as teachers of mathematics. Some student teachers teach mathematics the way they were taught. This is supported by reviewed literature (Mukeredzi 2013) which purports that conceptions and experiences have an effect on classroom practice since they influence a teacher's choice of content, students' activities and lesson presentation. It is against this background that the study sought to understand the student teachers' conceptions about mathematics during mathematics pedagogical practices informed by Dionne's (1984) theory. During pedagogical practices in mathematics education the lecturer's awareness of these conceptions is vital, as this may inform their practice and also help in addressing them. The second theoretical framework which was used as a lens in this study on the conceptions and experiences of student teachers during pedagogical practices in mathematics education was socio-constructivism (Vygotsky 1978; Kim 2001), which is discussed below.

3.5 Socio-constructivism

The socio-constructivism framework by Vygotsky (1978) and Kim (2001) was particularly useful for understanding and explaining student teachers' experiences of mathematics pedagogical practices in mathematics education.

3.5.1 Historical background of the socio-constructivist theory

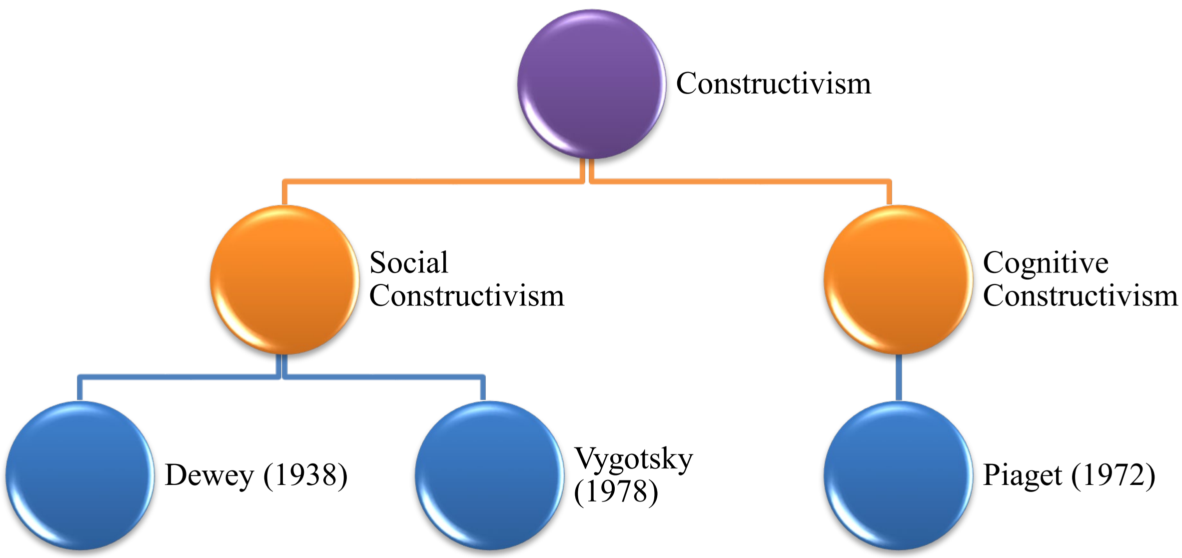
Socio-constructivism is a social learning theory (Vygotsky 1978; Kim 2001). Vygotsky believed that human development was a socially mediated process in which children acquired their cultural values, beliefs and problem-solving strategies through collaborative dialogues with more knowledgeable members of society. Vygotsky's theories stressed the fundamental role of social interaction in the development of cognition (Vygotsky 1978; Kim 2001), since he believed that the community played a central role in the process of meaning making. Thus, according to Vygotsky, peers, parents, caregivers, teachers and culture were responsible for cognitive development. Therefore, learning according to this theory has its basis in interacting with other people. After reading the works of Dewey (1938); Piaget (1972); Vygosky (1978); Bruner (1990) and Kim (2001), one may define constructivism as a learning theory that involves an active construction of new knowledge which is built on the learner's prior experience. Constructivism comes in different forms and has different proponents, and these will be discussed below.

3.5.2 Types of constructivism

There are many types of constructivist learning theories, however; this study is underpinned by socio-constructivism (Vygotsky 1978; Kim 2001). The applicability of constructivism as a theory draws on the guiding principles for its application, which makes it a dominant classroom practice for effective mathematics learning (Krahenbuhl 2016).

Literature surveyed (Mvududu and Thiel-Burgess 2012) indicates that when the roots of social constructivism in sociology, symbolic interactionism, philosophy and social psychology are traced, three types of social constructivism are distinguished. Constructivism is primarily a synthesis of the ideas from philosophy, sociology, psychology and education (Lijano 2018). One is based on radical constructivism (Piagetian), theory of the mind and pragmatism (Dewey), and the Vygotskian theory of mind, which like Dewey's theory is more thoroughly social. This is supported by literature reviewed (Duit 2016) which indicates that there are three major constructivist theories: those of Dewey (1938) from Vermont, Jean Piaget (1896–1980) from Switzerland, and Lev Vygotsky (1896-1934) from Russia. Their contributions are shown in Fig 3.1 below and will be discussed thereafter.

Figure 3.1: Major social constructivist contributors



Source: Researcher (2021)

As highlighted earlier, this study was guided by social constructivism and drew on the theories of Dewey and Vygotsky. Therefore, the history of socio-constructivism in this study was traced from the ideas of Dewey.

3.5.3 John Dewey (1938)

John Dewey was a pragmatist, educator, philosopher, progressivist and a social reformer (Gutek

2014). Literature surveyed (Williams 2017) indicates that Dewey was known as the father of progressive education and an advocate of social learning. Social learning, according to Dewey promoted students' engagement because they worked with others, resulting in a passion for lifelong learning. Dewey greatly impacted education, and was perhaps one of the most influential educational philosophers (Theobald 2015). Dewey believed that schools and classrooms should represent a social environment and that students learned best in a natural social setting (Flinders and Thornton 2013). He believed that students were all unique learners and that people should come together to solve a problem, through discussions and collaborative decision making. Surveyed literature (Williams 2017) indicates that Dewey thought that effective education was a result of social interactions and that the school or classroom setting should be treated as a social institution. Dewey also believed that education should be conceived as a process of living and not a preparation for future living (Flinders and Thornton 2013; Gutek 2014). Dewey (1938) and Gutek (2014) concur that schools and classrooms should represent real life situations and that students should be allowed to participate in learning activities flexibly and interchangeably, in a variety of social settings. Therefore, during mathematics pedagogical practices students should be afforded the opportunity to create or construct their own knowledge by asking questions, exploring and assessing what they already know in collaboration with peers. Learner-centered teachers believed that Dewey's work was supportive of their beliefs on how students should learn (Schiro 2013), since Dewey advocated for the classroom to be a social entity where students solved problems together as a community.

In the case of these student teachers who struggled to pass mathematics, such a learning environment would make them expert learners through actively constructing mathematical knowledge instead of reproducing a series of facts as dictated during mathematics pedagogical practices. Through these interactions, students would be constructing their own knowing through personal meaning, rather than teacher-imposed dictated knowledge, and teacher-directed activities (Schiro 2013). Dewey advocated for a hands-on approach to learning where students learn by doing. According to Dewey, traditional schools were not inspirational, and therefore did not create an environment for learning (Park and Choi 2014). Since Dewey conceived traditional schools as boring and monotonous, he also believed that they stifled student creativity. Dewey

(1938), like Lerman (1983); Dionne (1984); Ernest (1988) and Torner and Grigutsch (1994) in the relational conception about mathematics, believed that the teacher's role should be that of a learning facilitator and guide as they become a collaborator in the learning process and a knowledgeable other who guides students to independently discover new knowledge. Dewey (1938) also advocates for the consideration of a learner's past experience and the environment in the teaching-learning process. He calls for a classroom environment where there is experimental thought and activity, so that mathematical concepts are not just transmitted to the student teachers during pedagogical practices. Jean Piaget's theory will be discussed in the next section.

3.5.4 Jean Piaget (1972)

Piaget (1972) is usually referred to as the founding father of the theory of constructivism because of his notion of learning as individually constructed and learners' understanding and knowledge based on their own experiences, prior to formal education (von Glasersfeld 2013). Piaget referred to his work as cognitive constructivism (Chambliss 2013) in his writings about the stages of child development. He believed that cognitive development was a product of one's mind achieved through observation. However, his theory is not discussed in detail as my study focused on student teachers' experiences during mathematics pedagogical practices as opposed to their experiences prior to entering formal education. I however draw on some of his ideas and concepts in my data presentation and analysis. The next section discusses socio-constructivism by Vygotsky (1978); Kim (2001).

3.5.5 Vygotsky (1978) and Kim (2001)

Vygotsky played a key role in making student-centred and active learning theory influential in the classroom today through his emphasis on the social aspect of learning. This is also supported by literature surveyed (Vintere 2018) which points out that Vygotsky introduced the social aspect of learning into constructivism. According to Vygotsky (1978), learning has its basis in interacting with other people so mathematics concepts during mathematics pedagogical practices should be socially constructed when the students interact with the knowledgeable other, their lecturer or peers. Reviewed literature further (Noorloos, Taylor, Bakker and Derry 2017) indicates that socio-constructivism also emphasises the importance of context and culture in understanding what happens in society as far as construction of knowledge is concerned. Therefore, the teachers should consider what students know and allow their students to put their knowledge into practice as students do not come to school empty handed (without prior knowledge). From the socio-constructivist perspective, in every classroom situation the student should be the sole beneficiary in every learning situation (learner centrality). In the following section I discuss eight guiding principles of Vygotsky's (1978) socio-constructivist thinking.

First, just like Dewey, Vygotsky believed that learning is perceived as an active process in which the learner constructs meaning or understanding using sensory input. The learner in this case is centrally located to their learning, assumes responsibility for that learning and becomes an active learner who should therefore not accept knowledge passively but should engage with the world around him or her in the acquisition of the knowledge (Grady 2013; Vintere 2018). Therefore, in the context of this study, an active mathematics classroom environment where students are in charge of their learning is vital, and where discovery learning is promoted, it becomes a fundamental basis for learning.

Second, socio-constructivism proponents believe that knowledge is reality and the constructed knowledge should be interpreted thus, reflecting a sense of conceptual understanding. This is supported by reviewed literature (Amineh and Asl 2015) which indicates that real mathematical knowledge involves inventing ideas rather than mechanically accumulating a series of facts. This also relates to ideas by Dewey when he indicated that mathematical knowledge should not just be transmitted from the teacher to the learner. Kim (2001) also pointed out that social constructivism is based on specific assumptions about reality, knowledge and learning, and that reality is constructed through human activity. For example, during mathematics pedagogical practices the student teachers should make meaning out of their calculated answers.

Third, while the socio-constructivist stance is on hands-on experiences or learning by doing according to Dewey, Vygotsky believes that these activities should also engage the mind. Thus, according to Vygotsky (1978) individual learning should also be determined by the inborn characteristics and the external factors (context) that influence them (Piaget 1972) given that the context defines the possibilities and constraints of learning. Therefore, while the student teachers' inborn characteristics should help in the learning process, they need to be enhanced with practical mathematics activities in the classroom during mathematics pedagogical practices.

Fourth, the socio-constructivist theory also indicates that language plays an important role in any learning situation and thinking is activated by communication (Afurobi 2015; Amineh 2015). Language and learning are therefore intertwined. During mathematics pedagogical practices students need to interact and use language, which is a shared rather than an individual experience. Literature surveyed (Riccomini, Smith, Hughes and Fries 2015) indicates that mathematics instructors during the teaching and learning process should communicate mathematics concepts through the use of language. In other words, the language used by lecturers during mathematics pedagogical practices should be understandable to students if it has to convey meaning. Mathematics concepts should be explained in clear terms, in particular to help students who struggle to understand. This is further supported by surveyed literature (Lijano 2018) which suggests that learners talk amongst themselves when they are learning to help each other to understand.

Fifth, socio-constructivist theory also recognises the social aspect of learning and emphasises interaction with others as an integral aspect of learning (Vintere 2018). That is, meaningful learning is through interaction with others in natural contexts and solving mathematical problems as a community, as revealed by Dewey (1938). In the context of this study, in learning situations learning is possible through interactions with a knowledgeable other/s, in this case the lecturer and/or peers, thus learning is believed to be a combination of both an individual and a social process. Vygotsky therefore represents knowledge as a human product that is socially and culturally constructed and individuals can create meaning when they interact with each other and with the environment they live in (Baloche and Brody 2017; Mukeredzi 2018).

Vygotsky's socio-cultural theory of human learning describes learning as a social process and the origin of human intelligence is in the society or culture. Social constructivism therefore encourages the learner's own version of truth, influenced by his or her background, culture or knowledge of the world. Vygotsky thus believed in cooperative learning where learning involves discussions based on experience (Dionne 1984; Kim 2001; Vintere 2018). This is because cooperative learning is a socially situated activity that is enhanced through interactions with others, where students work together in small groups and maximise their own and each other's learning. Student teachers in this study could be put into smaller groups and given tasks for research, and then during mathematics pedagogical practices make presentations, thus giving them a chance for active involvement in their learning.

Sixth, according to Vygotsky (1978) prior knowledge is essential, given that new knowledge is built onto prior knowledge by assimilation and accommodation. Assimilation implying "fitting" an idea into what they already know likened to adding air to a balloon or filling existing containers. Accommodation is more substantial, requiring the student to reshape the balloon or the existing container to create space for new knowledge. This is in tandem with surveyed literature (Van Kesteren, Rijpkema, Ruiter, Morris and Fernández 2014) which indicates that it is not possible to assimilate new knowledge without having some structure developed from previous knowledge. Accommodation thus involves adapting one's existing knowledge to what is perceived. Constructivism is therefore a learning theory where construction of one's knowledge is done through reconciliation of a new experience or idea with previous experiences and ideas, leading to better understanding. The importance of prior knowledge in any mathematics classroom is vital because of the hierarchical nature of mathematics. For example, knowledge of addition is assumed knowledge when teaching multiplication, since multiplication can be taught in simplified terms as repeated addition.

Seventh, from the socio-constructivist theory emphasis is also placed on the need for motivation in any learning situation (Sweeder and Jeffery 2013). Motivation has a significant role to play in learning because if the student teacher has high motivation in the learning of mathematics during mathematics pedagogical practices, he/she is likely to achieve better results than the learner who is not motivated. Vygotsky (1978) believed that motivation not only helps learning but is essential *for* learning. In other words, during mathematics pedagogical practices these student teachers need to be motivated, since motivation is a vital ingredient which keeps students actively interested in what they study and pushes them towards continuing their education.

Eighth, Vygotsky concurs with Dewey when he advocates for a situation where the teacher should take the role of a facilitator in any learning situation and whose major role is to support the students' learning through scaffolding (Vintere 2018). Scaffolding is a step-by-step technique of supporting students, which increases the students' competence and eventually reduces the teacher's guidance. The constructivist teacher should guide students and provide them with opportunities to test the adequacy of their current understandings. The social constructivism perspective which assumes that cognitive growth first occurs on a social level and later on an individual level emphasises the role of ZPD (Zone of Proximal Development) (Kim 2001; Vygotsky 1978). Vygotsky defined the ZPD as a situation where students solve problems beyond their actual developmental level (but within their level of potential development) under adult guidance or in collaboration with more capable peers. Scaffolding students to reach their ZPD involves helping them master skills that are too difficult for them to master on their own, but can be done with guidance and encouragement from a knowledgeable person. Thus, lecturers who are facilitators in a social constructivist mathematics pedagogical practice classroom first provide support and help learners, then little-by-little this support is decreased and students learn independently.

In summary, Dewey (1938) and Vygotsky (1978) emphasised the social aspect in their constructivist theories. Dewey is well known for his pragmatist philosophy on constructivism that emphasises hands on approach to learning and interaction. Vygotsky stresses the influence of culture and language on the development of children. Vygotsky also places emphasis on the ZPD and scaffolding and how language plays a powerful role in shaping thought through interaction (noisy classrooms). Vygotsky also indicates that the teacher should establish opportunities for students to learn with the teacher and/or more knowledgeable peers. Overall, social constructivism promotes social and communication skills by creating a classroom environment that emphasises collaboration and the exchange of ideas.

3.5.6 Critique of Socio-constructivism

To begin with, literature reviewed (Agius 2013) argues that social constructivism is more of an approach than a theory. Agius further argues that time is wasted if negotiation is used as a form of learning, given that Vygotsky indicates that to achieve collaborative and consensual understanding during mathematics pedagogical practices, negotiation is a pre-requisite. According to Agius (2013) understanding mathematics, unlike other subjects, does not need the social negotiation purported by Vygotsky since it is a body of agreed knowledge and practice that needs to be taught.

Secondly, Clark (2013) indicates that social constructivism is a theory which believes in scaffolding by the teacher in order to achieve the ZPD, a concept which Vygotsky did not fully develop. According to Vygotsky, the ZPD is the difference between what the learner knows and what the learner is capable of knowing or doing with mediated assistance. From this perspective conceptual understanding should then be achieved through social interaction with a knowledgeable other, or with peers. Clark (2013) concludes that teaching or peer mediation is not a necessary condition for learning, which portrays Vygotsky's conclusion about teaching through mediation as false. A great deal of praise is given to social performance being ahead of individual performance in the ZPD; however, Vygotsky does not prove that this is the case. Concomitantly, while according to socio-constructivism scaffolding and mediation are fundamental in the construction of knowledge, there is no clarity regarding what is included and what tools are used. There is also no clear indication of the teacher's awareness of a learner's learning needs, so that they can 'construct' their own learning experience and so that the teacher changes the focus of teaching towards guidance and facilitation to address those needs.

Pritchard and Woollard (2013) argue that social classrooms at times do not cater for students' individual needs as some students may find the social constructivist classroom to be full of distractions. Further surveyed literature (Merill 2013) also says social constructivism ignores genetically determined aspects of learner personality. For instance, for the introvert this theory may be destructive since socialisation is a problem to them, while on the other hand for the extrovert who appreciates social contact, while they may enjoy social learning, this can disrupt classroom progress during learning for themselves and others.

However, notwithstanding the criticisms discussed above, Kapur (2016) indicates that socio-constructivism entered the education scene with a bang and has been widely adopted in education classrooms. This is probably due to its three-stage learning approach where meta-cognition occurs at the initial stage when the student teacher generates questions, for instance about applying mathematical formulae. Next the lecturer broadens and focuses upon the student's questions. Thirdly generalisation occurs, where the student applies their understanding to similar problems. In this study, the aim was to explore student teachers' conceptions and experiences of pedagogical practices in mathematics education. As such, the conceptions theory (Dionne 1984; Li and Schoenfeld 2019) defined above enabled understanding and explaining of conceptions, while the socio-constructivist theory (Vygotsky 1978) enabled understanding and unpacking of student teachers' experiences during mathematics pedagogical practices.

3.6 Chapter summary

In this chapter I discussed the two theoretical frameworks: conceptions about mathematics (Dionne 1984) and the social constructivist theory (Vygotsky 1978; Kim 2001). The use of the two theories was complimentary. Conceptions about mathematics enabled the understanding of student teachers' conceptions about mathematics, while socio-constructivism helped to unpack and explain student teachers' experiences in pedagogical practices in mathematics education. Dionne (1984) came up with three different conceptions about mathematics namely: the traditionalist, formalist and the constructivist conceptions. The socio-constructivism framework emphasises: active acquisition of knowledge through discovery; scaffolding in order to reach the ZPD; language use to help in the interactions and learning from the knowledgeable others. The next chapter discusses the methodology used in order to generate data that addressed the research questions.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This study sought to explore the conceptions and experiences of pedagogical practices of student teachers in mathematics education. I sought to develop an in-depth understanding of the conceptions and experiences of those student teachers who had struggled to pass O level mathematics, and had sat for the national examination at least two times in order to enter teacher education. During teacher training such students were exposed to the same pedagogical practices in mathematics education as those who passed mathematics with only one sitting, including other trainees who had even pursued mathematics up to A level.

The study addressed the key question: *What are the student teachers' conceptions and experiences of mathematics pedagogical practices in mathematics education in selected teacher training colleges in Zimbabwe?*
From this key question, the following subsidiary questions were developed:

4.1.1 Sub research questions

1. How do student teachers conceive pedagogical practices in mathematics education?
2. What are the student teachers' experiences of pedagogical practices in mathematics education?
3. In what ways do the conceptions and experiences influence their learning?

The previous chapter focused on the two theoretical frameworks (conceptions about mathematics (Dionne 1984) and socio-constructivism (Vygotsky 1978; Kim 2001) that framed this study. In this chapter, I discuss the methodology that I followed to generate data to address the key research question through its subsidiary questions, answering questions such as:

What I did? Why I did it? When I did it? How I did it? With whom I did it? Etc.

I begin by discussing paradigms broadly and the interpretive research paradigm in particular. Following this, I discuss the multiple site case study research design that I adopted in this study and thereafter the qualitative research approach. Third, a description of the sampling process is provided where convenience, purposive and self-selection sampling designs that were used to extract study participants are described. Following this is a detailed discussion of how each data generation instrument: questionnaire, focus group discussion, individual face-to-face interviews and lecture observation was pilot tested. A description of the data generation processes using each research instrument employed and the challenges faced in the process is presented. Fifth, an outline of how the data was analysed using open coding as the analytical tool is also provided. Sixth, I narrate the process of accessing participants; thereafter I describe the attempts made to enhance rigour throughout the study under the four elements of trustworthiness: credibility, confirmability, transferability and dependability. I conclude this section by explaining how ethical issues were considered in the research process. Before concluding this chapter, the limitations of the study and how the inquiry attempted to address them are discussed.

4.2 Paradigm

A paradigm refers to the researcher's way of thinking, based on his/ her beliefs or conceptions on the interpretation of generated data during a study. Surveyed literature (Taber 2013) indicates that a research paradigm intends to define approaches to social science research. In my study a paradigm provided a philosophical orientation which enabled me to examine and select methodological aspects in order to determine the research methods and data analysis procedure. Thus, a paradigm consists of human constructions from the research data (Scotland 2012) and my task was therefore to construct meaning from the subjective data generated on the conceptions and experiences of student teachers during mathematics pedagogical practices.
A paradigm therefore is a body of knowledge that forms some background for understanding a given phenomenon, pointing the way to where to look for answers. It provides a supportive structure, framework or some pointers to assumptions which guide the researcher through the

research activities. The assumptions are related to ontological, epistemological, axiological and methodological issues. Paradigms are therefore crucial for understanding and choosing methodologies for research. For this study, the interpretive paradigm was central to the methodology used. As my study sought to understand conceptions and experiences, it situated itself within an interpretive paradigm.

With regard to ontology, as my study sought to understand the conceptions of mathematics held by these students who struggled to pass the subject at O level and also their experiences during mathematics pedagogical practices, the ontological assumptions of this study, given its interpretive stance, was that reality is subjectively and socially constructed. Surveyed literature (Lehmann and Voelker 2014) indicates that ontology refers to the nature of reality. The ontological dimension in research aims to answer research questions that seek to understand "what" and this was relevant to my key research question which sought to understand *what the student teachers' conceptions and experiences of mathematics pedagogical practices were* during mathematics pedagogical practices. Reviewed literature (Lehman and Mortensen 2019) also posits that the ontological assumption of the interpretive paradigm is that there are multiple realities, and that one can only seek the reality of real-world phenomena by studying them in detail in the context in which they occur. Therefore, the study sought to understand the conceptions and experiences of student teachers in mathematics education from the student teachers' perspective in their natural settings - the teachers' colleges in which they occurred. Reality is subjective, like conceptions and experiences. I therefore used words uttered by the participants in order to provide evidence of the different subjective perspectives the student teachers held, thereby reporting their multiple realities. This is supported by (Coleman, Micko and Cross 2015) who indicates that when researchers compile a phenomenology, they report how individuals participating in the study conceive their experiences differently.

The epistemological assumptions of inquiry refer to the philosophy which deals with generating knowledge. Epistemology comes from "*episteme*", a Greek term for knowledge, referring to the theory of knowledge, the philosophy of knowledge, and "how we come to know" (Mukeredzi 2009). Epistemology therefore refers to the relationship between the knower (researcher) and the knowable (researched). In other words, it addresses the relationship of researcher to that which they are inquiring into; it is about how we come to know as researchers – the distance between the participant and the researcher (Mukeredzi 2009). Thus, from the epistemological perspective knowledge may be viewed as a mental state, just like conceptions and experiences. Epistemology is thus the relationship between the researcher and reality, or how this reality is captured or known (Gale and Dolbin-MacNab 2014). Therefore, in terms of epistemological assumptions, there was no distance between participants (student teachers or lecturers) and the researcher, as knowledge of conceptions and experiences about pedagogical practices was generated through focus group discussions, face-to-face interviews and lecture observation.

Axiology places emphasis on values in any research process. Literature (Viega 2016) indicates that axiology is a theory of values, and values are aspects of human behaviour. Axiological assumptions address the role of values in a study. Answering the question, what is the role of values, the qualitative researcher acknowledges that research is value laden and that there are some biases (Creswell and Poth 2016). In other words, the researcher openly acknowledges and discusses their values that influence the data, including their interpretation against that of participants. They admit the value laden nature of data and also report their own values and biases. In this study, as I was the major data generation tool, my presence was apparent in the narrative through the interpretation and presentation of data. My role as researcher, and the reduced distance with participants had implications for axiological assumptions – the role of values in a study. Thus, axiological assumptions affect the values of researchers and participants. The values of participants are explored and analysed through their conceptions and experiences, to determine how these conceptions and experiences influence their current position as student teachers.

The methodological assumptions of inquiry seek to address how a researcher can go about finding out answers to the phenomenon under study. This is supported by reviewed literature (Luria 2019) which indicates that methodological assumptions are concerned with how the researcher finds out whatever it is that he/she believes can be known, based upon prior epistemological assumptions. Further literature reviewed (Creswell 2013) purports that methodological assumptions consist of the assumptions made by the researcher regarding the methods and techniques used in the process of data generation to enable understanding of the phenomenon. This therefore refers to the procedures that I used to understand or capture "insider" knowledge of the student teachers' conceptions and experiences during mathematics education pedagogical practices.

4.2.1 Interpretive paradigm

My study was located within the interpretive paradigm. The interpretive paradigm therefore paved a path for me to follow in my study. Interpretivists view reality as socially constructed and fluid (Wilson 2017) therefore in order to generate data on conceptions and experiences I had to use interactive methods - interviews and focus group discussions to ensure dialogue between the researcher and the researched – between myself and the participants. Reviewed literature (Thanh and Thanh 2015) further indicates that interpretive approaches rely heavily on naturalistic methods (interviewing and observation). I generated data from the student teachers and lecturers in their respective colleges (natural setting) without much interference with the participants and the phenomena under study. These methods enabled dialogue with participants and collaborative construction of meaningful reality on their conceptions and experiences during mathematics pedagogical practices. The interpretive paradigm was also preferred due to its alignment with the conceptions theory and Vygotsky which focus on individual constructions and perspectives. Conceptions are individual worldviews which are subjective – which links well with the interprective paradigm as it addresses subjective meanings people draw from experiences.

While a questionnaire generally suggests a positivist stance where knowledge is "external or out there" (Mukeredzi 2009), in this study it was only used to identify those students who sat for O level mathematics more than once, and not as a tool for generating data to answer the research questions. In this case the tool (questionnaire), generally associated with positivism (McGuirk and O'Neill 2016), helped me to generate genuine knowledge which was critical for pointing me to the relevant and appropriate sources of data on the conceptions and experiences of pedagogical practices in mathematics education. Thus, data on the conceptions of and experiences during mathematics pedagogical practices was socially constructed through appropriate methods from appropriate participants. Mathematics education lectures were observed, thereby minimising distance and thus making the data subjective. The research design will be discussed next.

4.3 Research design

A research design is the framework of research methods and techniques chosen by a researcher (Creswell 2014). It is therefore a plan used to collect and analyse data on a research problem, and in this study, it was broadly a case study research design. A case study is an intensive study about a person, or a group of people. According to Yin (2013), case study data is observed at micro level and examination of the data is conducted within the context of its use, that is, within the situation in which the activity takes place. Yin (2013) implies that an individual or a group of participants are studied in their local environment. Surveyed literature (Rashid, Rashid, Warraich, Sabir and Waseem 2019) indicates that a case study is descriptive and seeks to discover and understand the phenomenon, process, perspectives and worldviews of the people involved in their natural setting. In this study I wanted to understand student teachers' conceptions and experiences during mathematics pedagogical practices and I did that in their respective colleges. In a case study type of research, one can intensively investigate and explore a phenomenon thoroughly and deeply. This case study, which is a qualitative research design, was adopted to gain an in-depth understanding of the participants' conceptions and experiences.

Specifically, this study adopted a multiple-site case study design where the 'case' was student teachers' conceptions and experiences of pedagogical practices in mathematics education in selected teachers' colleges. I examined each of the four selected colleges individually and I was also interested in understanding the conceptions and experiences of each and every student on a one-on-one basis, hence the use of the individual face-to- face interviews. This multiple case research design was therefore more powerful than single-case designs as it provided more extensive descriptions and explanations of the phenomenon or issue due to replications. The primary school teacher training colleges were studied as separately bound systems or cases. A bound system is specific and/or unique according to place, time and participant characteristics (Hyett, Kenny and Dickson-Swift 2014).

A multiple-site case study is a case study which contains more than a single case whose evidence is more compelling (Stake 2013; Yin 2013; Alpi and Evans 2019). Multiple-site case studies are also often referred to as repeated experiments. Ghofur and Ahmad (2017) indicate that a multiple-site case study allows wider exploring of research questions and theoretical evolution. The inherent replication in multiple-site case studies strengthens the results by replicating the patterns, revealing concurrences and differences and thereby increasing the robustness of the findings (Yin 2013). Okuyama (2016) also indicates that multiple-site case studies help the researcher understand the similarities and differences between the cases. This research design therefore allowed me a wider discovery of the conceptions and experiences during pedagogical practices in order to create more convincing findings. Thus, multiple sites enabled capturing different dimensions of the conceptions and experiences of the student teachers for comparison and this also enabled contextual triangulation (Johnson, O'Hara, Hirst, Weyman, Turner, Mason, Quinn, Shewan and Siriwardena 2017). Having described the research design, the next section discusses the research approach.

4.4 Qualitative approach

A qualitative study focuses on answering questions like "why, how and what", and it is also often referred to as a subjective approach where findings are in written format (Hammarberg, Kirkman and de Lacey 2016). The qualitative approach in this study was adopted due to its systematic subjective quality which is used to describe life experiences and situations to give them meaning (Creswell and Poth 2016). Given that conceptions and experiences are subjective, I therefore adopted the qualitative approach which was ideal for understanding the world of the participants (experiences and conceptions) through their verbal responses. Creswell and Poth (2016), state that qualitative research focuses on the experiences of people and stresses the uniqueness of the individuals. This therefore implies that the data generated in my study was based on student teachers' personal experiences and conceptions. Holloway and Wheeler (2002:

30) also refer to qualitative research as “a form of social enquiry that focuses on the way people interpret and make sense of their experiences and the world in which they live”. In this study, as I wanted to understand how student teachers who struggled to pass O level mathematics to enter teacher training conceived and experienced pedagogical practices in mathematics education and whether their conceptions and experiences affected their learning, the qualitative approach was therefore the most appropriate.

Critical to a qualitative research approach is its flexibility in the research process, as well as its provision for depth and detail in the researcher’s presentation of the findings. The flexibility of the qualitative approach in my study enabled adjustment of my research instruments each time that was necessary, before I went to the next site or the next interview session. Adjustments were also in such a way that following the interview guide sequence of questions was not rigid as I tried to follow up, probe for more data and encouraged participants to elaborate on their responses. This is supported by reviewed literature (Maxwell 2012) which indicates that the qualitative research approach has a flexible structure as the design can be constructed and re-constructed to a great extent.

The multi-modal nature of the qualitative approach also enabled me to use three methods to generate data. Multi-modal approaches to data generation are peculiar to qualitative research because shortfalls of one method can be covered by the strengths of the other, thus enabling the complementary aspect and triangulation (Hine 2015) and they thus help to avoid method-boundedness. This valuable multi-modal quality of qualitative research in this study enabled the use of focus group discussions, and face-to-face interviews with student teachers and lecturers, and observation of mathematics education lectures.

Further, researchers who use this approach adopt a person-centred and humanistic perspective to understand human lived experiences without focusing on the specific concepts (Jolley 2019). In both the focus group discussions and the face-to-face interviews, I gave participants adequate time to talk and elaborate on their conceptions of and experiences in mathematics pedagogical practices and would take note of the non-verbal cues of each participant. Reviewed literature

(Narag and Maxwell 2014) defines field research as a qualitative method of data generation that aims to observe, interact and understand people while they are in a natural environment. I went into the field to generate data, visiting student teachers in each of the four selected colleges. In this study the use of probes and open-ended questions yielded in-depth responses. Surveyed literature (Seixas, Smith and Mitton 2018) indicates that a qualitative research approach enables thick description of participants' feelings, conceptions, opinions and experiences, and interpretation of the meanings of their actions, which was the case in this study. Having discussed the paradigm, design and approach, the next section discusses population.

4.5 Population

A research population is a well- defined collection of individuals or objects known to have one or more similar characteristics (Bauer 2014). The population for this study consisted of all third-year student teachers and all mathematics education lecturers in the four selected primary teacher training institutions. The student teachers had similar characteristics; that they all had passed O level mathematics, were training as primary school teachers and were not specialising in mathematics. For the lecturers, the characteristic that they possessed was that they were all mathematics education lecturers in a primary school teacher's college. With regard to the sites, the population of the sites was made up of all primary teacher training colleges in Zimbabwe. It was from this population that a sample was extracted.

4.6 Sample and sampling techniques

The concept of a sample arises from the inability of researchers to investigate all individuals in a given population (Yin 2013). The sample is a representative of the population from which it was drawn and it must be a good size to warrant analysis (Cohen, Manion and Morrison 2017). As this was a qualitative study, a sample of 40 student teachers and 4 lecturers was deemed adequate for analysis. Cohen, Manion and Morrison (2013) points out that qualitative studies work with characteristically small samples since they aim to accumulate an in-depth understanding of phenomena. Further reviewed literature (Gentles, Charles, Ploeg and McKibbon 2015) points out that as the researcher seeks to study experiences in-depth, the quality and exhaustive nature of each case becomes more important than the number of participants. Thus, a qualitative sample size should be large enough to provide data that is sufficient to describe the issue under study.

This study used three sampling techniques: convenience, purposive and self-selection sampling.

4.6.1 Convenience sampling

4.6.2 Sampling for colleges

At the time of the study I was a lecturer at one of the selected colleges, hence it was convenient to sample out participants at this college. Another two colleges selected were also located in the same province, which was also convenient. The proximity made the sites accessible and the process cost effective. Zimbabwe had a total of 17 teacher training colleges. Out of these I wanted to select four; a combination of government and private colleges. I thus sampled out two government colleges and two private teachers' colleges. Of the private colleges, I decided to sample out those that were under different governance. As such I sampled one Catholic college and one Dutch Reformed Church college. For the government colleges I sampled the one where I was employed, and a second from a different province. Selecting colleges from different responsible authorities and different provinces gave me the opportunity to make an analysis of variations in the conceptions and experiences during the mathematics pedagogical practices of my key informants: the student teachers and the lecturers.

Figure 4.1: Map showing the locations of the provinces where the research sites were located

The two private and one government colleges were in Masvingo province. The one government college in a different province was in Manicaland. The actual colleges are not indicated to subvert anonymity. These provinces are reflected on the map, Figure 4.1.

The Table 4.1 shows the four selected research sites or colleges and their responsible authorities. As mentioned above, participants were drawn from two private colleges and two government colleges. In the Table and throughout the thesis the sampled colleges are identified by codes (letters) A, B, C and D for purposes of subverting anonymity.

Table 4.1: College site that were sampled for the study

College	Responsible Authority
College A	Government, Public
College B	Catholic Church, Private
College C	Reformed Church, Private
College D	Government, Public

Source: Researcher 2021

From the table, colleges A and D were the government primary teacher training colleges, while Colleges B and C were the private colleges. Colleges B and C, although in the same province, were situated in different districts while College D was located 300km away from my home province.

4.6.3 Accessing participants

As already highlighted, the study was carried out in four selected teacher training colleges. Prior to visiting the colleges, I had communicated with college authorities and set appointments (see Table 4.6). On arrival at the college I called on the Vice Principal (VP) to re-introduce myself face-to-face (I had introduced myself in the letter), and reminded them of the purpose of my visit. I produced my Ethical Clearance from the Durban University of Technology (see Appendix 11), and my letter of Consent from the Ministry of Higher and Tertiary Education Science and Technology Development (MHTESTD) (see Appendix 10). The VP then ushered me into the Principal's office and introduced me, at the same time reminding the Principal about the purpose of my visit. An HOD was then assigned to take me to where I would find third-year students who were on a free period to avoid interfering with academic programmes. I chose to engage the third-year students in my study as they had more experience in pedagogical practices than other year groups and would probably be more open to share conceptions and experiences. Again, I also elected to explore third-years because at my college I taught first-year and second-year students. Thus, apart from knowing me as one of the staff members, I did not teach the third-year group.

As highlighted above, I also employed the convenience sampling strategy to extract student teachers to answer the questionnaire (see Appendix 1). It was from the conveniently sampled student teachers that I would purposively sample out those who had sat for O level mathematics examinations more than once to participate in the study. I wanted 50 conveniently sampled students per college.

4.6.4 Convenience sampling of student teachers

After assembling the students, the HOD ushered me into a hall and left. I introduced myself to the students and explained the purpose of my visit. In order to allay fears, particularly of those students at my college, I assured them that the information they were going to share with me was solely for my study and had nothing to do with their learning and/or assessment in mathematics education or during mathematics pedagogical practices. This was important as there was likely to be a power dynamic, not because I was not teaching them, but because I was one of the lecturers. However, surveyed literature (Tietze 2012) points to the advantages of researching familiar contexts or participants, where the researcher has a greater understanding of the culture being studied, does not disrupt the flow of social interaction unnaturally, and has an established intimacy which promotes both the telling and the judging of truth. I therefore ensured that I would generate research data without prejudice. Literature reviewed (Greene 2014) points out that one practical step during data generation is to minimise the impact of biases when one is an insider-researcher. Thus, in the hall I asked for 50 volunteers, 25 males and 25 females, who were not A level graduates but were willing to participate in my study. I had an overwhelming response, especially at College C (one of the private colleges) where some A level graduates wanted to participate. I dismissed them politely, telling them that I had brought a limited number of questionnaires, but assured them that I would consult them should the need arise. I thanked the rest of the students and requested them to leave so that I would remain with just the 50 conveniently selected student teachers. This gave me an adequate number to select participants for the actual study. I then asked them to sign the consent forms, following which I administered the instrument. I asked the student teachers to write their student number at the top right hand of their questionnaire. The student number would be used to identify the students selected purposively for the study. This was the approach that I used for convenience sampling of student teachers at all the selected colleges.

Table 4.2: Convenience sampling for the questionnaire

Colleges	**Number**
College A	50
College B	50
College C	50
College D	50
Total	200

Source: Reseacher 2021

Preparation for the focus group discussion, and face-to-face interviews and observation with students and lecturers

In all four selected colleges I was given a quiet wing in the library which was comfortable. Each time before participants arrived, I tested the recorder and kept a spare on hand. When participants arrived, I welcomed them and thereafter reminded them of the purpose of the meeting, the approximate time required for the meeting and the procedure we would adopt, emphasising that there was no wrong answer. I then reminded them of ethical issues and requested their permission to record the discussions. Thereafter I asked them to sign consent forms.

I always started sessions with simple questions to relax the participants, and thereafter we would move onto more demanding questions. At the end of each discussion I summarised the discussion and asked whether they had questions or additions, and also whether there were omissions or misrepresentations.

4.6.5 Purposive sampling of student teachers

a) *For focus group discussion*

After conveniently sampling 50 student teachers, I needed to purposively sample 10 student teachers from each college. Purposive sampling enables selecting information-rich participants (Mukeredzi 2009) who can provide relevant research data (Bakkalbasioglu 2020). The study was targeting those student teachers who wrote O level mathematics more than once, hence the need to use this type of sampling technique to extract information rich participants.

Sim, Saunders, Waterfield and Kingstone (2018) observe that the principle of selection related to purposive sampling is the researcher's judgment as to typicality of interest. I was interested in understanding conceptions and experiences in mathematics education from the student teachers' point of view, therefore my selection criteria was centred on picking participants with relevant data for answering the research questions. I therefore wanted to select student teachers who had the greatest number of exam sittings from the conveniently selected sample. Thus, the inclusion/exclusion criterion that I used was the greatest number of sittings for the O level national mathematics examination. This was supported by surveyed literature (Cohen, Manion and Morrison 2013) which indicates that cases to be included in the sample are handpicked by the researchers on the basis of their judgment of the possession of the particular knowledge being sought. To purposively select ten participants per college I followed four steps.

First, I went through the questionnaires, sorting them according to gender. Second, I looked for those female students who had four sittings. Third, I looked for students who had three sittings, and finally those with two sittings. I followed the same process with male students, and at all the colleges. In all of the colleges I ended up with between seven and nine participants for each gender group, when I needed five. To come up with five, I then looked for those who had the most years between their first O level sitting and the time they entered teacher education.

The approach enabled me to obtain a gender balanced sample, as shown in Table 4.3. Heterogeneous groups benefit students as they help improve their attitudes toward each other and help build a sense of community, thus providing valuable social and academic interactions (Zhou 2016). I therefore preferred the heterogeneous grouping in order to enable understanding of the conceptions and experiences during mathematics pedagogical practices of both genders.

After the purposive sampling I went back to the respective colleges and identified the participants using their student numbers and set up appointments for focus group discussions, except in College D which was 300km away, where I administered the questionnaire then met participants the following day for focus group discussions. Table 4.3 below shows the student distribution with respect to the number of exam sittings.

Table 4.3: Purpose sample for focus groups with number of sittings

College	**4 sittings**	**3 sittings**	**2 sittings**	**Total**
A	1	6	3	**10**
B	1	6	3	**10**
C	1	7	2	**10**
D	3	6	1	**10**
Total	**6**	**25**	**9**	**40**

Source: Researcher 2021

The focus group discussions and the face-to-face interviews for both student teachers and lecturers were audio recorded in order to accurately capture the responses.

At the end of each focus group discussion I explained that I was going to hold face-to-face interviews with some of them. I also explained that I only needed five participants for the face-to-face interviews and so requested them to give me a few minutes. Sitting at a different table, I purposively picked five participants **(**in one group I would have three males and two females, while in the other I would have two males and three females). From the group of ten I picked those who had been more active - whom I thought had contributed immensely during the focus group discussions. Back with the participants I thanked them politely, in particular those I had not sampled. I then informed them that they could contact me with any additional data, after which I shared my contact details. After this I set up appointments for individual face-to-face interviews with the five participants.

b) Purposive sample for the face-to-face interviews

Table 4.4 shows the participants for the individual interviews**.**

Table 4.4: Purposive sample for face-to-face Interviews with number of sittings

College	**4 sittings**	**3 sittings**	**2 sittings**	**Total**
A	1	3	1	**5**
B	1	3	1	**5**
C	1	3	1	**5**
D	2	2	1	**5**
Total	**5**	**11**	**4**	**20**

Source: Researcher 2021

4.6.6 Lecturer self-selection sampling

Participants for the lecture observations and face-to-face interviews were self-selected (voluntary participation). Self-selection sampling is a type of sampling technique where participants choose to participate in research on their own accord (Robinson 2014). This sampling approach promotes commitment to the research process and willingness to provide more insight on the phenomenon under scrutiny (Manson and Robbins 2017). It was for this reason that I chose to adopt self-selection for lecturers, given the loads of work that lecturers had to handle in the teacher training college system. Participation in this study involved being interviewed and observed lecturing during mathematics pedagogical practices. Thus, this was an extra burden on the already overloaded lecturing staff, hence the need for self-selection. I also wanted mathematics lecturer participants who were teaching mathematics education to third-year student teachers. To enable self-selection: First, the HOD ushered me to the mathematics section where I met all the mathematics lecturers. In all of the primary teachers' colleges, all mathematics lecturers taught mathematics education in addition to mathematics 'main' – the specialisation. It was these mathematics education lecturers that were targeted in this study as it sought to understand the conceptions and experiences during mathematics education lectures.

I introduced myself, explained the purpose of my visit, my study and how I expected lecturers to participate. I also outlined the ethical issues and explained that all the data generated was purely for my academic pursuits. Additionally, I explained that all the recordings, both audio and video, were to be safely kept on a computer with a password and that the data would only be shared with my supervisors. I further explained that on course completion I would surrender for safe keeping all the audio and video recordings and hard copies to my supervisors, who would lock them away and destroy them by shredding after five years.

There were likely to be relationship dynamics between myself and the participating lecturers, particularly at College A where I was working as a lecturer, as these were colleagues in the same department. Unluer (2012) who researched core workers indicates that peers give importance to a study by sharing information and allocating time for the project on a voluntary basis. However, Brewis (2014) pointed out that the stranger-researcher is more easily able to critically observe events and situations which the insiders may take for granted as unquestionable "truths". I tried to maintain an open mind and critically observed and noted issues during the interviews and observations. The lecturer participants who were self-selected in this study had a strong feeling about my research and were very willing and volunteered to participate. This ensured that adequate data was generated through the volunteering of information without coercion during interviews. These lecturers were also willing to be observed teaching. Thus, the same lecturers who were interviewed face-to-face were observed lecturing thereafter. From each college I thus requested one volunteer as I only needed one participant per college. This sampling procedure helped me in reducing the amount of time required to search for an appropriate individual that met the selection criteria needed for my sample. The distribution of the self-selected participants is reflected in Table 4.5 below.

Table 4.5: Self-selected sample for lecturers

Colleges	**Number of lecturers**
College A	1
College B	1
College C	1
College D	1
Total	**4**

Source: Reseacher 2021

4.7 Pilot testing

The tools used in this study: the questionnaire, focus group discussions, face-to-face interviews and lecture observation were pilot tested and adjustments were made before the main data generation phase. Pilot studies or feasibility studies, also referred to as small scale versions or trial runs, were done prior to the major study (Sim 2019). The pilot studies were used to identify any question ambiguities, time requirements, and whether adequate data would be generated to answer the research questions using these methods. The process of pilot testing indicates barriers, clues, pitfalls and problems that the researcher may not have realised, before conducting the main study (Cohen, Manion and Morrison 2017). Thus, this process was vital for these reasons.

The procedure for accessing participants outlined above was also followed to access pilot study participants. I conducted the pilot study with student teachers and lecturers who were not going to be involved in the main study. To reduce costs, I carried out the pilot studies at College A where I was working. I thus pilot tested with one focus group interview and three face-to-face interviews, following the appropriate interview schedules (see Appendices 2 and 3). I also pilot tested one lecturer interview and one lecture observation (see Appendix 4 and 5), where I observed the same lecturer teaching mathematics education to the second-year students.

4.8 Data generation procedures

As alluded to above, the study employed a questionnaire, focus group discussions, face-to-face interviews and lecture observations to generate data. These methods were aligned to the philosophical orientation, research design and research approach adopted for this study where the focus was to generate subjective data from the perspectives of the participants (Tobi and Kampen 2018). The variety of data generation instruments provided multiple sources of evidence and promoted methodological triangulation. Table 4.6 below shows the data generation itinerary for all the selected colleges and member checking at two colleges.

Table 4.6: Data generation itinerary

College	Questionnaire (Pilot)	FG (Pilot)	FFI (Pilot)	OBS (Pilot)	Questionnaire	FG	FFI	OBS	Member checking
A									
Students	4 June 2018	5 June 2018	6 June 2018		3 September 2018	5 September 2018	6 September 2018		9 November 2018
Lecturer			9 June 2018	9 June 2018			7 September 2018	7 September 2018	
B									
Students					24 September 2018	26 September 2018	27 September 2018		16 November 2018
Lecturer							28 September 2018	28 September 2018	
C									
Students					01 October 2018	03 October 2018	04 October 2018		
Lecturer							05 October 2018	05 October 2018	
D									
Students					19 February 2019	19 February 2019	20 February 2019		
Lecturer							21 February 2019	21 February 2019	

Source: Researcher 2021

According to Table 4.6, data was generated between 3 September 2018 and 21 February 2019. As highlighted above, in other colleges there was spacing between administration of the questionnaire and the data generation process, but for College D which was 300 km away from my home province I could not make more than one trip because of travel costs. Consequently, after face-to-face interviews with students, I stayed over for the second night and then interviewed and observed the mathematics lecturer the following day.

4.8.1 Data generation through questionnaire

A questionnaire is a data generation instrument consisting of a series of questions and other prompts for the purpose of eliciting data from respondents (Aati, Taylor, Horne and Dalbeth 2014). The questionnaire in this study was vital for generating large amounts of data from a large sample in a short period and in a relatively cost-effective way. Surveyed literature (Patten 2016) indicates that questionnaires can be viewed as a kind of written interview which is used to gather information from many respondents in a short space of time, at a low cost. As already alluded to, the questionnaire was administered to a conveniently selected sample of 200 student teachers (50 per college) as a spring board for purposively selecting 40 (10 per college) study participants; those student teachers who had written the O level mathematics national examination at least twice. In addition, the questionnaire was also vital for generating biographical data which provided a broad picture of the demographic information of the third-year students in the colleges explored (see Appendix 1).

Questions one to four sought to elicit biographical data around gender, age, year of study and the highest academic qualification, and question five was on teaching experience. Question six wanted information on the year of their first attempt at writing O level mathematics. Questions seven and eight sought to elicit details about their re-writing of the O level mathematics examination. These closed-ended questions required respondents to select appropriate pre-decided categories and the participants spent between ten and fifteen minutes responding, after which I collected the questionnaires. This is supported by reviewed literature (Aati et al 2014; Hyman and Sierra 2016) which indicates that closed questions are easier and quicker for respondents to answer, and the answers of different respondents are easier to compare. The questions related to the number of times they wrote the O level mathematics examination were vital for the purposive sampling, while the gender question enabled the balancing of participants by gender. The year of study helped me confirm that I had the appropriate year group that I sought to explore.

Data generation through the focus group discussions is discussed next. Table 4.7 shows a breakdown of the participants for the different data generation methods.

Table 4.7: Data generation table for participants

Participant	Questionnaire	Focus group	Face-to-face interviews	Lecture Observation	Total
Student teachers	200	40 (8 groups, 2 groups per college)	20 (5 per college)	----	260
Lecturers	---	---	4 (1 lecturer per college)	4 (1 lecturer per college)	8
Total	**200**	**40**	**24**	**4**	**268**

Source: Reseacher 2021

4.8.2 Data generation through student teacher focus group discussions

A focus group discussion is a method of generating data where a group of five to ten people from similar backgrounds or experiences, such as student teachers, are engaged to discuss a specific issue of interest (Barrett and Twycross 2018). Literature reviewed (Kamberelis and Dimitriadis 2013) defines focus group interviews as group discussions arranged to examine specific sets of topics. Furthermore, Kamberelis and Dimitriadis (2013) indicate that the group is focused because data is generated in some form of collective activity. Thus, I used the focus group discussion as a collective way of generating data on conceptions and experiences during the mathematics pedagogical practices of student teachers who struggled to pass O level mathematics. Rosenthal (2016) also adds that a focus group as a research method involves more than one participant per data collection session. This is supported by Nyumba, Wilson, Derrick and Mukherjee (2018) who indicate that focus group discussions allow the participants to reveal what is on their minds, and not what the interviewer suspects is on the interviewees' minds. Given that the focus group discussion is a social gathering of participants that in this case were familiar with each other, they therefore provided each other with group confidence and support and this also enabled participant comparisons of opinions while keeping each other in check (Mukeredzi 2015). As a researcher, the focus group discussions also provided me with access to comparisons of responses that participants made from their diverse experiences. Surveyed literature (Kamberelis and Dimitriadis 2013) indicates that focus group discussions can be very valuable for providing access to consensus/diversity of experiences on a topic. Participants came from different academic struggles with regard to mathematics; therefore, they revealed both similar and divergent stories on conceptions and experiences during mathematics pedagogical practices.

The focus group discussions were guided by a schedule with open-ended questions which kept me not only on track, but also focused on the interview and the topic. The questions elicited data on the conceptions and experiences during mathematics pedagogical practices. Surveyed literature (Brinkmann 2013; Mishra 2016) indicates that interview guides prepared beforehand contain well-thought out questions which are focused on the phenomenon under scrutiny, so they target the “heart of the matter”, thereby ensuring that the answers obtained are correct or accurate. Further reviewed literature (Whitehead and Whitehead 2016) purports that interview schedules increase the reliability and credibility of the data gathered. These focus group discussions which relied on a pre-planned list of open-ended questions which were systematically framed guided me during data generation and enabled me to probe the interviewees to elaborate on their original responses. The open-ended questions also gave the participants an opportunity to express their opinions and give detailed answers. Creswell (2013) argues that qualitative research focus group discussions which centre on open-ended questions are intended to elicit views, conceptions and opinions from the participants. He further argues that a good interviewer should be a good listener. The focus group discussions also allowed participants to build their answers on other participants’ responses, thereby providing rich data. Guha and Mishra (2016) suggest that having more than one interviewee present can provide two versions of events – a crosscheck, and one can complement the other with additional points. This was evident in the focus group discussions, as the participants reflected on their and their peers’ responses which created a rich, more complete and reliable record of the conceptions and experiences during mathematics education.

I conducted focus group interviews with the 40 student teacher participants, a total of 8 focus group meetings - 2 group meetings per institution. I adopted mini focus group discussions which use a smaller number of participants in a group (Rivaz, Shokrollahi and Ebadi 2019) to manage them effectively and afford each group member ample time to air their views fully. Thus, each focus group consisted of five participants (as explained above; one group had three males and two females, while the other had two males and three females) who were diverse in gender, age and background, thereby creating a heterogeneous group. Reviewed literature (Dilshad and Latif 2013) points out that in heterogeneous groups, participants differ on the basis of race, gender, learning ability, previous academic performance, or other relevant characteristics. In my study heterogeneous grouping proved effective because interaction was maximised.

The discussions which were audio recorded were held in quiet sections of college libraries and the group interviews took approximately two hours each. Literature reviewed (Alhassan 2018) points out that the researcher facilitates or moderates a group discussion between participants. Therefore, I took a peripheral rather than a centre-stage role in the focus group discussions. I listened carefully to the participants' responses, probed and followed up on areas of interest, and kept looking at them, nodding my head and showing that I was moving with the speaker. Nyumba et al. (2018) indicate that during a focus group discussion probing questions help participants to understand the questions better. In this study, probing and following up also promoted elaborations on responses, thereby providing more comprehensive in-depth data.

However, the focus group discussion has its shortcomings, as revealed by Acocella (2012) who indicates that people are difficult to organise in one place at the same time, and some may dominate the discussion whilst the reserved may be shy to make contributions. I made appointments prior to the interview sessions which helped to bring them together, and during the discussions addressed the introverted participants directly, looking them straight in the eye, which encouraged them to respond.
The next section discusses the face-to-face interviews with the student teachers.

4.9 Face- to-face interviews with student teachers

In addition to seeking data to answer the questions on the nature of their conceptions and experiences, the interview sought to establish whether the conceptions and experiences influenced the participants' learning. From the five participants selected per college, I also held a total of twenty individual face-to-face interviews. In all four colleges the face-to-face interviews with the student teachers were held a day after the focus group discussions. Due to work pressures three of the colleges had requested me not to space the interviews. As such the participants only had one night for reflection on their focus group discussion responses before their individual interviews. Again, at College B as the students were in their final term they indicated that if I wanted to do member checking with the participants at this college, delayed face-to-face interviews and transcriptions meant that I would not find them for this exercise as they would be writing final examinations. The interview duration was approximately one hour.

A face-to-face interview captures verbal and non-verbal cues including body language, which can indicate a level of discomfort with the questions (Vogl 2013). During the face-to-face interviews, where participants seemed unclear of the questions I always clarified by elaborating further. The interviewer has control over the interview and can keep the interviewee focused and on track, up until completion of the interview (Vogl 2013). Consequently, during interviews I listened attentively, looked at them, nodded my head and made expressions/verbal sounds such as "Mmm-hmm". I was able to repeat what they said word-for-word, using phrases such as, "What you're saying is…" This made the student teachers open up during these interviews, more than they had during the focus group discussions, as they were sharing more personal or sensitive information on their conceptions and experiences. Again, for some student teachers the face-to-face interview afforded them an opportunity to express themselves without fear. I was able to address questions directly to them by looking directly in their eyes when speaking. Research asserts that individual face-to-face encounters improve response rates (Cohen, Manion and Morrison 2017). Just like in the focus group discussions, the face-to-face interviews were recorded to create an accurate record of the participants' responses. I also used an interview schedule for the face-to-face interviews. Consolidation of the interview recording was done by taking down sparse notes.

4.9.1 Face-to-face interviews with lecturers

The face-to-face interviews with the lecturers preceded the non-participant lecture observations. This was vital as it helped in establishing and making connections between what was said during the interview and what was done in the lecture. These lecturer interviews were vital for comparisons with the students' responses, thereby enabling me to pick up on issues raised by the student teachers and promoting triangulation of the data. The interviews were guided by an interview schedule which was vital as this enabled me to maintain focus on the critical aspects of the study. Reviewed literature (Cohen, Manion and Morrison 2017) posits that an interview guide is vital since it helps to improve interview skills by minimising mistakes and helping the researcher to address pivotal aspects of the study. The semi-structured questions on the guide consisted of questions eliciting data related to the conceptions about mathematics and the students' experiences during mathematics pedagogical practices generally. But in these lecturer interviews I specifically wanted to elicit data that would enable understanding of: how the lecturers introduced lectures; moved along the stages of the lectures; the lecturer-student engagements; student-lecturer and student-student engagements; as well as how they concluded those sessions. The interviews took approximately one hour. These lecturer interview sessions and the lecture observations were held on the same day, as reflected in Table 4.7 above. The time between the interviews and the lecture observations varied between 30 minutes and 90 minutes, depending on the observation slots that I was allowed by the college administrations, and in some instances, this was when the lecturers had classes. The lecture observation will be discussed next.

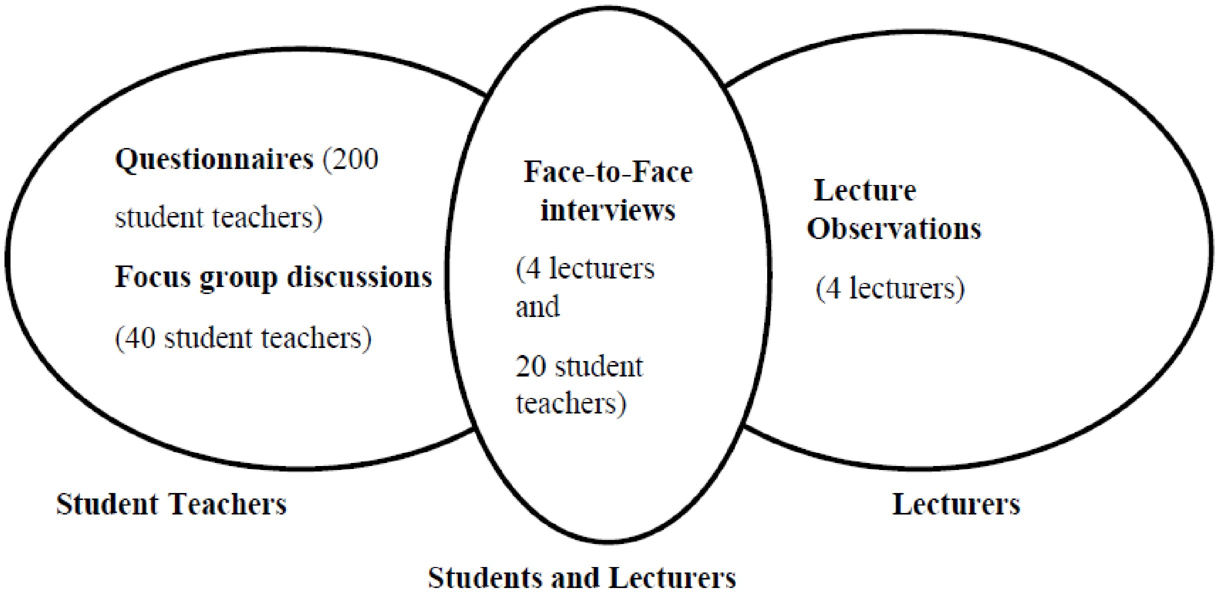
4.10 Lecture observation

Given that qualitative research demands the presence of the researcher in the natural setting, I used observation as one of the tools for data generation. The strength of the observation tool is that the researcher will not only hear what the participants are saying but also have an opportunity to see, feel and smell as they interrelate with the participants (Yin 2015). In the observations which were subsequent to the interviews, the lecturers delivered a mathematics education lecture to the third-year students. It was the third-year students who had struggled to pass O level mathematics whose conceptions and experiences were investigated in this enquiry. After providing details about my study and the purpose of my visit, and asking the students to complete consent forms, I then carried out the observation. I observed four male (one from each institution) mathematics lecturers. Having only male participants was because mathematics has always had a shortage of female students and lecturers. This is consistent with surveyed literature (Farley 2014; Wang and Degol 2017) which indicates that women are underrepresented in Science, Technology, Engineering, and Mathematics (STEM) careers.

I chose to be a non-participant observer in order to capture all the proceedings in the lectures. Observation is a method of data generation in which researchers observe within a specific research field (Cotton, Stocks and Cotton 2010). My study sought to understand the pedagogical practices in mathematics education, therefore during each lecture observation I was looking for the lecturer's classroom practices throughout the lecture. The lecture observations were divided into three parts: the introduction, body and conclusion of the lecture. Therefore, I was looking at how both lecturer and students engaged during these three phases. Interactions, the questioning techniques and the lecturer's responses to students and vice versa were also under observation. In this study I was particularly interested in the student teachers who struggled to pass mathematics, therefore I was also looking at how they were catered for during mathematics pedagogical practices. I also wanted to compare and confirm what the students and lecturers had said in the interviews with regard to the lecture proceedings.

Observation of the mathematics lectures minimised over dependence on the respondents as I was able to see the pedagogical practices in action to compare them with the responses. This also minimised interviewer bias, as noted by Thomson and McLeod (2015) who indicates that data generated through observation is more objective and generally more accurate. This is because the researcher can use their own five senses in the data generation process. Observation also offered opportunities to compare and gain new insights that may not have been revealed in the focus group discussions and face-to-face interviews (Copland 2018). Guba and Lincoln (1981: 193) point out that "the observation method helps to generate firsthand data which allows the researcher to see the world as the participants see it and capture the phenomenon in and on its own terms, grasping the culture in its own natural ongoing environment". This study also employed observation to complement and triangulate the data generated through focus group discussions and face-to-face interviews (Yin 2015). The lecture observations further enabled me to describe the existing situations making use of my senses (seeing and hearing) and thereby providing a picture of the phenomenon under study. I was guided through the observation by an observation checklist on which I recorded my observations. With permission from the participants, I recorded the lecture proceedings using an unobtrusive device - a video camera. Figure 4.2 below reflects a diagrammatical summary of the data generation. Member checking was only possible with the participants in Colleges A and B (See Table 4.7), one government and one private college which were conveniently available.

Figure 4.2: Summary of data generation



Source: Researcher (2021)

4.11 Challenges met during data generation

Data generation presented three main challenges related to accessing participants at College C, limited personal financial resources and member checking. Firstly, accessing participants at College C was a "mission" as I made many trips *just* to obtain gate keeper permission, notwithstanding that I had sent a letter of information and each time would be given appointments. Due to economic hardships, on one particular day I used public transport to get to this college as there was no fuel in the country. I arrived at the taxi rank around 06h30, where rank marshals informed me that transport to that college was available around 10h00. On reflection, I realise I should have made transport enquiries beforehand. The forms of public transport to this college were small ex-Japanese cars which were used in Zimbabwe at the time, called "*mushikashika*". Big by stature, I was instructed to occupy the front seat. Little did I know that three more people including the driver would join me in the front seat! Normally that car was only supposed to carry five passengers, but a total of eleven passengers were fitted into that small car. It was an uncomfortable trip where we could not even sit up properly as we were packed in "like sardines" for the entire journey. I eventually got to the college at 14h00, just in time for my appointment scheduled for 14h30. I went straight to the VP's office, where I was informed that the Principal was away. From this I learnt that even though I had an appointment it was important to call and remind them of my visit, and so further confirmed my appointment a day before, rather than assuming that the Principal would be available.

As if this was not enough, the weather suddenly changed and it started raining. I was not prepared for such weather conditions as I had neither an umbrella nor any protective clothing; hence I had to wait for the heavy rain to subside. Once the rain subsided to just a drizzling rain I left the college and started hiking back home, however it started raining heavily again and I got soaked to the skin. Fortunately, a colleague from another institution, who was on External Assessment, passed me on their way back to town, so I got a lift. Permission was finally granted after a struggle to meet the Principal.

Secondly, in relation to limited personal financial resources, Zimbabwe was facing economic problems and a cash crisis at the time of the research. Consequently, Zimbabwean Banks were not disbursing cash, so even if an individual had money in their bank account, they could not draw any cash or access their salaries, myself included. However, I had already set the appointments up with the research sites (the colleges) at a time when limited cash was available, so given the economic uncertainty I decided to proceed on schedule. Confirming the Zimbabwean situation, Sibanda (2019) indicates that the persistent cash crisis in Zimbabwe is a symptom of a multifaceted economic problem that is rooted in the entire macro economy from production, to investment, and all the way to consumption. Thus, travelling to the different colleges was expensive and public transport was not dependable, both in terms of timetables and transport fees. Fortunately, I was able to borrow money from family members to continue with my study.

Thirdly, I could not engage with participants from two of the colleges for member checking as it was examination time for the third-year student teachers and both staff and students had become very busy. Immediately after examinations the students left the colleges and the lecturers embarked on internal and external assessments. However, informed by Yin and Lu (2014) and Candela (2019) who view member checking as a process in which the researcher asks one or some of the participants in the study to check the accuracy of the transcriptions, I felt that the member checking done by 20 of the 40 student participants and 2 of the 4 lecturers was adequate. Further, given that they all confirmed the accuracy of the transcriptions, there appeared to be no pressing need to seek out the participants from the remaining colleges for this purpose.

Having discussed the challenges that I faced during the data generation phase, the next section discusses the data analysis.

4.12 Data analysis

Data analysis is a process when useful detail is extracted from generated data in order to help explain the phenomenon under study. Surveyed literature (Spencer, O'Connor, Ritchie, Barnard and Ormston 2014) indicates that the analysis process begins with data management and ends with abstraction and interpretation, from organising the data, to describing it, to explaining it. Further reviewed literature (Baskarada 2014) also indicates that researchers generally analyse for patterns in observations through the entire data collection phase. Data analysis therefore involves examination and arranging of the data generated and all research materials that may have been elicited into manageable form. In this study on conceptions and experiences during mathematics pedagogical practices, two approaches to data analysis were adopted: in-field data analysis and post data generation analysis. Related literature (Harder 2020) indicates that data analysis often goes on simultaneously with data collection; hence I adopted this dual approach to data analysis. In-field analysis commenced from the time I first started generating data. This was useful as I was able to identify the patterns emerging. The end-of-data generation analysis in this study was done manually at the end of the field work, using open coding. Open coding involves an interpretive process by which raw research data is systematically put into chunks, coded, categorised and then clustered into themes. Surveyed literature (Glaser 2016) defines open coding as an essential methodological tool for qualitative data analysis that was introduced in grounded theory research. Glaser (2016) further indicates that open coding is the initial interpretive process by which raw research data is first systematically analysed, categorised and then themed.

While I was aware that qualitative data analysis could be done using computer software packages, I wanted deeper immersion into my data to understand it better and decided that I could always use computer-aided analysis at a later stage, if found to be necessary. Manual open coding, though very involved and time consuming was also a learning curve for me since it was my first time using it, but by the end of the process I realised that it was worth my while, rather than having spent money on software. Reviewed literature (Zamawe 2015) indicates that although software aids data analysis, the researcher must always remain in control and they must know that no software can analyse qualitative data, since software cannot understand the nuances of the meaning of a text. Zamawe (2015) further indicates that manual qualitative analysis has the goal and benefit of allowing thorough understanding of the experiences or opinions of the interviewees. Therefore, I felt that through manual analysis of the data, I would extract deeper and more subtle meanings from the data. Manual data analysis in my study was accomplished in eight steps, which are illustrated in Figure 4.3 and explained thereafter.

Figure 4.3: Steps followed in data analysis in my study

MANUAL OPEN CODING

1. Transcriptions
2. Familiarisation with data
3. Sorting and organising
4. Assigning codes to data
5. Clustering related codes into categories
6. Review, define, cluster related categories into themes
7. Hermeneutic cycle (back to data to check all codes)
8. Development of an interpretation

Source: Researcher (2021)

4.12.1 Step One –Transcriptions

The post data generation analysis commenced with transcribing verbatim into prose the data from the audio and video tapes. Reviewed literature (Stall-Meadows and Hyle 2010) indicates that data transcription is a process whereby audio and video recordings are interpreted or translated into words that can be studied and coded. Personally, engaging in the process of transcribing was a worthwhile experience of immersion in my data, as familiarisation with it promoted the recall of prominent instances during the interviews and focus group discussions, which gave meaning to the data and helped my understanding of the emerging themes. During transcription I closely observed the data by repeatedly listening to the audio tapes and watching the video recordings in order to pick up on the emerging themes. When transcribing, producing a written account of the spoken words, though time consuming, enabled capturing of all the spoken words and remarks verbatim. Literature reviewed (Turner, Cardinal and Burton 2017) indicates that if researchers transcribe on their own, it allows for recall of the visual observations that took place during the interview and can help add meaning to the content interviewed, which was the case in my study. After transcribing, I printed my transcriptions so that I could use the hard copies for the next stage of the data analysis.

4.12.2 Step two – Familiarisation with data

After the transcriptions the qualitative data was now in prose. I started reading and re-reading the prose, and listening to and watching the video recordings many times in order to familiarise myself more with the data. This was supported by reviewed literature (Spencer, Ritchie, O' Connor, Barnard and Ormston 2014) stating that researchers mostly familiarise themselves with the data (interview transcripts and/or field notes) by reading through the transcripts, in the process gaining an overview of the substantive content and identifying topics of interest. While I was reading, I was also on the lookout for patterns being revealed by my data. Erlingsson and Brysiewicz (2017) indicate that this is an important phase in the data analysis process and the researcher should read and re-read the transcribed interviews while keeping the aim of the study in focus. This step also involved bracketing and reduction of my own biases, and making a concerted effort to maintain an open mind in order to get into the world of the participants (Erlingsson and Brysiewicz 2017). At this stage I had to set aside my own perceptions, conceptions, beliefs and pre-conceived notions about pedagogical practices in mathematics education so that I could understand what the participants had said, rather than making my own conclusions. The numerous times that I carefully listened to the entire tapes, watched the entire videos and read and re-read the transcriptions helped me to understand my data for the later stages of data analysis.

4.12.3 Step three-sorting and organising data

At this stage I had to read through, sort out and arrange the data according to the different research questions, drawing together data from the focus group discussions, the face-to-face individual interviews and the lecture observations. This sorting and organising of the data according to the research questions allowed me to get a full picture of the student teachers' conceptions and experiences during mathematics pedagogical practices. Literature (Erlingsson and Brysiewicz 2017) indicates that when sorting and organising data, answers to questions of social and theoretical significance are provided. Erlingsson and Brysiewicz (2017) further point out that keeping your research aim and question clearly in focus helps divide the text up into units of meaning.

4.12.4 Step Four-Assigning codes to data

The fourth stage of my open coding was the creation of initial codes. A code is a label that is attached to a phrase or a short sentence of the data being analysed (Blair 2015). Also known as coding or indexing, I identified broad ideas, concepts, behaviours or phrases and assigned codes to them (Furber 2010). Coding helped me in structuring and labeling the data. At this stage I used highlighters to highlight key words and phrases, and made notes to code the data. I thus broke the generated data down into smaller components and that helped me to make data driven codes based on the participants' responses. I listed all the ideas and clustered the similar topics (codes) together into major topics, unique topics and outliers.

4.12.5 Step Five - Clustering related codes into categories

Next, I reviewed and revised the codes, which I then clustered into categories. I took the text data and segmented the sentences into categories, and then labelled the categories with a term in the actual language of the respective participants. I thus re-examined each and every transcription in order to answer the question, "what is this about?" (Creswell 2013). This open coding helped me to reduce the bulky data into smaller pieces of purposeful data as I looked only for the underlying meanings.

4.12.6 Step Six- Review, define and cluster related categories into themes

After clustering the related categories I then examined and modified the categories, clustered the naturally related categories to form themes, and then attached names to them. I presented the themes, showing their relatedness while considering the student teachers and their conceptions and experiences, and while bearing in mind that the responses that I was supposed to include best answered the research questions. A theme is used to identify the major elements of an analysis of a text, since it is a higher level of categorisation. Cohen, Manion and Morrison (2013) refer to this stage of finding themes as the stage of determining themes and summarising. Mukeredzi (2016) also refers to this stage as a stage of scrutinising categories of relevant meaning to determine the central themes peculiar to these categories which will express the essence of the cluster. The themes were therefore modified and summarised in relation to the data on the conceptions and experiences. This exercise was done to see whether it was necessary to add other themes, thus enabling the identifying of general and unique themes derived from the focus group discussions, face-to-face interviews and lecture observations.

Below is a table illustrating how I coded, categorised and ended up with a theme.

Question One: How do student teachers conceive pedagogical practices in mathematics education?

College A

Table 4.8: An example of coding, categorising and theming

Data	**Codes**	**Categories**	**Theme**
- Lecturer taught for understanding	- Taught for understanding	- Teaching strategy	- Classroom practice
- He would give clear explanations and demonstrations	- Clear explanations and demonstrations	- Teaching strategy	
- Mathematics learning is learning with understanding	- Learning with understanding	- Teaching strategy	

- He would cater for our individual differences - She would encourage us to do corrections and she was inclusive when teaching	- Cater for individual differences - Inclusive when teaching	- Diversity - Diversity	

Source: Researcher 2021

4.12.7 Step Seven- Hermeneutic cycle (Back to Data to Check All Codes)

Hermeneutics as the theory and practice of interpretation, and interpretation is never closed but ongoing, with movement of understanding from the whole, to the part, and back to the whole (Robinson and Kerr 2015). At this stage I went back to the themes and reviewed them, comparing and contrasting the various themes, checking for overlaps, and scrutinised the themes again for distinctness and whether splitting or combining was necessary. I went back to the data and checked to see whether I had captured all codes and also whether all categories were represented in the themes. Reviewed literature (Widdowson 2013) suggests that at this time there is a need for the involvement of an independent judge for verification of the categories for meaning relevant to the research questions. Therefore, at this stage I had to engage my supervisors to help confirm the themes and identify any errors and omissions.

4.12.8 Step Eight- Development of an interpretation

My last stage of data analysis was related to contextualisation of the themes and developing a narrative (Nowell, Norris, White and Moules 2017). At this stage I stopped and examined my data analysis, repositioning the themes in their overall contexts from where they emerged to see whether there were relationships.

This helped me to determine whether the analysis could be put together into a narrative that depicted a clear impression of the conceptions and experiences during mathematics pedagogical practices, as revealed in the literature. After contextualization, I then had to summarise all the focus group discussions, face-to-face interviews and lecture observations to portray the core of the conceptions and experiences of the student teachers, as lived and revealed by both students and lecturers. At this stage there was a need to provide a rich description of the conceptions and experiences of the student teachers during mathematics pedagogical practices from their point of view, as Singleton and Straits (1999: 349), quoted in Mukeredzi (2016) rightfully say, "… capturing in their language and letting them speak for themselves". I was now prepared to develop an interpretation of the data into a narrative.

The above section provided the step-by-step approach to data analysis that I followed, using open coding of the data on the conceptions and experiences during mathematics pedagogical practices. In the next section I discuss how the study ensured trustworthiness.

4.13 Trustworthiness

Qualitative researchers aim at ensuring the rigour and trustworthiness (Le Roux 2016) of their research findings. Trustworthiness is considered a more appropriate criterion for evaluating rigour in qualitative studies. In order to ensure the process is trustworthy, Connelly (2016) proposes that the research should satisfy four criteria: credibility, transferability, dependability and confirmability. This is further supported by literature by Kyngas Kaariainen and Elo (2020) which indicates that the four key components of trustworthiness are credibility, confirmability, transferability and dependability. These four factors related to trustworthiness are discussed in the next section.

4.14 Credibility

Credibility refers to the extent to which a research account is believable and appropriate, with particular reference to the level of agreement between participants and the researcher. Credibility ensures that the study measures what is intended and is a true reflection of the social reality of the participants (Korstjens and Moser 2018). Shenton (2004) argues that in order to ensure credibility, researchers should always be on guard to make sure that they are actually recording the phenomenon under scrutiny. To comply with what Shenton (2004) says about credibility, in this study credibility was ensured with triangulation of the data, peer debriefing, prolonged involvement by the researcher and member checking.

Triangulation involves using multiple methods, data sources, observers or theories in order to gain a more complete understanding of the phenomenon being studied (Yin 2015). In this study triangulation was vital for promoting robustness, richness, depth and well-developed research findings. I therefore employed four types of triangulation: methodological, theoretical, data and contextual triangulation. These are discussed below.

To begin with, methodological triangulation implies using more than one method to generate data on the same topic (Fusch, Fusch and Ness 2018). The study used a questionnaire, focus group discussions, face-to-face interviews and observation of lectures in order to confirm findings, generate comprehensive data and to enhance understanding of the studied phenomena of the conceptions and experiences of student teachers during mathematics pedagogical practices. The logic of methodological triangulation is based on the premise that no single method ever adequately solves the problem of rival explanations (Lodhi 2016).
Second, theoretical triangulation was also employed to enhance credibility. Theory triangulation is the use of multiple theories when examining a phenomenon through different lenses (Pitre and Kushner 2015). I used two theories to underpin this study: conceptions about mathematics theory (Dionne 1984) and socio-constructivism theory (Vygotsky 1978; Kim 2001).

Data triangulation also manifested in this study where there was use of a variety of data sources including time, space and persons (Heale and Forbes 2013). Data was generated from both the student teachers and mathematics lecturers, and at different times and sites.

The fourth form of triangulation which helped me promote credibility was environmental triangulation (Heale and Forbes 2013). This study was a multiple-site case study involving four teachers' colleges which were in different locations (rural, peri-urban and urban).
Further, peer debriefing has been associated with ensuring credibility. Peer debriefing is when the researcher engages other researchers going through research processes, and receives feedback which ensures credibility (Murphy Odo 2016). In this study I held sessions with my peers in Zimbabwe and also during cohort sessions with peers at the Durban University of Technology, where I received feedback on different sections of my study, thereby enhancing its credibility. Again, feedback and comments from my supervisors also strengthened the study's credibility.

Credibility in my study was also enhanced through prolonged fieldwork. Prolonged field involvement refers to the length of time that the researcher is engaged in the field during the research period (Creswell 2013). The data generation process using a questionnaire, focus group discussions, face-to-face interviews and lecture observations prolonged my stay in fieldwork to promote credibility. Member checking is another important technique that qualitative researchers use to establish credibility (Cope 2014). This is a technique in which the data, interpretations and conclusions are shared with the participants and this allows participants to clarify what their intentions are, correct errors and provide additional information if necessary (Creswell 2013). In this study, member checking involved taking transcriptions back to participants to confirm the accuracy of the data captured, which I did with participants at Colleges A and B (see Table 4.7). The next section discusses confirmability.

4.15 Confirmability

Confirmability refers to the ability of others to confirm or corroborate a study’s findings (Amankwaa 2016). Shenton (2004: 72) asserts that, “steps must be taken to help ensure as far as possible that the work’s findings are the result of the experiences and ideas of the informants, rather than the characteristics and preferences of the researcher”. I presented a table with dates showing when and where I generated data. I also produced a detailed methodological description which enables the reader to determine the link between the findings and the data generated. I gave a detailed description of the type of my research, how I generated and analysed data and also justified every move taken and tools used in the methodology. Another way of enhancing confirmability was to reduce bias (Shenton 2004; Korstjens and Moser 2017). During data generation I maintained neutrality to reduce bias. I tried not to influence responses and remained open-minded throughout. As for the students at the college where I was employed; I emphasised that they would not be intimidated and thus, discouraged from telling the truth as I was going to treat their contributions with confidence. I further assured them that the information was gathered solely for the purpose of my study and would only be shared between myself and my supervisors.

Also critical to confirmability is an audit trail to enable readers to trace the process and product (Carcary 2020). I thus documented and kept a sufficiently detailed record of all the stages of the research process. Reflexivity is another way of promoting confirmability (Creswell 2013). “Reflexivity refers to active acknowledgement by the researcher that her/his own actions and decisions will inevitably impact upon the meaning and context of the experience under investigation” (Horsburgh 2003: 308; Dodgson 2019). In order to achieve reflexivity, I kept and maintained a reflexive journal in order to record and reflect on the research process throughout the research journey. The next section discusses transferability.

4.16 Transferability

Transferability refers to the degree to which the research can be transferred to other contexts (Farley-Ripple 2012). Transferability is established by providing readers with evidence that the research findings can be applicable to other contexts, situations, times and populations (Shenton 2004).

Purposive sampling was used to promote transferability, since specific information is maximised in relation to the context in which the data collection occurs (Baskale 2016). The student teachers in this study had struggled to pass mathematics and purposive sampling therefore helped me to identify the appropriate students for the study. Reviewed literature (Robinson 2014) indicates that purposive sampling helps the researcher to seek a specific group of participants who have experienced the phenomenon being studied. Use of different teachers' colleges which were situated in different environments under the control of different responsible authorities also promoted transferability. Shenton (2004), in relation to her work, writes that the use of multiple environments helps to enhance transferability. In this study a multi-case study approach was used to ensure transferability of the findings. In addition, I also produced thick descriptions of the research sites in Chapter Five and thick descriptions in the data presentation and analysis chapters to enable the reader to decide on the suitability of the findings to other similar contexts.

4.17 Dependability

Dependability, also often called auditability, generally refers to a situation when the research process is described in sufficient detail to facilitate another researcher repeating the work. Surveyed literature (Shenton 2004) indicates that if the work is repeated in the same context, with the same methods and with the same participants, similar results will be obtained. Further, reviewed literature (Denzin and Lincoln 2011) purports that dependability can be enhanced by using overlapping methods, stepwise replications and inquiry audits. I maintained an audit trail which detailed records of all the stages of the data generation process, the data analysis process and the results of the study.

In this study member checking, triangulation and prolonged engagement in the field (Cohen, Manion and Morrison 2013) discussed above also enhanced dependability. All this was meant to boost confidence in the trustworthiness of my findings, and a deeper understanding of the phenomenon at hand (Nowell, Norris and White 2017).

4.18 Ethical considerations

The nature of my study was based on student teachers' personal information on conceptions and experiences during mathematics pedagogical practices; hence there was a need to consider ethical procedures carefully. Ethics is a well-established branch of philosophy that studies the sources of human values and standards, and tries to locate them within theories of human individuals and social conditions (Artal and Rubenfeld 2017). To be ethical in research implies avoiding causing harm and achieving good. I therefore could not avoid being ethical in this study, since this entailed protection of the welfare and rights of my participants. Cohen et al. (2013) point out that researchers should be guided by ethical principles of participants' autonomy, non-maleficence, and beneficence.

As a Doctoral student with the Durban University of Technology, I first sought permission from my university to conduct the study. To cater for participants' autonomy, I obtained informed consent from the various gatekeepers before moving onto the fieldwork stage. My study was conducted in primary teachers' training colleges; therefore, there was a need to obtain permission for the study from the Ministry of Higher and Tertiary Science and Technology Development (MHTESTD). As the study aimed at understanding student teachers' conceptions about and experiences of mathematics education, the Principals of the four selected primary school teachers' training colleges had to grant me permission to carry out the study in their colleges. The consent of the participants was also sought before completion of the questionnaire and engaging in the focus group discussions, interviews and lecture observations. I also sought permission to use an audio and video recorder.

I explained to the participants that their participation was voluntary, and that if at any stage of the research they wanted to withdraw, they were free to do so without any prejudice. As power dynamics were likely in the colleges, particularly in College A where I was working as a lecturer, even though I did not teach this particular year group, I assured the students that whatever they told me would be treated in confidence and would not be used for anything other than the research. I stressed that the data would only be shared with my supervisors and no one else. Furthermore, I also assured the students at my college that the study had nothing to do with their learning and assessments. As I have already mentioned, the data generated would be kept safe by my supervisor.

I also ensured the confidentiality and anonymity of the participants and colleges by using codes instead of their real names throughout the report. I also asked students to write their student numbers onto their questionnaires, thus subverting anonymity.

Non-maleficence means non-harming or inflicting the least possible harm to reach a beneficial outcome. Reviewed literature (Elton 2021) reveals that non-harm during research includes no physical, emotional and social infliction of pain during the research. I assured my participants that they would not be put in a situation where they could be harmed as a result of their participation in this research. The participants did not fall in a vulnerable group since they were student teachers and mathematics lecturers who were well positioned to make informed decisions to participate or terminate their involvement in the study.
Having discussed ethical considerations with regards to this study, the next section discusses the limitations of the study.

4.19 Limitations of the study

In research of this magnitude, limitations often form a part of the process. The researcher's task is therefore to minimise the impact of limitations so that the quality of the findings is enhanced. Three main limitations were identified in this study, and they were related to the methodology, researching familiar contexts, and researcher biases.

To begin with, the philosophical orientation, design and approach of the study, inclusive of the sampling designs, gave rise to lack of generalisability of the findings. It is generally understandable and acceptable when using qualitative approaches that generalisability is not the main aim of such studies. Padgett (2008: 182) indicates that constructivists challenge the relevance of generalisability in qualitative research, “arguing that an emphasis on generalising strips away the context that imbues a qualitative study with credibility”. However, transferability of this study’s findings could be considered on the understanding that the findings could only be limited to similar specific groups of participants or circumstances (Cresswell 2013). It will therefore be up to the reader to assess the findings and decide whether or not to transfer these findings to another setting, based on their understanding and experiences, the thick descriptions of the research sites and the data presented in this thesis.
Secondly, I was a lecturer in one of the research sites selected. Researching familiar contexts has its own dynamics as detaching myself from my colleagues and students was not entirely possible, thus only hypothetical. This is supported by surveyed literature (McDermid, Peters, Jackson and Daly 2014) which indicates that there are difficulties associated with interviewing participants in the same organisation and with whom the researcher has a pre-existing and ongoing relationship. There are strategies can be used to mitigate negative situations and ensure ethical conduct, such as dealing with issues surrounding dual roles, practising reflexivity, building trust and rapport, self-disclosure and maintaining confidentiality. Given that I conducted research with fellow lecturers and student teachers, this direct involvement may have hindered the way that participants discussed their conceptions and experiences during mathematics pedagogical practices. To ensure minimum impact on the findings, I encouraged my participants to provide honest responses to the questions on the pedagogical practices in mathematics education and assured them that their participation had nothing to do with their own assessments or their work.

Another limitation was related to piloting where the pilot study was conducted in the same college where the actual study was conducted. However, participants for the pilot study were drawn from the 1st year students and lecturers who were not involved in the actual study. Furthermore, I was not lecturing to these 1st year students. Since the main purpose of a pilot study was to test my research instruments in order to makeany necessary adjustments before the main study. Using the same participants from the pilot study would affect the results of my data analysis. Chan, Leyrat and Eldridge (2017) indicate that participants used in the main study may change their behaviour if they had previously been involved in the pilot study.

Fourth, data generation for this study was done without the help of research assistants. Although I could have used assistant researchers, I intentionally decided against it to subvert anonymity and confidentiality.

Concomitant to the above, another limitation may have emanated from my pre-conceived notions about the participants or expectations of some responses, which may have affected the findings. Reviewed literature (Ryen 2016) purports that a researcher's misconceptions of given answers or misunderstandings of respondents' answers may impact on the research findings. I therefore tried to remain open-minded throughout the process, and made use of probing to get accurate in-depth clarifications and responses. Again, during data generation and analysis, I made huge efforts to bracket and reduce my own notions and preconceived ideas. Furthermore, discussions with my supervisors eliminated some of these subjectivities, introducing objectivity and criticality in the research process. The focus group discussions and face-to-face interviews were audio recorded and the lecture observations were video recorded to help minimise bias.

4.20 Chapter summary

This chapter has described the methodology that was followed in this study. The chapter highlighted that this was a multiple-site case study which adopted a qualitative approach. The multi-modal quality of qualitative research enabled the use of focus group discussions, face-to-face interviews and lecture observations as the methods of data generation. The chapter also discussed sampling and the sample of the study which comprised of student teachers and lecturers from four selected primary teachers' training colleges. Furthermore, the chapter discussed how the data was analysed using open coding, as well as how rigour was promoted. The chapter also outlined the considerations given to ethical issues throughout the study.

Limitations of the study, including how I addressed them to minimise their impact on the study's findings, were also outlined.

Having provided details about the research design and methodology followed in the study, in the next chapter I discuss the research sites where the study was carried out.

CHAPTER 5

RESEARCH SETTING

5.1 Introduction

The study sought to explore student teachers' conceptions about mathematics and their experiences during mathematics pedagogical practices in selected teachers' colleges. The previous chapter discussed in detail the methodology followed in generating data to address the research questions developed in Chapter One of the thesis. This chapter discusses the study sites. Having a separate chapter for the research setting, which includes the participants' profiles instead of placing that information in the methodology chapter as is usually the case, was driven by two considerations. First, the methodology chapter was already long, comprising of 40 pages, so adding another 25 pages would make the chapter far too long. Second, placing the research settings and profiles in a separate chapter enabled me with enough space to provide sufficient detail about the settings and the participants.

The data for this chapter was generated from either the Vice Principals (VP) or Heads of Department (HOD) who were assigned to assist me during the data generation visits to the colleges. I also extracted some of the data from the colleges' online handbooks and literature. In addition, my own observations during data generation also provided another source of data. However, the bulk of the data for this chapter was drawn from the research participants - the student teachers and lecturers.

In Zimbabwe at the time of the study, teacher education resided in teachers' colleges and universities. There were 11 universities and 17 teachers' colleges. Of the 17 colleges, 3 were secondary teacher training colleges, while 14 were primary teacher training colleges. This study was undertaken in four selected primary teachers' colleges. It is these four primary teachers' colleges, which were used in this study as the research sites that are discussed in this chapter.

Such a description of the research setting was deemed essential to ensure a clearer understanding of the context in which the data was generated, analysed and explained.

The chapter commences with a brief general overview of the research sites in which the participants of the study were enrolled. These sites were critical for providing a vehicle for identifying research participants. Following is a diagrammatic presentation and description of college academic departments. The study found that the academic departments were generally similar in all four selected colleges, as reflected in Figure 5.1. A description will then be provided of each of the college sites where the student teachers experienced mathematics pedagogical practices. For each site a historical background of the institution is provided, followed by the college organogram, the college mandate, its vision and core values, and how these influence student teachers' conceptions and experiences. The biographic data of the student teachers who participated in the study is also presented and the chapter conclusion draws the various threads together.

5.2 General overview of the research sites

Teacher education drives the education system in any country and its mandate of generating teaching human resources can be strengthened through research. As such the findings of this research on the conceptions and experiences of student teachers who struggled to pass O level mathematics before joining teacher training may influence discussions and planning for student teachers who enter teacher education after sitting for mathematics more than once. The four selected primary school teachers' colleges were located in two provinces, namely Masvingo and Manicaland. Two were government teachers' colleges while the other two were missionary colleges.

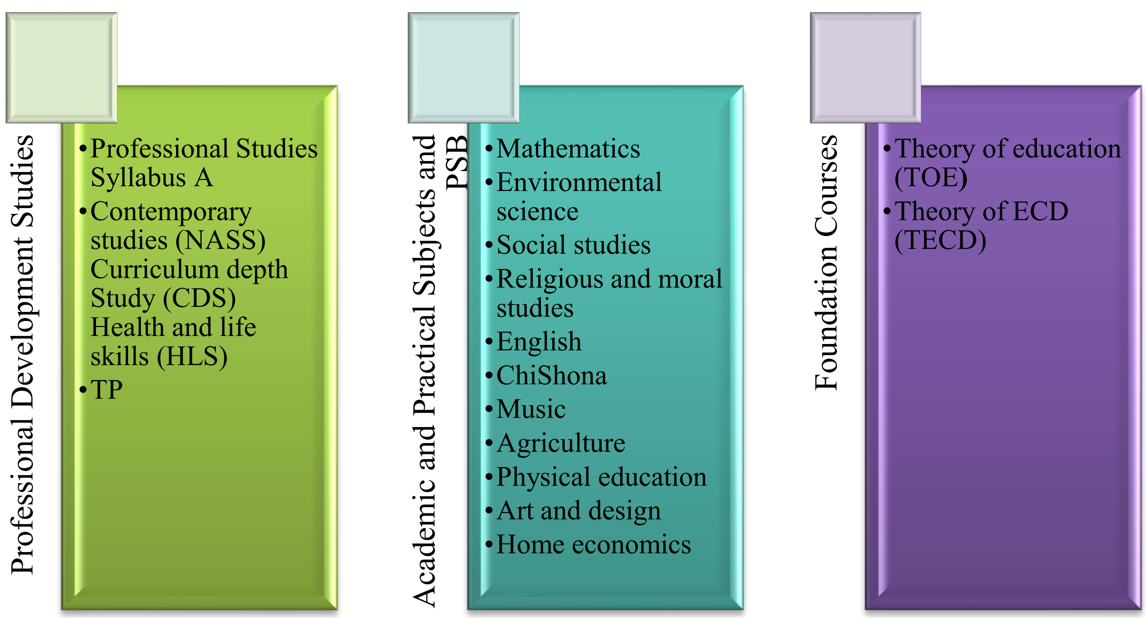
All of the colleges provided students with residential accommodation and students could choose to reside either on or off campus. However, at the time of the study accommodation was being offered on a first come, first served basis subsequent to payment of tuition and accommodation fees in full, due to large enrolments. Those students who stayed off campus either stayed with relatives or secured a place to rent in neighbouring suburbs.

When I undertook this study, all primary teacher training colleges were following the 2-5-2 model of teacher training, which I defined in Chapter One. With this model student teachers were in college for the initial eight months, on TP for the following twenty months and then back in college for the final eight months. The primary school teacher training programme duration was then three years. Unlike the primary school student teachers' programme, the secondary school teacher training programme duration was either three years for O level graduates or two years for students who had A level qualifications. As already stated, during mathematics education lectures student teachers covered aspects on pedagogics and mathematics subject knowledge, and this was Mathematics PSB. In other words, the module involved the generic teaching of mathematics, as well as specific approaches to teaching primary school mathematics content. In the four selected sites studied, their Mathematics PSB syllabi broadly covered the methods course and primary school mathematics content, with some variations in depth and assessment procedures. However, I will not go into those details as this is outside my study.

The Mathematics Professional Studies Syllabus B (PSB) was a compulsory module (core-module), a mathematics methods course for all students taking the mathematics general course, as illustrated in Figure 5.1 below. Upon graduation these student teachers would teach all of the primary school curriculum subjects, inclusive of mathematics, a subject that the students explored in this study had struggled to pass. In Zimbabwe as in other countries, formal learning started in primary school and this was when formal mathematics learning also began. The mathematical base was laid in primary school by teachers, including those who had struggled to pass O level mathematics and would be carrying various conceptions about mathematics.

While in college student teachers studied all primary school curriculum subjects and at the time of this study there were 19 subjects in all. They would then choose a subject specialisation from the academic and practical subject lists. While mathematics was one of the specialisation subjects, it was poorly subscribed to, which portrayed the poor conceptions that students generally held about mathematics (du Preez 2018). Participants in this study were not specialising in mathematics; instead they were studying the core-module of mathematics education - Mathematics PSB. In addition, given that this was a core-module which covered methods of teaching, mathematics education lectures combined mathematics specialists and the general pedagogues - those who had struggled to pass. This was notwithstanding the problematic aspect of diverse cognitive levels. Such arrangements were likely to have further compounded the pedagogues' conceptions of mathematics. Student teachers were also exposed to contemporary subjects like health and life skills (HLS), national strategic studies (NASS) and educational foundations modules like the theory of education (TOE), the theory of ECD (TECD) and the professional studies syllabus A (PSA). The PSA module covered the general techniques of teaching all primary school subjects, including the principles and strategies of teaching, classroom control, management and organisation.

Figure 5.1: College academic departments and common modules in all of the colleges studied



Source: Researcher (2021)

All modules in Professional Development Studies were also compulsory for all students. The academic and practical modules (PSB) were subject specialisations where each module had a corresponding methods course. Each student was supposed to do all of the professional development studies and the foundations courses, and then choose one subject of specialisation. In addition, those students in the general course would do all of the PSB for each of the academic subjects (i.e. they needed to learn the methods of teaching the different academic subjects) indicated in Fig 5.1 above, which made a total learning load of 19 subjects. With such a load the students' conceptions were likely to be influenced negatively, especially if they struggled with some subjects. The educational foundation modules - TECD and TOE - were taken by student teachers specialising in the foundation phase and junior course respectively.

The visions of the selected colleges were drawn from the Ministry's vision which was generally to instill professionalism, integrity, creativity and innovativeness. Instilling professionalism in future teachers would promote ethical and moral behaviour, honesty, empathy, accountability, commitment, devotion and conscientiousness, a desire for life-long learning and enquiry, relational dimensions with their students and colleagues, interdependence, agency and resourcefulness (Creasy 2015). The motto 'Art, Science and Service' (College A Handbook) embraced the Ministry's niche which was intended to nurture and instill a scientific orientation inclusive of mathematics and motivate the teacher trainees, in particular those who struggled with mathematics, to develop positive conceptions about the subjects. After discussing the general overview of all the colleges, the next section discusses the selected research sites individually.

5.2.1 College A

College A was a government institution and as such the Ministry of Higher and Tertiary Education Science and Technology (MHTESTD) stipulated tuition and accommodation fees and took responsibility for any infrastructural developments.

The college opened its doors to the first 200 students in January 1981 at a farm north east of the nearest town. They operated in crowded, make-shift buildings (pre-fabricated). Learning in such conditions was likely to have brought about undesirable conceptions during pedagogical practices. However, after a couple of years the college moved to the new site which was more spacious. The college followed the ZINTEC 2-5-2 model as discussed earlier. The first class graduated in December 1984. The ZINTEC programme was phased out in 1987.

In January 1988 the college launched a three-year conventional programme where student teachers were on campus for the first year, out on TP for the 2nd year and then back on campus for their final year (1-1-1), as explained in detail in Chapter One. This three-year conventional teacher training model was followed until 2010. The college was officially opened on 15 October 1994 by the then President of Zimbabwe, the late Robert Gabriel Mugabe.

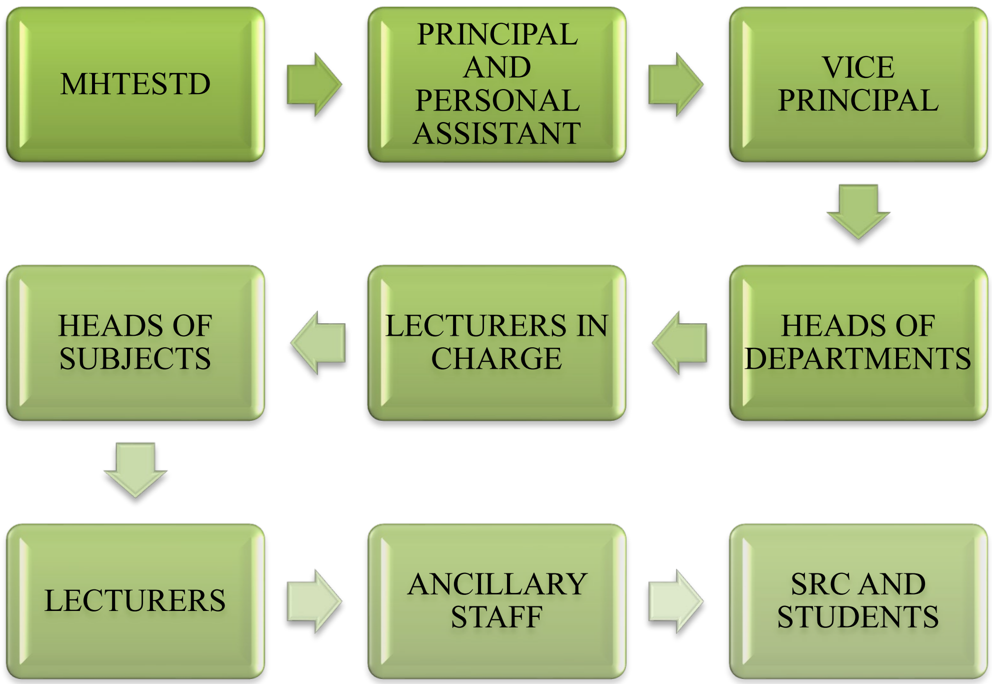
The year 2011 saw the re-introduction of the 2-5-2 model of teacher education to accelerate the rate of teacher production, as the education sector faced teacher shortages due to the country's economic meltdown. Reviewed literature (Weda and De Villiers 2019) indicates that Zimbabwean teachers migrated to other countries to escape the generally poor conditions prevailing in Zimbabwe during the 2000s, which included economic and political uncertainty, hyperinflation, the breakdown of service provision, and the scarcity of cash and other commodities. Although teacher supply had improved, this was the model of teacher education which was operational at the time of this study. In addition, the college introduced a certificate course to O level graduates with less than 5 O level subject passes to train as para-professionals for ECD in response to the national outcry for trained ECD or foundation phase teachers. The para-professionals did not necessarily need five O level subject passes like the ECD specialist student teachers. Such trainees graduated with certificates as they were more practical and less theoretically oriented than the diploma student teachers. Para-professionals were not employable by the public service (Dozva and Dyanda 2012) but would be absorbed into the private sector to teach in private ECD centres.

The college opened an ECD centre which catered for both ECD A and B classes. ECD A enrolled children aged three years while ECD B enrolled the four to five-year old children who

were being prepared for Grade One. In the South African context, ECD A would be Grade RRR while ECD B would be Grades RR and R. Thus, apart from training ECD para-professionals and professionals the centre enrolled children aged between three and five years for ECD classes. During TP some students specialising in ECD from the college were attached to this centre.
In February 2018 the college was given an additional mandate to train secondary school science teachers. This new programme, the Science Teacher Education Programme (STEP), was launched in May 2018 with an initial enrolment of 120 students majoring in mathematics, sciences (chemistry, biology and physics), geography and agriculture.

The college had a staff establishment of 95 lecturing staff (with at least a Master's Degree) and 59 ancillary staff skilled in various fields. Some of the lecturing and ancillary staff resided on campus but the majority stayed off campus. On campus residence was advantageous as staff paid low rentals, had free municipal water and electricity, free Wi-Fi and no transport costs.
Having discussed the college's history, the next section presents the college's organogram. The organisational structure shows the hierarchical and reporting structure and the chain of command within the organisation. Surveyed literature (Ahmady, Mehrpour and Nikooravesh 2016) points out that for every organisation to be effective, it must have an organisational structure which determines the hierarchy and the reporting structure in the organisation. The structure can be tailored to meet the needs of the organisation, and may contain information such as the job titles, names, or areas of responsibility for the staff. The organogram for College A is therefore presented diagrammatically below.

Figure 5.2: The organogram for College A



Source: Researcher (2021)

In Figure 5.2 the MHTESTD was the responsible authority for College A, thus the Principal was the highest-ranking officer within the college's administration. The Principal represented the Ministry and reported directly to them. The Principal had a personal assistant. All the other positions are indicated in the diagram above. All members above the lecturers formed the College Academic Board (CAB). The CAB was the think tank of the college which discussed the academic welfare of students and this could impact on the students' conceptions. This academic authority of the college was responsible for academic policy formulation regarding the courses of study, among other functions.

The college had a student teacher population of 2700 at the time of my study. There were 650 (250 males and 400 females) first-year, 700 second-year (230 males and 470 females), and 650 (200 males and 450 females) third-year students. Enrolment was biannual, given the 2-5-2 model that was pursued. With an academic staff compliment of 95, I calculated the lecturer to student ratio as 1:14 for on campus students. However, given that those on TP were also taught through supervision and other forms of learning support, this changed the ratio to 1:21, which was a reasonable ratio to influence positive conceptions during mathematics pedagogical practices. The college had five halls of residence; three for females and two for males. However, at the time of this study the college faced accommodation challenges as they were sharing facilities with a university located on the campus. As such, some students sought accommodation in nearby suburbs. The shortage of accommodation would possibly influence the conceptions of off campus student teachers given the related dynamics, for instance rentals and bus fare.

The college received fresh clean water from the local municipality and electrical power from the Zimbabwe Electricity Supply Authority (ZESA). However, at the time of this study Zimbabwe was facing severe power shortages and College A, like all other places, also experienced lots of load shedding. The power outages were likely to impact the student teachers' conceptions about learning as opportunities for research became limited.

With regards to students' catering services, the college had a kitchen. Resident student teachers were provided with meals; breakfast, lunch and supper, while off campus trainees were allowed to buy from the campus canteen. The kitchen had eight staff members and a staff to student ratio of 1:250, which was apparently too big a ratio to serve the student teachers appropriately and this might also have influenced their conceptions about learning and the college. The agriculture department had a thriving garden that supported the college kitchen by providing eggs, vegetables, green mealies, chicken and pork.

In addition, there was a clinic which was headed by a qualified state registered male nurse and it had additional support staff who provided both medical and counselling services (where necessary) to both on and off campus students and staff. This facility was likely to positively influence student teacher conceptions, in particular the participants in this study. A doctor visited once a week and serious medical cases were referred to the general hospital in town.

College A's library which had a sitting capacity of 500 students was well stocked with computers, photocopiers and the latest books on various subjects. The library also had an automated security system and closed-circuit television cameras (CCTV) for surveillance, which minimised the stealing and destruction of books. The library staff held Diplomas in Records Management and Information Science. During orientation for new student teachers, the library staff took the students through the library processes and gave them orientation activities on how to use the library.

The college had adequate learning space comprising a lecture theatre which had a sitting capacity of 1000 students, used for mass lectures for the core modules and also for the Principal's assemblies, with a fitted white board and public address (PA) system. For the subject specialisations, each subject had a spacious base room equipped with a white board and an interactive board, thus for the 11 subject departments there were 11 base rooms. The Physical Education (PE) Department boasted a state-of-the-art gym where students experienced both PE lectures and fitness exercises. The gym was open to both students and staff for fitness exercises after hours.

The college was also known for being a National ICT centre for Zimbabwe's teachers' colleges as it had a state-of-the-art ICT Department which was officially opened by the then MHTESTD Minster, Dr Amon Murwira, in 2019. The centre had computers, laptops, LCD projectors, speakers and interactive whiteboards, and was air conditioned. Such facilities were likely to positively influence students' conceptions. To increase computers in the ICT centre, UNESCO had donated 40 desktops and 40 laptops which were accessible to both student teachers and staff. College A seemed to have been geared towards the twenty-first century and was set to produce technologically literate teachers. The college had two buses and a fleet of cars for TP supervision and lecturers had to have authority to drive those cars. Permission was granted by the Ministry. The next section discusses the biographical data for the students from College A who participated in this study.

Table 5.1: Biographic data for student teachers who participated in the study at College A

Number	Participant	Gender	Age	Year of study	Academic qualifications	Number of exam sittings for O level mathematics
1	A	F	31-35	3	O level	3
2	B	M	18-25	3	O level	3
3	C	F	18-25	3	O level	2
4	D	F	Over 35	3	O level	3
5	E	F	Over 35	3	O level	3
6	F	M	31-35	3	O level	4
7	G	M	26-30	3	A level	3
8	H	F	31-35	3	O level	2
9	I	M	18-25	3	A Level	2
10	J	F	31-35	3	O level	3

Source: Researcher (2021)

As seen in Table 5.1, six participants had sat for the mathematics exam three times, one had sat four times, and three had sat for the exam twice. Thus, the majority of the participants had had at least three sittings. The picture depicted here is that these students had actually struggled to pass O level mathematics. With so many exam sittings, students were likely to have developed some negative conceptions about mathematics. Such conceptions would need to be addressed in teacher education during pedagogical practices.

The table also shows that four students were in the age range of thirty-one to thirty-five years and two were over thirty-five years of age. Regarding gender distribution, six were women and four were men. This distribution is consistent with reviewed literature (Hoque and Zohora 2014) which shows the bulk of the statistics from around the world consistently confirming that the teaching profession is dominated by the feminine gender. Having discussed the first research site which was a government institution, the next section discusses College B, a private institution.

5.2.2 College B

Unlike College A which was a government college, as explained in Chapter Four, College B was a private college under Catholic governance and owned by the Roman Catholic Diocese in the province. The church as the responsible authority was involved in the college's administration. According to the VP of this college, major decisions such as the fees structure, enrolment and procurement were made by the responsible authority. If such decisions were delayed, that would impact negatively on students' learning, thereby affecting their conceptions.

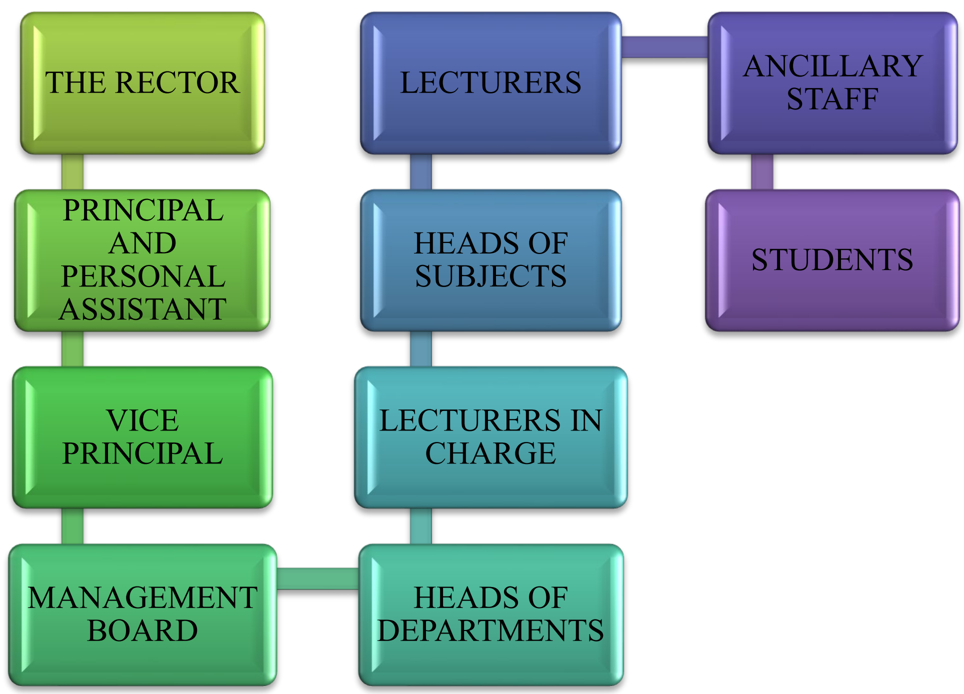
The VP explained that Catholic institutions in Zimbabwe were led by a Catholic priest, who represents the church. Besides administrative duties, the church representative would also celebrate church services (Mass) and counsel both staff and student teachers. In some cases, the religious leader would teach some counselling classes. The message of hope preached during Mass would possibly influence conceptions in a positive way. A church which was built on high ground on the campus was very conspicuous to anyone who visited the college. On the roof top of the church was a glittering Cross, which symbolised the Catholicism and religious ethos of the college.

College B was situated approximately 45 km south of the nearest Masvingo town. The college was in a rural setting, unlike College A which was in a peri-urban area. College B was the only Roman Catholic owned Teacher Training College in the country and like other primary teacher training colleges in Zimbabwe it offered both ECD and the general course Diploma in Education.

The college opened its doors to teacher training at a centre approximately 20 km west of town, under the administration of a Catholic priest. This is supported by reviewed literature (Bone 1970; Tarusikirwa 2016) which indicates that early missionary teacher training centres were run by clergy Principals. At that time the college offered a Primary Teacher Higher (PTH) course to Rhodesia Junior Certificate graduates, as explained in Chapter One. The college then moved to its present site in a rural setting in 1963, still under the same leadership. The college was closed during the liberation war and re-located to Bulawayo and renamed the United College of Education, Bulawayo. However, after the war the college re-located back to its previous location, the present site.

The staff compliment was 57 lecturers, which included the religious priests and nuns, and 63 ancillary staff deployed in various sections of the college: library, kitchen, garden, accounts office, college grounds and canteen, as well as hostels. Unlike in College A where the lecturers outnumbered the ancillary staff, here it was the opposite, which could possibly impact students' learning and the development of their conceptions.

Figure 5.3: The organogram for college B



Source: Researcher (2021)

The Rector, a priest and the Head of College B, represented the responsible authority. Under him was the Principal and like in College A above, the Principal had a personal secretary. Next in line was the VP, then the members of the management board. Like in College A, both the Principal and the VP were males. There were ten members of the College Management Board, headed by the Rector, and responsible for major decisions that affected student teachers' learning and welfare. Figure 5.3 above shows the rest of the hierarchy of College B.
The student enrolment was 2606, with 1908 female and 698 male student teachers. From my discussions with the VP, the female students outnumbered the male trainees because fewer men applied for teacher training and due to the economic meltdown in the country, most men had migrated to seek greener pastures. The 57 lecturers handling the large student body translated to a student lecturer ratio of 1:46, which was very disproportionate and unlikely to enable individual attention, particularly during mathematics pedagogical practices. This was likely to have affected the student teachers' conceptions, especially those who struggled with mathematics like the participants in this study. Reviewed literature (Ajani and Akinyele 2014) indicates that small class sizes actually give teachers an opportunity to spend time with each student, which more directly enhances students' learning and academic success and may impact their attitude (conceptions) towards a subject, in this instance mathematics. Effects of the large class sizes were also revealed by participant ST8 in an FGD at this College:

> *… The lecturers are few and are overwhelmed with work, and we are so many students in college… in the mathematics section we only have four lecturers so hey, they work under pressure*.

In mathematics education lectures attended by some of the students who struggled to pass mathematics, a lower student-to-staff ratio would nurture closer relationships with the lecturers and promote opportunities for individual attention, which would probably help address conceptions, through more interactive discussions to enhance mathematical understanding.
With respect to accommodation students, lecturers and some ancillary staff were accommodated at the college. Other ancillary staff were from the local villages and thus operated from their homes. In my discussions with participants I learnt that there were four halls of residence for the

student teachers and each hall had a lecturer warden to help with residential issues. However, some students could not afford the boarding fees and therefore resided off campus in the local community.
At the time of the study College B had previously experienced water challenges; as such water was being pumped from boreholes using diesel generators or electrical power when it was available. The college canteen with a kitchen staff of 12 (5 males and 7 females) was responsible for the preparation of meals for resident students and also for off campus students to buy. The college kitchen was supported by a thriving garden run by the Agriculture Department which supplied vegetables. The Agriculture Department also reared chickens that provided chicken meat and eggs for the students.

Further discussions with the VP revealed that there was a campus clinic, which had a staff compliment of seven (2 males and 5 females) medical staff. The clinic catered for college students and staff, secondary and primary school students, and the surrounding rural community. This was unlike College A which did not cater for the community. As in College A, there was a visiting doctor from one of the Catholic mission hospitals, however this doctor made monthly as opposed to weekly visits that took place in College A. The involvement of the doctor in their health issues would probably have a positive impact on students' conceptions as this facility and would ensure that they were kept healthy.

At the college site were a primary school and secondary schools. The VP revealed that this primary school was used as a TP centre for the student teachers from the college.

The college library had adequate computers and books. The librarian and four other library assistants engaged new students and staff on library orientation to facilitate easy access to books. The library had a sitting capacity of 300 students. Considering the enrolment of 2606 students, the library capacity was far too small. This would probably negatively affect the student teachers' conceptions.

It appeared the learning space was also inadequate to accommodate the large student body. For mass lectures they used two lecture halls and one had poor lighting, and both venues had black boards but no PA systems. During lecture observation the mathematics PSB lectures were held in a hall with pillars inside. Such situations were likely to inhibit the development of positive conceptions about mathematics, especially in students who struggled with the subject. According to the VP, the sitting capacity for this small hall was 200 students and the other slightly bigger hall could accommodate 500 students at a given time. The mathematics education lectures that I observed had approximately 450 students in the small 200-seater hall.

The college had only one small science laboratory which was not enough since it was the only venue. Thus, learning in such an environment could possibly influence students' conceptions.

The Physical Education (PE) Department had one PE base room and next to the base room was a gym. However, most of the gym equipment was non-functional. Students apparently could not use the broken-down equipment which was likely impact their conceptions, given the Greek saying which goes, "a healthy mind in a healthy body".

During the college tour the VP showed me a newly erected ECD centre where the ECD specialist student teachers practiced and were deployed for TP.

The college had three small and two big buses, but at the time of the study only one of the big buses which was donated by the late President of Zimbabwe, Mr R G Mugabe, was on the road. The HOD explained that the bus was used for TP supervision, students' field trips and sporting activities. All of these activities possibly brought about positive conceptions which probably created positive learning during mathematics pedagogical practices.

As College B was a church institution which was set up for evangelisation, the big church on site was used for students, staff and the local community to celebrate Mass and other religious services.

The next section shows the bio-data for students who participated in the study.

Table 5.2: Biographic data for College B students who participated in the Study

Number	Participant	Gender	Age	Year of study	Academic qualification	Number of exam sittings for O level mathematics
1	A	F	Over 35	3	O level	4
2	B	F	26-30	3	O level	3
3	C	M	26-30	3	O level	3
4	D	M	26-30	3	O level	2
5	E	F	31-35	3	O level	2
6	F	M	18-25	3	O level	3
7	G	M	18-25	3	O level	3
8	H	F	31-35	3	O level	2
9	I	F	Over 35	3	O level	3
10	J	F	31-35	3	O level	3

Source: Researcher 2021

The bio-data displayed in the table above suggests that the students struggled to pass mathematics. One student had passed mathematics after four exam sittings and six had passed after three exam sittings, while another three had passed after two attempts. Again, like in College A, the majority of the participants had written their O level mathematics exam three times. In the case of the participants in this study, it was likely that the more times they had to sit their O level mathematics exams, the more likely they were to develop conceptions incompatible to their mathematics learning. The age range was probably another pointer to the struggle as two of the participants were over thirty-five years of age, three were in the range of thirty-one to thirty-five years, while another three were in the twenty-six to thirty-year range. The last two were fairly young, in the 18-25 year-range. Thus, the majority were aged between 26 and 35 years.

The third research site which was also a church institution is discussed in the next section.

5.2.3 College C

College C was another church owned institution like College B, but it was owned by the Dutch Reformed Church in Zimbabwe. Just like in College B, the church as the responsible authority was involved in the college's administrative issues and major decisions. Again, delays in decision making by the responsible authority were likely to increase any negative conceptions in the students. Within the college grounds was a primary school, a high school, boarding schools for the deaf and blind, and a hospital with a big national eye unit.

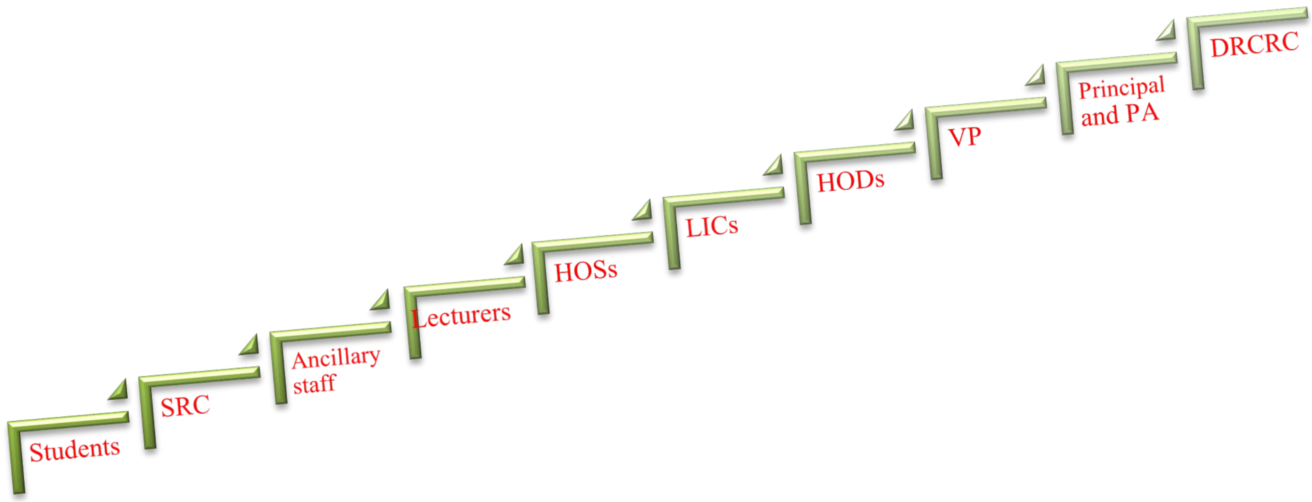
The first mission station at College C was established in 1891 by the Dutch Reformed Church in the then Southern Rhodesia, after authority was granted by a local chief in the rural area near the Zimbabwe ruins (Rutoro 2007). Permission was granted to set up a mission at a place about 35km south east of the nearest town, on a 6000-acre piece of land. The mission was named "Morester", meaning morning or day star. The mission grew to be a theological college and a big hospital, which was opened in 1894. Ten years later another mission sub-station was established 120 km away along the highway to Mutare.

Other facilities that were also established were a printing press for religious literature, and the teachers' college which was opened in 1902 (Merwe 1981). The main purpose of this mission was to promote evangelisation and in 1936, 1000 local people were employed to teach and spread the Gospel to the children. In 1948 the mission centre expanded and this huge complex including College C was handed over for local control in 1977.

At the time of this study College C was the oldest tertiary education institution in the country, having been established in 1902 (Merwe 1981). Its contribution to the achievement and growth of teacher education in Zimbabwe reflected the pivotal role played by the churches in

Zimbabwe's teacher education before and after independence in 1980 (Tarusikirwa 2016). The college remained under the governance of the Dutch Reformed Church in Zimbabwe up until the time of this study. College C was also a pioneering tertiary institution in the establishment of the then T4 teacher preparation programme. The T4 Lower Primary Teachers' Certificate was equivalent to the current ECD programme.

Figure 5.4: The Organogram for College C



Source: Researcher (2021)

Like all the privately-owned colleges such as College B, the responsible authority was at the top of the hierarchy, in this case the Dutch Reformed Church Representative Council (DRCRC). The Principal who was second-in-command had a personal secretary. Next was the VP and under the VP were the HODs. Unlike Colleges A and B, at College C both the Principal and the VP were women. The Lecturers in Charge (LICs) reported to HoDs and the Heads of Subject and the lecturers reported to the LICs.

The staff compliment consisted of 80 lecturing and 62 ancillary staff. The ancillary staff, like in the other colleges, included the administration officers, librarians, drivers, office orderlies, copy typists, technicians, security staff and cleaners.

The college had a bus and a fleet of cars for TP and other purposes. Both the academic and ancillary staff were accommodated on campus, as well as students. However, some lecturers commuted from town.

Table 5.3: Biographic data for college C students who participated in the study

Number	Participant	Gender	Age	Year of study	Academic qualifications	Number of exam sittings for O level mathematics
1	A	F	31-35	3	O level	3
2	B	F	18-25	3	O level	3
3	C	F	18-25	3	O level	3
4	D	M	26-30	3	O level	3
5	E	F	26-30	3	O level	3
6	F	M	31-35	3	O level	2
7	G	M	Over 35	3	O level	2
8	H	F	Over 35	3	O level	3
9	I	F	Over 35	3	O level	4
10	J	F	26-30	3	O level	3

Source: Researcher (2021)

According to Table 5.3 above, like in Colleges A and B, there were more females (7) than males (3). Seven out of ten students had sat for their mathematics exam three times, which was the majority and this signified their struggle to attain an O level pass in mathematics. This struggle was likely to have prompted some negative conceptions about mathematics. This struggle may also have brought about low confidence, low motivation and poor performance during mathematics pedagogical practices.

The next section provides a discussion on the fourth college site.

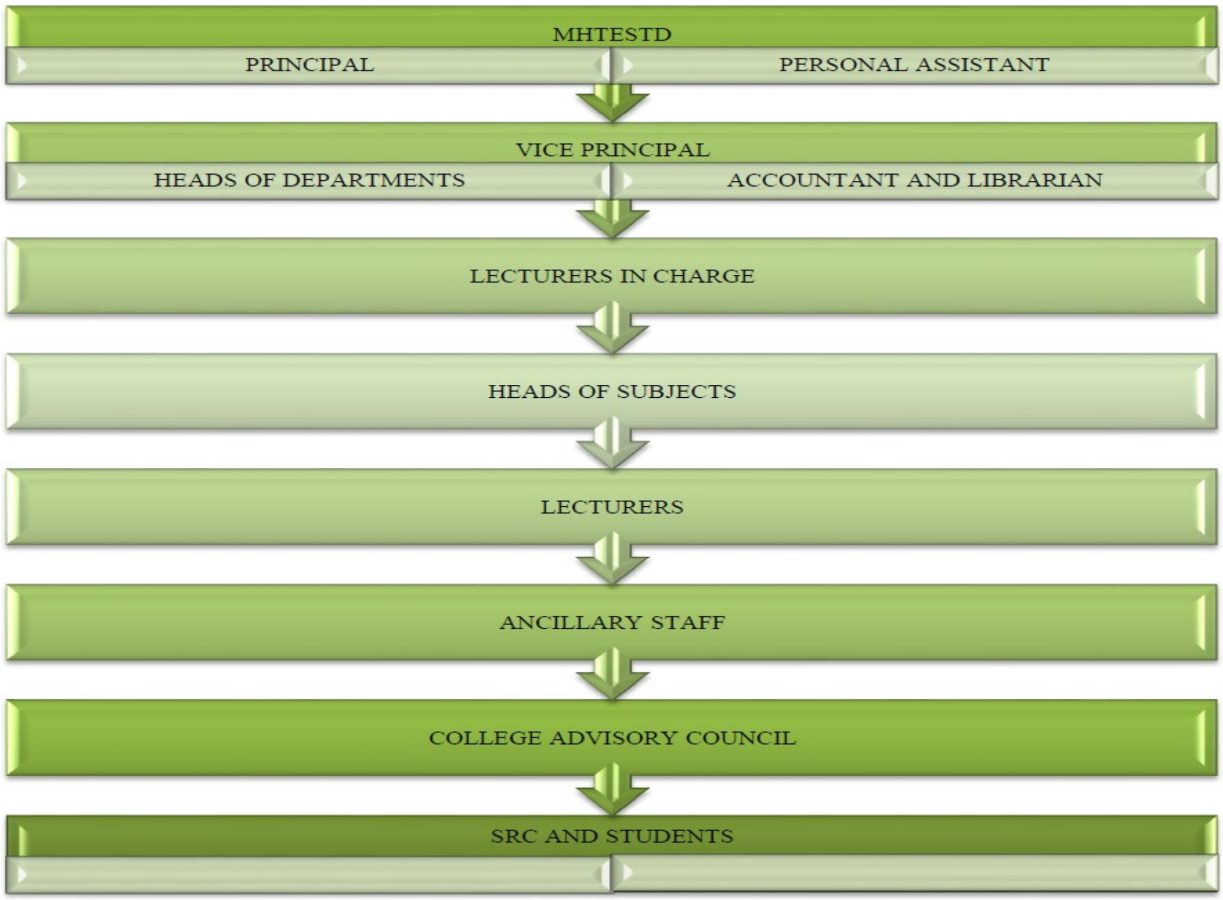
5.2.4 College D

This college, like college A, was a government institution. The Ministry thus made all major decisions regarding the running of the college. As in College A, maintenance and infrastructural development work were also the responsibility of the Ministry.

The college started as a high school set up by Roman Catholic nuns in 1958 in the Eastern Highlands town of Mutare. The idea of establishing a teacher training college came up in 1981when they (Catholics) approached the government for assistance to embark on a project of that magnitude as the church had limited capacity. The college was then established as a primary teachers' training college in 1981 by the Government of Zimbabwe, with the assistance of the Swedish International Development Agency (SIDA).

The college started training teachers using the three-year 2-5-2 ZINTEC model due to the brain drain in the country at the time. Based on the College Handbook, most students at this college were predominantly from Manicaland province. This was because students, parents and guardians generally preferred institutions close to their homes for cost effectiveness related to accommodation and transport (College Handbook). The college organogram is given below.

Figure 5.5: The organogram for College D



Source: Researcher (2021)

Unlike colleges B and C, but like College A, College D was another government teachers' college where the MHTESTD was the responsible authority. The Principal as Head of Station at this college was a lady. Next was a male VP. The rest of the college organogram is organised hierarchically, as shown in Figure 5.5 above. Like in the other research sites, the Heads of Subjects headed specific subject areas which offered a subject specialisation as well as a subject PSB. This was the focus of my study, as I sought to understand the conceptions and experiences during mathematics pedagogical practices in mathematics PSB.

According to the HOD of Academic Studies, the college had a staff complement of 73 lecturers and 54 ancillary staff. The college had an enrolment of 2510 students. Like in the other colleges discussed above, College D had limited accommodation hence this facility was offered to those students whose tuition and accommodation fees were fully paid at the beginning of the term. The lecturer student ratio was 1:35, and such a ratio was bound to promote positive conceptions because the ratio was moderate to allow for individual attention.

College D had three halls of residence and with the high student enrolment (2510), some resided off campus. Accommodation in an urban setting where the college was situated was generally expensive and with the economic situation during the time of the study, this probably affected the students' conceptions of their learning broadly and of mathematics pedagogical practices in particular.

There were 12 staff in the college canteen which catered for students' meals. Unlike the other three colleges discussed, the SRC in College D was responsible for designing the kitchen menu (College Handbook). The agriculture department supplied the college canteen with their produce. There was a thriving fishing project which supplied fish to the college canteen and the surplus was sold to staff members (College Handbook).
The college also had a flourishing garment production project which produced tracksuits and graduation gowns for sale to students at affordable prices.

There was a campus clinic, run by a qualified nurse and an assistant. The facility was for students and staff. Unlike Colleges B and C which extended their services to the community, Colleges A and D confined this health service to the college community. Specialist services were provided by a doctor who visited the college once a week. Serious medical cases were referred to the general hospital in town. Counselling provided by the medical personnel would help those student teachers who struggled with mathematics to maintain some motivation generally but especially with regard to mathematics.

The library was the centre of knowledge for both students and staff and it had a sitting capacity of 500. Both lecturers and students borrowed books for their research (College Handbook). The library was also equipped with computers connected to the internet for surfing. The library staff consisted of four library personnel; one man and three women. All new student teachers were taken through a library orientation, as in the other colleges, and this vital quality assurance strategy was likely to have helped to reduce levels of anxiety during assignment writing and may thus have created a suitable atmosphere for positive conceptions.

College D had a base room for each subject and there was one hall for mass lectures and assembly. The college had one bus and a fleet of double cab trucks for TP supervision and other functions.

Table 5.4: Biographic data for College D participants

Number	Participant	Gender	Age	Year of study	Academic qualifications	Number of exam sittings for O level mathematics
1	A	F	Over 35	3	O level	3
2	B	F	31-35	3	O level	3
3	C	F	31-35	3	O level	4
4	D	M	26-30	3	O level	4
5	E	M	18-25	3	O level	3
6	F	F	26-30	3	O level	3
7	G	F	31-35	3	O level	4
8	H	F	Over 35	3	O level	2
9	I	F	31-35	3	O level	3
10	J	F	18-25	3	O level	3

Source: Researcher (2021)

Unlike the other three colleges, this college had the greatest number of participants with the greatest number of exam sittings, which suggests that these students struggled more than those in the other colleges to pass mathematics. There were three students with four exam sittings, six wrote mathematics three times, and only one wrote mathematics twice. Negative conceptions in mathematics may have developed during these numerous attempts to pass O level mathematics. With regards to age, six students were over thirty years of age. This may have contributed to the development of negative conceptions. Like in the other colleges studied, there were more women (8) than men (2) who participated in this study.

Data for this study was also generated from mathematics lecturers drawn from the four sites discussed in this chapter. The bio-data of the lecturers is shown in Table 5.5 below. One lecturer per college was selected to participate and they were labelled as L1, L2, L3 and L4 throughout this report.

Table 5.5: Bio-data for lecturers who participated in the study

No.	College	Lecturer Code in the Study	Gender	Qualifications	Years of Experience
1	A	L1	M	MSCED (Mathematics)	8
2	B	L2	M	MSCED (Mathematics)	23
3	C	L3	M	MSCED (Mathematics)	10
4	D	L4	M	MSC Operations Research	15

Source: Researcher (2021)

Given that three of the lecturer participants had a Master of Science Degree in Mathematics Education (MSCED Mathematics) and one had a Master of Science in Operations Research (MSC Operations Research), and their many years of experience, these lecturers had the capacity to modify the conceptions about mathematics held by the student teachers who struggled to pass the subject at O level. The four lecturer participants taught mathematics as a specialisation, and mathematics education – (mathematics PSB), which was the focus of my study.

5.3 Chapter summary

The chapter provided a general overview of the selected colleges which generally offered a broad curriculum that was aligned to national and global demands. From the overview, all of the sites followed the 2-5-2 teacher training model and teacher education resided in teachers' colleges and universities. All colleges offered a core module; Professional Study Syllabus B (PSB) – the mathematics education which was the focus of my study, and also mathematics specialisation. The selected colleges had similar academic departments. Across all colleges studied, contemporary issues such as Information Technology (ICT), Health and Life Skills (HLS) and National Strategic Studies (NASS) were offered and the breadth of the curriculum was intended produce pragmatic primary school teachers. The Ministry's vision of professionalism, integrity, creativity and innovativeness was adopted by all four colleges studied (Ministry of Higher Education and Technology Policy 2001). All the teacher education institutions were geared towards producing teachers who were knowledgeable and had skills that were vital for being an effective classroom practitioner.

The historical development of each college that was discussed showed that College C was the oldest college and College B was the only Catholic teachers' college in Zimbabwe. The different colleges had similar reporting structures; however, they differed on the responsible authority. For the private colleges, the responsible authority was the Rector in College B and the DRCRC in College C, and these were responsible for making all decisions. In the government colleges the responsible authority was the MHTESTD. Government institutions were better resourced than the church owned colleges. In other words, the public institutions had better learning venues and material resources than their private counterparts. The findings also revealed that the government colleges were situated in urban areas while the church owned colleges were in the rural areas. The church owned colleges were located in rural areas as the initial focus of the missionaries was on evangelisation. Evangelisation mainly targeted rural folk in Zimbabwe and they built churches and schools which provided the proselytising grounds for converting Africans to Christianity (Ruzivo 2017).

With regards to the qualifications of the mathematics lecturers explored, all had relevant qualifications, at least a Master's degree, and were likely to have a positive influence on their students' conceptions of mathematics. On average the student enrolment per college was 2000, while the average staff compliment was 70 lecturers per college. All the colleges enrolled more females than males, given that some literature indicates that primary school teaching is perceived as a woman's job (McDowell and Klattenberg (2019). In all four colleges, the majority (25) of the participants in this study had had three O level exam sittings, a few (six) had had four exam sittings and nine had had two exam sittings. The repeated sittings signified a struggle to pass O level mathematics, hence the need to study the conceptions and experiences during mathematics pedagogical practices.

The next chapter focuses on data presentation and analysis addressing research question one.

CHAPTER 6

DATA PRESENTATION AND ANALYSIS: STUDENT TEACHER CONCEPTIONS OF PEDAGOGICAL PRACTICES IN MATHEMATICS EDUCATION

6.1 Introduction

The study sought to explore student teachers' conceptions and experiences of pedagogical practices in mathematics education in selected teachers' training colleges. The student teachers explored in this study, as alluded to in Chapter One, were those students who had struggled to pass the national mathematics examinations at O level (equivalent to Grade 11) before entering teacher education. The previous chapter discussed the research sites from where the data was generated and analysed. Chapter Four presented the research design and methodology adopted for the study. Locating this study within the interpretive paradigm, a multi-site case study design and qualitative approach were adopted. Data was generated from both student teachers and lecturers using 24 audio recorded individual face-to-face interviews (with lecturers and student teachers), 8 focus group discussion meetings (with student teachers), and 4 video recorded lecture observations.

The data was analysed in two stages: in-field inductive analysis during field work to identify patterns, and end-of-data generation deductive analysis which commenced with organising and sorting the data according to the research questions, followed by open coding, then categorising the codes and clustering the categories into themes of relevant meaning (Maguire and Delahunt 2017). The themes provided the framework for the presentation and analysis of the findings in this and the subsequent data analysis and presentation chapters.

In the presentation and analysis, the findings are clustered and pooled together across all participants and data sources (interviews, focus group discussions and lecture observations). I adopted this approach because the responses were broadly similar. The data generated in relation to the conceptions broadly revealed that the student teachers studied held traditionalist conceptions of pedagogical practices in mathematics teacher education. My study was informed by two theoretical frameworks: socio-constructivism (Vygotsky 1978; Kim 2001) and conceptions about mathematics (Dionne 1984). As discussed in detail in Chapter Three, the socio-constructivist theory puts emphasis on learner-centeredness, where student teachers are engaged in problem solving activities in an interactive way. The teacher assumes a facilitative role of stimulating the student to progress to their Zone of Proximal Development (ZPD). Vygotsky (1978: 86) defines the ZPD as "the distance between the actual development level as determined through problem solving, under adult guidance, or in collaboration with more capable peers". For a student to progress to their ZPD - maximum potential level, learning is scaffolded through social interaction with the knowledgeable 'other/s' (the lecturer or peers). If support from the lecturer or a more competent 'other' is provided, the student is then left to complete the task on his/her own (Vygotsky 1978; Kim 200; Bada and Olusegun 2015). From this perspective language is a vital tool in the learning process for the provision of verbal instructions.

With regard to the theory of conceptions, also detailed in Chapter Three (Dionne 1984), three types of conceptions about mathematics namely, traditional, Platonic and constructivist conceptions are offered. Conceptions of mathematics theory, as adapted from Sapkova's (2013) definition, refer to views that students hold of a subject, and what they believe is required in doing and learning it. The student in the traditionalist classroom is a passive recipient of knowledge (knowee) and the teacher is the dispenser of knowledge (knower). In the Platonic classroom, mathematics is conceived as full of proofs, as well as formulae to be memorised, where the teacher is the explainer of these proofs. In the third conception, the constructivist teacher is a learning facilitator where the learner brings some knowledge to the learning situation, and then the teacher builds on this prior knowledge. I thus draw on these theories to understand and explain my findings. I also draw on the literature enunciated in Chapter Two to show how my findings relate to the existing research.

The study revolved around the major research question: *What are the student teachers' conceptions and experiences of pedagogical practices in mathematics education in selected teacher training colleges in Zimbabwe*?

This major research question was addressed through three sub-questions:

1. How do student teachers conceive pedagogical practices in mathematics education?
2. What are the student teachers' experiences of pedagogical practices in mathematics education?
3. In what ways do the conceptions and experiences influence their learning?

In this study each of the three research questions constituted a chapter. The decision to separate chapters was driven by a need to present manageable-length chapters. Presenting the data analysis in one chapter meant a tedious and lengthy chapter of more than 100 pages. Alternatively, one chapter might have given rise to limited discussion and elaboration on some findings.

The purpose of this chapter is to present the analysis of data addressing the first research sub question: *How do student teachers conceive pedagogical practices in mathematics education?* To address this question, data were generated through focus group discussions with student teachers, face-to-face interviews with both student teachers and lecturers, and observations of lectures.

From the participants' responses to this question, their conceptions emerged around three major themes: conceptions about learning mathematics, conceptions about lecturer classroom practice, and conceptions about research. These themes, which frame the chapter, are discussed and summarised and were appropriate through their sub-themes. The chapter commences with a discussion on student teachers' conceptions of learning mathematics during pedagogical practices. This is followed by a discussion on conceptions about lecturer classroom practice. The last section discusses student teachers' conceptions related to research. Following this, is the chapter summary.

In presenting and discussing the findings, colleges are identified as College A, College B, College C and College D, as highlighted in the methodology chapter, while lecturers are identified as L1, L2, L3 and L4. Student teachers are identified as ST1 to ST10. Meanwhile, focus group discussion is represented by FGD and the face-to-face interview by FFI. Such codes were adopted to subvert anonymity and confidentiality as well as for easy identification and ensuring appropriately spread quotations during the data reporting.

6.2 Student teachers' conceptions about learning mathematics

As alluded to in Chapters One and Three, conceptions are students' strong ideas, beliefs or mental concepts and abstractions about something (Usman 2017). Again the students explored, as mentioned earlier, are those students who had struggled to pass mathematics at O level. Thus in this study, conceptions about mathematics were what these student teachers believed about mathematics. From the theoretical framework in Chapter Three, Dionne (1984) views these mathematics conceptions as falling into three different categories: traditional, formalist and constructivist. However, in this study it was mainly the traditional and very limited constructivist conceptions that emerged.

When asked how they managed to pass mathematics, one participant ST1 in an FGD at College C responded: "*As an individual, I did my own practice. Mathematics is not for everyone, I know. I acquired question papers from friends and repeatedly went through them".* The student teacher's conceptions reflected traditionalistic conceptions as they had to go through papers over and over, which suggested that concepts were not grasped so they had to learn through repetitive means. Other conceptions being revealed in that response were that mathematics was for a selected few *(mathematics is not for everyone)*. Further, drawing on conceptions about mathematics theory, the use of question papers was an indication that the student was worried about passing mathematics (end product) and not the conceptual understanding of mathematics (process) (Dionne 1984; Toner and Grigutsch 1994; Schoenfeld 2016; Yang, Leung and Zhang 2019). Similarly, in an FGD at College A, ST3 replied: "*I passed because I practiced over and over again. I passed mathematics by practicing more and the teacher drilled the concepts in me".* ST3's conceptions were similar to those expressed by ST1 about continuous practice. The student teachers passed mathematics by repetitive means *(over and over again)* and practice which included drilling by the teacher. However, ST1 just kept on practicing with examination papers while ST3 was further assisted by the teacher in drilling of the concepts. Drilling promotes the acquisition of knowledge or skill through repetitive practice (Willacy and Calder 2017). Information is simply transmitted to the student from the teacher, without building their engagement level with the subject being taught (Skemp 1978; Lerman 1983; Kuiper and de Pater-Sneep 2014). The drilling approach is thus not learning mathematics for comprehension, but learning of mathematics facts through memorisation (Berrett and Carter 2018), which is traditionalistic.

In an FGD at College D, conceptions about mathematics were also revealed by student ST5 who said: "*It's a challenging problem, it's about cramming. For example, if you are about to write an O level exam, it's about cramming formulas".* In the same vein, in an FFI at College B another participant ST1 indicated: "*I agree with the assertion that mathematics is about memorising facts because it is difficult".* From the response given by ST5, her conceptions about mathematics were that cramming the mathematics formulas was 'the' way to go in preparing for examinations. However, after cramming one can reproduce facts but cannot give meaning to those regurgitated facts (Dionne 1987; Toner and Grigutsch 1994; Berrett and Carter 2018). The student teacher ST1 conceived learning of mathematics as memorisation since it was a difficult subject. This displayed the traditional conceptions of mathematics held by the student. Such students like ST5 and ST1 only used given mathematical formulae and rules to apply and manipulate figures (Skemp 1978). From the literature surveyed, (Martin 2013; Willacy and Calder 2017) this student needed to understand that the beauty of mathematics did not come from the memorisation of basic facts, but rather from the use of basic facts to solve problems which a person could encounter on a daily basis.

Responses by ST5 and ST1 indicated conceptions aligned to the rote strategy of learning mathematics. From the literature consulted, rote learning is a memorisation strategy based on repetitive means, where information is stored in the memory for quick retrieval (Ernest 1988; Kang 2016). However, rote or repetitive learning is not a higher level or critical thought process. The mathematical base will not be strong enough to accommodate further mathematics learning. Rote learning, memorising or drilling is often influenced by assessment requirements, in this case a pass in O level national mathematics examinations, according to the sourced literature

(Schoenfeld 2016; Yang, Leung and Zhang 2019). So a student teacher who does mathematics with those conceptions and using those strategies holds traditional conceptions about mathematics. According to conceptions about mathematics, Ernest (1988: 2) echoes that, "Traditionalists conceive mathematics as a set of unrelated but utilitarian rules and facts". Literature surveyed (Grady 2018) also says traditionalists conceive mathematics as a collection of isolated techniques unrelated to real world applications. From this stand point, the traditionalists conceive mathematics as a subject with no relation to daily life and which is only studied for its immediate utility. This conception of emphasis on the result and not the process is traditionalistic in nature and it results in a surface understanding of mathematics. Studies consulted which involved prospective secondary teachers and experienced teachers revealed that traditionalist teachers have the problem of weak conceptual knowledge of school mathematics (Toner and Grigutsch 1994; Schoenfeld 2016; Yang et al. 2019; Radovic, Maric and Passey 2019). Therefore, when such student teachers enter the classroom as teachers they may view their roles in the classroom, not as facilitators of learning, but rather as dispensers of knowledge to passive (students) recipients.

However, contrary conceptions about learning mathematics were indicated in an FFI at College B, when ST4 revealed: *"No, I don't think mathematics is about memorisation. It's about knowing".* The conceptions about mathematics reflected here were that mathematics should be taught for understanding. When asked about mathematics having a connection to daily life, ST4 went on to say:

> *... It actually has a connection to our daily lives…. What I mean here is every day we meet problems. As I have already said, mathematics is a subject that helps us solve problems. In working out problems you have got a solution in order for you to work out that problem, so mathematics takes us to our daily life where we meet problems… even how to organise things its mathematics.*

Probing more, I asked ST4 whether mathematics was about answers or processes and he said:

No, I don't think so. I think the way… the process is more important to the answer. Yes, one might get the answer wrong at the end but having done the correct working, and I think such a person will get some rewards.

Similarly, when I asked the student teachers what they conceived about mathematics learning, ST9 at College A mentioned during an FGD: "*I don't agree with memorising. I think mathematics is about grasping the concepts because some concepts apply in daily life".* ST4's conceptions about pedagogical practices in mathematics were that the process was more vital than the product and also that mathematics knowledge was vital for application in daily lives. This student teacher held constructivist or relational conceptions about mathematics and could use already acquired mathematical knowledge and apply it to a new mathematical concept which was to be learnt (Skemp 1978). The student teacher in the classroom would take on the role of a facilitator and all learning of mathematics would be learner-centred (Skemp 1978; Vygotsky1978; Dionne 1984; Toner and Grigutsch 1994; Kim 2001; Radovic, Maric and Passey 2019). From the above responses it would appear that most student teachers held traditional conceptions about mathematics, and it also emerged that the passes in mathematics were prepared for in the traditionalist way.

The response by ST9 also suggested that conceptions about learning mathematics in pedagogical practices involved mastering mathematics concepts to enhance mathematics application to daily life. The student teacher's conceptions were that mathematics was not confined to the classroom. Such conceptions were in line with the constructivist viewpoint, where mathematics is useful in our everyday life (Lerman 1983; Dionne 1984; Ernest 1991; Yang et al. 2019).

Interviewing lecturers with regard to the conceptions of learning mathematics that their student teachers held, L1 at College A replied:

It's something very difficult. You find out that at some stage some pupils might try to move away from the subject mathematics to try another subject which is better for

> *them, but it's too late and many conceive the subject to be a very difficult thing… very difficult.*

The lecturer suggested that student teachers had the conception that mathematics was very difficult and they often opted for those subjects that they conceived as easier. Reviewed research has it that what makes mathematics appear difficult is fear, and when most students tackle mathematics it restrains their creativity and natural intelligence (Scherer 2017). This was also confirmed by L2 at College B in an FFI, who commented: "… *One, they think mathematics is very difficult and two, it's also abstract, and sees it as a subject for those who are talented".* The response implied that students conceived mathematics as a difficult subject and that it was meant for a 'selected' few. This kind of conception is traditionalistic in nature, according to the conceptions about mathematics theory (Yang et al. 2019). When I probed further about what the source of such conceptions could be L2 said:

> *Because they wrote mathematics several times, some have written two times, three times and others four times, and if you ask them they will think that they will fail mathematics. They think mathematics is very difficult, as a result they will not work and they will not consult.*

The lecturer revealed that the conceptions being held by the student teachers were traditionalistic in nature since they conceived mathematics as difficult and not intended for everyone (Toner and Grigutsch 1994; Yang et al. 2019). The traditionalistic student views mathematics as a body of knowledge whose truths appear to be necessary and certain (Lerman 1983). To confirm the views of the lecturer that mathematics is a difficult subject, another student teacher ST7 at College D indicated in an FGD that: *"I just thought to myself that mathematics is a difficult subject and those who pass do a lot of cramming to master the concepts".* At College A, ST1 also said in an FFI: "*The notes portrayed the usefulness of mathematics subject but it is very difficult".* In the same vein ST9 in an FFI at College B revealed: *"Well there are some topics there which are challenging for someone who has had difficulties in mathematics. I had difficulties grasping the concepts, the lecturer explained well but I had confusion".* Similar sentiments were made by ST5 in an FGD at College C, who indicated that: "*Mathematics is a very difficult subject which needs cramming and mastering of formulae… yes, mathematics is a difficult subject".* ST7's response suggested that mathematics was a difficult subject whose concepts could only be mastered through rote means. If during mathematics lectures the student teacher conceived mathematics to be done in this traditional way, this represented a shallow approach to learning mathematics during pedagogical practices (Toner and Grigutsch 1994; Waldrop and Bowdon 2015). Like ST7, the other students discussed above conceived mathematics as very difficult and ST9 clearly spelled out that though the lecturer made efforts to explain he was still confused about the mathematics concepts being learnt. ST5 would thus apply a series of steps without knowing why they were being applied or what they meant, thus making use of rules without reasons (Skemp 1978; Lerman 1983; Toner and Grigutsch 1994). All these students held the traditionalist conceptions that mathematics was difficult and only required memorising the mathematics formulae during pedagogical practices.

Conceptions also surfaced when I asked another lecturer, L3 at College C, in an FGD how students conceived his pedagogical practices, and he replied: "*They do not understand the science of teaching mathematics".* The lecturer conceived that the students did not understand the reasons behind the teaching of mathematics. It could be that L3 at College C implied that students were exposed to the traditionalistic approach of learning mathematics, which was result oriented, and as such lacked clear understanding and critical thinking. Consequently, they did not understand the pedagogical practices in mathematics. Literature indicates that the scientific way of understanding mathematics is to view it as a set of logical and sequenced steps which call for critical thinking, that all scientists follow when attempting to answer scientific (since mathematics is a science) questions (Lederman, Lederman and Antink 2013).

Still on the conceptions of mathematics that students held, L3 at College C indicated: *"They come to college not prepared to do mathematics, as they think they are done with it at O level".* From the response, these students' conceptions were that they would not learn mathematics again since they had passed O level mathematics. Then L3 added that: *"Usually they do it the way they were taught".* The conception behind this response suggested that conceptions could be transmitted; this is supported by research reviewed that if one experiences the traditionalistic way of doing mathematics they will in turn teach in the same way (Thompson 1984; Hudson, Henderson and Hudson 2015). This, as literature further indicates, is given that what teachers do or do not do is in response to their earlier experiences (Mukeredzi 2013).

From the above discussion, most students held strong traditionalist conceptions about mathematics. Their conceptions were that mathematics learning should be done through cramming facts, rote learning, drilling, and regurgitating facts. However, the students generally conceived learning of mathematics as effective when taught in a constructivist way which connects it to real life. All the lecturers across all colleges studied confirmed that the student teachers portrayed traditionalistic views as they conceived mathematics as meant for a ‘selected few’, the talented students. According to lecturers, students lacked the logical aspect of mathematics concepts acquisition and thus many of them opted to study other curriculum subjects which they viewed as easier compared to mathematics. Students also revealed conceptions that mathematics was a very difficult subject to tackle as it caused more confusion during pedagogical practices, since they had struggled to pass mathematics before coming to college. Another theme that emerged was around conceptions about lecturer classroom practice and this is discussed in the next section through its sub-themes. In the context of this study classroom and lecture room will be used interchangeably.

6.3 Conceptions about lecturers’ classroom practice

Classroom practice refers to all the learning and teaching activities done by the teacher that promote learners’ learning, which involve using a set of teaching strategies and methods of instruction employed in the classroom. Reinke, Herman and Stormont (2013) note that this is the interaction between the teacher and his/her learners to expand their cognitive and skillful perceptions through appropriate classroom management, the teacher’s determination to teach, and continuous evaluation to meet desired teaching objectives. In the context of this study, this implies all the learning activities related to lecturer practice that a lecturer engages in to enhance the teaching and learning of student teachers. Under this theme of conceptions about lecturer classroom practice, student teachers' conceptions emerged around seven sub-themes: teaching strategies, possession of content, student motivation, handling students' responses, classroom communication and interaction, teaching for understanding, and teacher quality. These sub-themes are discussed in turn below.

6.3.1 Teaching strategies

Teaching strategies involve all the general pedagogical methods and approaches that a lecturer or teacher employs in the classroom to enhance learners' learning. According to literature reviewed (Berg and Seeber 2016), learning is a process by which relatively permanent changes occur in behavioural potential as a result of experience. When one has gone through a learning process there should be a change in behaviour. Learning is thus a process of acquiring knowledge, in this case mathematical knowledge, through teacher, lecturer or peer instructors. The data indicated that the majority of the student teachers in this study conceived approaches to learning mathematics through their lecturer's teaching strategies.

When I asked the student teachers on the best approaches to learning mathematics, ST9 at College A pointed out in an FGD: *"After explaining and demonstrating, give more time to the learners so they may understand better. Explain and demonstrate and give time for the learners to also do it, and assist them where necessary".* According to this student teacher, explanations and demonstrations were vital for one to grasp mathematics concepts. The student teacher conceived explanations and demonstrations as critical in the lecturer's pedagogical practices for conceptual understanding. Naidoo (2017) views an explanation as a structured teacher-talk intended to clarify concepts so that students understand them. The explanation should engage learners and promote their understanding. Odora (2017) also says explanations lead to clarifying interrelations, demonstrating and justifying concepts. In the teaching of mathematics, explanations were important because they helped in making mathematical concepts clearer. ST9 went further to say that demonstrations were also crucial in the teaching of mathematics because the student could see all the moves and steps that the lecturer took. According to Sweeder and Jeffery (2013), demonstrations are a way in which teachers can convey a concept or an idea visually, and students can develop a deep and rich understanding of mathematical concepts. In the context of this study, a demonstration was thus a practical display of how a mathematical problem could be worked out. The response also suggested that the student should be given time to practice while the lecturer was monitoring and assisting – scaffolding to enhance understanding. This student teacher who struggled to pass Ordinary level (O level) mathematics therefore conceived effective pedagogical practices in the teaching of mathematics as containing explanations that punctuated the demonstration of a problem. The student teacher's conceptions were that during such explanations and demonstrations, the lecturer should not rush through the work but pace the lecture appropriately.

For students to adequately understand they also need to practice some problems with close supervision by the lecturer, thereby scaffolding the student teacher to achieve their ZPD level (Vygotsky 1978). This is in line with the socio-constructivist theory (Vygotsky 1978; Kim 2001; Yang et al 2019) which emphasises the centrality of the students' active participation in their learning. Again, from a socio-constructivist perspective, during explanation the lecturer uses language to impart knowledge, while the student engages in learning from the knowledgeable 'other'. Literature surveyed indicates that it is only after the student teacher has mastered the mathematics concepts in-depth that they can lay a mathematical foundation for the primary school child when they go out into the teaching field (Odom and Bell 2015). Subsequent to explanations and demonstrations the student teacher could work on their own, following what the lecturer had said.

Another student, ST1 at College B also indicated their conceptions about pedagogical practices during an FGD by saying: *"I think a lecturer should use many methods to explain mathematics*". The use of multiple methods often motivates students to want to learn more and also helps them to choose a method which is more appealing to them when they become teachers, since these students come from diverse backgrounds. Another underlying factor may be to promote understanding; if they do not understand using one method, they may understand using another. From this participant's conception about mathematics pedagogical practices, learning must be done using multi-modal approaches to reduce monotony. This is also confirmed by the constructivist conceptions about mathematics which advocate for numerous representations and expressions in teaching and learning mathematics (Lerman 1983; Ernest 1988; Toner and Grigutsch 1994). These student teachers struggled to pass mathematics; therefore by varying the teaching methods the lecturer might motivate them into learning and mastering this subject that they struggled to pass at O level.

A student, ST2 at College C, also indicated in an FGD: *"Mathematics should be learnt in an interactive way by discovery; concepts will not be forgotten".* The student teacher's conceptions suggested that mathematics concepts could be retained if they were acquired through students' active engagement. This concurs with the socio-constructivist perspective which puts emphasis on students' active involvement in their learning and learning through experiencing the knowledge construction process, unlike the traditional conceptions about mathematics where the responsibility for students' learning rests with the lecturer to teach passive, receptive learners (Lerman 1983; Dionne 1984; Kim 2001; Bhattacharjee 2015). Furthermore, Skemp (1978) in his relational conception posits that students should be afforded an opportunity to explore while the teacher monitors progress so that they develop confidence in mathematics. ST2's conceptions were that the learner should acquire knowledge on his/her own, as propounded by the socio-constructivist theory.

Another participant, ST6 at College C, also revealed their conceptions of pedagogical practices in an FFI by saying: *"The best approach to learning mathematics is the use of relevant and adequate media… and methods, and activities should be child-centered".* From the quotation above, the student teacher's conceptions were that the use of appropriate media enhanced effectiveness during pedagogical practices. Media refers to any tools or aids used to enhance student understanding in the teaching and learning of mathematics. Media in the classroom are appropriate for triggering ideas, making difficult concepts more understandable, and for holding students' attention on important ideas (Dewey 1938; Piaget 1972; Botha, Van Putten and Kundema 2019). Media use therefore enhances learning by motivating the student and assisting the lecturer to make concepts comprehensible. Clark (2015) summarises it by saying using

media engages students, aids their knowledge retention, arouses interest in the subject matter, and helps the lecturer to illustrate the relevance and meaning of concepts.
From the discussion above the student teachers conceived explanations, demonstrations, closely monitored student practice with scaffolding, interactive and learner-centered teaching, multi-modal teaching strategies and the use of media as vital for effective pedagogical practices in the mathematics classroom. These strategies suggest active pedagogical practices in mathematics education, which if effectively performed, may bring about holistic learning in the sense that they apply to a broad range of fields in which a learner acts as an actual or potential instigator of change in society (Mukeredzi 2009).

When I asked what they valued more in mathematics learning, a correct answer or a correct method, another student, ST7 at College A, said in their FFI: *"I think a correct answer, because one gets more marks".* Similar sentiments were expressed by student ST3 at College C, whom I also engaged in an FFI, who said: *"I think the answer should be considered the most. How I get it will determine someone's intelligence. The fact that I came out with the answer is important".* ST7 and ST3 conceived a correct answer in pedagogical practices in mathematics education as more important in order to get marks, and felt that getting the correct answer was a reflection of intelligence. Both students overlooked the fact that one can get a correct answer from a wrong working. Such conceptions reflect traditionalist conceptions (Skemp 1978; Lerman 1983; Dionne 1984; Toner and Grigutsch 1994) that put emphasis on the result rather than the process required to get the result. The traditionalist teacher is examination oriented and therefore focuses on completing the syllabus and students passing examinations, hence, the mention of the correct answer being more important. Sahlberg (2011: 97) says, "We prepare children to learn how to learn, not how to take a test". Sahlberg (2011) supports the constructivist perspective which puts emphasis on the process and not the result in mathematics; it is not the answer which is important but the process (Vygotsky 1978; Toner and Grigutsch 1994; Kim 2001). Thus, teaching primary school children or any other learners is teaching them for understanding and retention of mathematical knowledge. Mukeredzi (2009), arguing against examination focus, points out that teaching and learning should be holistic and all-inclusive of complementary strategies and activities in the learning process to encompass discovery, reflection, reflexion, observation, demonstration, trial and error, and growing with challenges and collaboration which will birth autonomous, responsible and civic individuals. Yunus, Salehi and Chenzi (2012) also in literature propound that: in teaching mathematics, engaging students in open, honest, public discussions of appropriate methods is the best way to enable them to gain deeper understandings of the subject mathematics. If lecturers during mathematics pedagogical practices place more emphasis on methods and processes in working out problems than on answers, this will impact positively on students' conceptions of learning mathematics.

Another participant, ST6 at College A, also said in an FFI: *"I value both; a learner should know how to work, following the correct method and get the correct answer".* The response here indicated that the student teacher conceived that both the process and result were important during pedagogical practices. This implied that the participant was not leaving any room for failure by seeking a total understanding of both mathematical ideas and concepts (Prayogi and Yuanita 2018).

In an FGD held with student ST4 at College B, this was said:

> *In mathematics I think I value a correct method because it shows that one has got some light on how to do this thing, unlike answer. Someone can just plagiarise an answer, so if you plagiarise an answer and you score ten out of ten, you score hundred percent but then you don't know how to do it, how to come about to get that answer, then you probably will not be a mathematician.*

The response shows the student teacher's conceptions about mathematics pedagogical practices were that the method was more important, as getting the correct answer would not help in understanding and in making them a mathematician. This was in support of the socio-constructivist view which argues that the 'how' is more important than the 'what' (Vygotsky 1978; Kim 2001). Although this student teacher struggled to pass mathematics, he/she was likely to develop into a constructivist teacher who conceived the procedure to be more vital than the product (Skemp 1978; Dionne 1984; Toner and Grigutsch 1994). It appeared that this student teacher conceived learning mathematics as effective using the constructivist way. In mathematics, when the student goes through the method, showing all the working step-by-step, this illustrates that they have understood the concept (*has got the light*). This is generally the appropriate way of learning mathematics for retention. Such concepts which may have been mastered may later be retrieved and used in other higher order concepts, since mathematics concepts are generally interrelated and hierarchical. In addition, in mathematics pedagogical practices it is not just the answer that is taken into consideration, but also the display of the content that has been taught and learnt (Ryve, Nilsson and Pettersson 2013). Students should therefore conceive that mathematics as a subject is a process of enquiry, not a finished product, because its results remain open to revision and modification (Ernest 1988).

It appears that the responses provided by these student teachers reflected the conceptions of the teaching strategies that they were likely to adopt when they become mathematics teachers. Students across all colleges conceived that if lecturers used diverse methods during mathematics pedagogical practices, including methods that were interactive in nature, this would help them in the acquisition of mathematical concepts. Two of the student teachers' responses reflected great emphasis on the process, while their peers placed more emphasis on the product or the result, revealing the types of conceptions they held. Those student teachers who placed emphasis on the method of working out mathematical problems represented the constructivist teachers, while those who conceived the answer as more important represented the traditionalist teachers (Lerman 1983; Dionne 1984; Ernest 1988; Toner and Grigutsch 1994). However, in this study, overall the students' conceptions about mathematics teaching and learning strategies reflected close alignment to traditionalist perspectives, where the lecturer adopts a dispenser of knowledge role of mathematics practice as opposed to a facilitative role. In the constructivist standpoint the student is located at the centre of the knowledge construction process, taking responsibility for their learning, rather than in the traditionalist standpoint where students are passive recipients of mathematical knowledge (Vygotsky 1978; Toner and Grigutsch 1994; Kim 2001).

When I observed the lectures of participants L2 at College B and L3 at College C, though they dictated notes, lecture-student interaction prevailed through question and answer sessions. The lecturers seemingly conceived that knowledge acquisition was more effective through interactive means as the students were not just passive recipients of information during the mathematics pedagogical practices. However, this was not the case with L4 at College D, who just lectured and read out notes for student teachers to take down, displaying traditionalist conceptions (Dionne 1984; Toner and Grigutsch 1994).

It would also appear that this lecturer lacked knowledge of the learners and their backgrounds (Shulman 1987; Timostsuk 2015). An awareness of the learners' diversity would have led to the adoption of inclusive pedagogical practices that accommodated those who struggled to pass mathematics at O level. Given that all lecturers participated in student teacher selection in their colleges, they would all be expected to understand the nature of the students enrolled in their colleges. Consequently, I was inclined to think that some lecturers simply did not want to be bothered about those students who struggled to pass mathematics. The student teachers who struggled to pass mathematics had to take down notes during the mathematics lecture and explanations were very limited. Shulman (1987) advocates for learner knowledge, where he propounds that specific understanding of the students' characteristics and backgrounds and how these can be used to adjust instruction to facilitate comprehension need special consideration. While dictation has its merits, it would appear that for the student teachers in this study who struggled to pass mathematics, the issues related to the use of text as commands, the use of commands as text and the use of sound-alike words (Mukeredzi 2009) and others would be problematic. These student teachers could fall behind and fail to understand the concepts, hence the need to adopt mathematical pedagogies that are interactive in nature.

From the above discussion, student teachers' conceptions were that clear demonstrations punctuated with clear explanations were effective during mathematics pedagogical practices. They also conceived scaffolding as an essential aspect for pre-service teachers to get to the ZPD through socialisation by skillful lecturers or peers during pedagogical practices. Other conceptions that emerged were that the use of a variety of teaching methods and strategies during pedagogical practices, complemented by the use of media, enhanced the learning of mathematics.

Student teachers' conceptions around teaching strategies further revealed another three aspects, cooperative learning, handling diversity and remediation, as vital aspects in pedagogical practices in mathematics education and these are discussed below.

6.3.2 Cooperative learning

Cooperative learning is a teaching strategy which aims at organising activities into academic and social learning experiences. This participatory learning is an active and reflective form of learning, centred on the learner. According to literature the teacher is typically a facilitator of students' learning in small, heterogeneous groups, participating in collective tasks designed by the teacher in such a way that they mutually maximise their learning (Baloche and Brody 2017). Cooperative learning strategy is a helpful instructional strategy which promotes students' learning achievement (Van Dat 2016). The learning strategy is viewed as an effective way of teaching mathematics at college to enable students to work collectively in small groups and achieve mathematics goals. The students may be of different or similar ability levels and the lecturer assigns the same or different activities to the groups.

Cooperative learning was common across all of the colleges and from all of the data sources, as revealed by participant ST8 at College A in an FGD, responding to a question on their conceptions of learning mathematics in groups: *"I think it's good because learners may be free to share ideas with other learners than with the teacher".* This was also confirmed by student ST3 in an FFI at College D, who said: "*Mathematics must be learnt slowly but surely and must be learnt in groups, and learning mathematics in groups will help in sharing ideas".* These student teachers conceived that learning in groups was helpful for the exchange of ideas with peers. The conceptions of the student teachers were that the lecturer should not be the only source of knowledge, as propounded by socio-constructivism and conceptions about mathematics (Dionne 1984; Toner and Grigutsch 1994; Kim 2001) where students can help each other learn interactively. In the context of this study, the lecture room had students of mixed ability; some who had passed mathematics at their first sitting and those that had struggled to pass - sat for the national mathematics examination more than once. Dewey (1938) believed that students were unique learners and that they should come together to solve a mathematical problem, through discussions and collaborative decision making. An effective mathematics lecturer, according to literature, is expected to develop student teacher conceptual interpersonal skills and so respond to diverse students' abilities in the classroom environment (Slavin 2014). Cooperative learning is therefore a social instructional strategy of small groups where students of different academic abilities may assist each other in learning mathematics during mathematics pedagogical practices (Gillies 2014). Use of cooperative learning strategy in mathematics is aligned to the socio-constructivist theory where grouping enables one student to learn with and from the knowledgeable 'other/s' (Vygotsky 1978; Kim 2001). From the literature reviewed, many educators conceive that the traditional lecture approach commonly used in colleges and universities to teach mathematics is ineffective compared to active learning methods (Goos 2014). Traditionalist conceptions could be demystified by cooperative learning which transforms the classroom into a 'noisy' constructivist classroom (Dewey 1938; Toner and Grigutsch 1994; Kim 2001). Literature surveyed (Gull and Shehzad 2015) further indicates that cooperative learning impacts positively on students' achievements in mathematics since students engage in divergent and critical thinking, thereby internalising mathematics facts. ST3 conceived that mathematics pedagogical practices should involve teaching mathematics concepts slowly and engage students in collaborative learning to enable the sharing of ideas. Constructivism indicates that learners' conceptions are derived from a meaning-making search in which they engage in a process of constructing individual interpretations of their experiences (Amineh and Davatgari 2015).

These students' conceptions around cooperative learning suggested mixed ability grouping. In mixed ability grouping students no longer compete but cooperate and equal opportunities to learn are availed (Capara 2015). Students generally advocated for a situation where they (student) acquired mathematics concepts actively and not as passive recipients, like what took place in the observed lecture at College D. Zhao (2003: 97), talking about cooperative learning, says the "characteristics of constructivist teaching models include: prompting students to observe and formulate their own questions; allowing multiple interpretations and expressions of learning; encouraging students to work in groups; and using their peers as resources to learning".

This implies that by engaging students in group work the lecturer will be creating a constructivist classroom which encourages students to learn interactively from and with each other. Bada and Olusegun (2015) call this being a resource for others while drawing on others as resources. The social interaction is vital as it locates the student at the centre of their learning activities while the lecturer acts as a facilitator, as advocated by both the socio-constructivist theory (Vygotsky 1978; Kim 2001) and the conceptions about mathematics theory (Toner and Grigutsch 1994).

However, contrarily participant ST2 in an FGD at College A complained that: "... *Group work is time wasting and less content will be covered".* Such conceptions about pedagogical practices in mathematics education reflected by ST2 about time and content coverage rather than in-depth acquisition of mathematical knowledge suggested a results-oriented focus. The student was moving away from the constructivist way of learning, where knowledge should be actively and socially created through engagement with knowledgeable peers (Ernest 1988; Toner and Grigutsch 1994; Kim 2001). The student's conceptions about mathematics pedagogical practices were clearly traditionalistic in nature, advocating for the lecture method for or attainment of results and syllabus coverage.

Similarly, student ST7 in an FDG at College B revealed: "*In groups you may grasp some concepts, but learning may be spoiled because they may not participate, but I think it's okay".* While this participant conceived that group work during pedagogical practices in mathematics education was beneficial, they portrayed mixed conceptions in a situation where some students would be '*passengers*' who would not participate. ST7's conceptions did not fully support cooperative learning, but suggested some tolerance of the strategy (*it's ok*). While cooperative learning has advantages, as shown above, it also has its own shortcomings. The group work activities can be marred by the personalities of the group members, in this case a mixture of those who struggled and those who did not struggle to pass mathematics. Non-participation by students within group work activities is another weakness of this grouping strategy if not closely monitored. While the two respondents above represented a few other students whose conceptions were against cooperative work, most of the student teachers' conceptions were that meaningful mathematics learning occurred collaboratively.

When the lecturers were asked about the teaching methods they used, one lecturer L1 in an FFI at College A responded: "*Aah, basically since it is tertiary isn't it? Though where necessary I ask students to help one another through group discussions, I mainly use lecture method".* Thus, the lecturer's conceptions about pedagogical practices in mathematics education were that at tertiary level lecturing was the appropriate strategy. While this lecturer implied some group work, he further said that he mainly used exposition. To confirm what he had said about the lecture method, during lecture observation the same lecturer (L1) did not use any cooperative learning at all. The only form of interaction with student teachers was when he was dictating notes. Literature has it that in the lecture method, lecturers take the role of a *'verbal textbook'* and the student becomes a *'tape recorder'* that during examinations will reproduce what was said by the lecturer (Laal and Laal 2012; Paris 2014).

Similarly, in an FFI participant L2 at College B revealed: *"Lecture method and sometimes I use PowerPoint but it will be the lecture method".* Basically the lecture method was dominant, even during power point presentations. The lecturer conceived that a lecturer should transmit knowledge – deliver the lecture while students took down notes. This conception put the emphasis on the lecturer rather than on the student teachers, negating the aspect of student centrality in their learning (Vygotsky 1978; Kim 2001). According to Slavin (2014), during a lecture content is conveyed in what is intended to be one-way, uninterrupted discourse, as though delivering a speech. The lecture method as a teaching strategy has its strengths and shortcomings. Such strengths include handling large numbers of students at a time and more effective use of time as more content is covered in a short period. However, there is a need for unguided student time outside of the classroom for the student to understand and internalise the lecture's content. The lecturer should also develop writing and speaking skills and these are often developed when students are exposed to opportunities to verbalise their ideas during pedagogical practices. While one can argue that the ZPD can be achieved through use of the lecturer's notes, constructivist and conceptions theorists emphasise real human verbal interaction (Vygotsky 1978; Toner and Grigutsch 1994; Kim 2001). In this respect, the basis of education is people interacting with other people (Fisher, Frey and Lapp 2015).

However, participant L2 at College B seemed to contradict himself in an FFI, because when I asked him how he enabled student teachers to talk to each other he said: *"Yaa I will give them some work to do, say in a group; group tasks".* This response suggested that he engaged student teachers in group discussions. But when I had asked initially he said that he only used teacher exposition methods, and then at a later stage in the same interview he mentioned group work. Contrary to this response, during the observation of his lecture the student teachers were not engaged in any group work activities, which confirmed his earlier response in the individual interview. So, it appeared as if this lecturer conceived pedagogical practices in mathematics education as composed of teacher exposition methods. In other words, this lecturer adopted the traditionalist conceptions where he assumed the role of knowledge transmitter.

Another lecturer, L3 at College C, also revealed in their FFI: *"I dominate as I give and explain notes, but here and there engage the students through question and answer*". In another FFI lecturer L4 at College D also confirmed the lecture method, saying: *"… Just the lecture method."* According to this response, L3 conceived pedagogical practices to be around controlling all the activities in the mathematics lecture room, though at times their pedagogical practices included question and answer sessions. The lecture room was turned into a traditionalist classroom where the conceptions of pedagogical practices in mathematics were about learning by repetitive means from the dispenser of knowledge. The dominant figure reflected in the response implied that the knower possibly wanted to show off their possession of content knowledge. Any interaction between the lecturer and the whiteboard places the lecturer in control (Attard and Orlando 2014), thus turning the lecture room into a traditionalistic classroom according to conceptions about mathematics (Skemp 1978; Dionne 1984; Toner and Grigutsch 1994).

With respect to cooperative learning, 38 pre-service teachers conceived it to be the ideal teaching strategy during pedagogical practices to enable the students to share ideas, rather than the lecturer being the sole source of knowledge. According to these students, they also conceived that cooperative learning removed the aspect of students being treated as passive recipients of knowledge. However, two student teachers conceived cooperative learning during pedagogical practices as time wasting and a hindrance to syllabus coverage. Other students also portrayed mixed conceptions about the strategy when they gave cooperative learning the benefit of the doubt. Unlike most of the students' responses, all four lecturers in the four teachers' colleges revealed during their FFIs that they conceived group work activities as ideal, and that lecturing was the most dominant and applicable teaching strategy adopted in the selected teacher education colleges, portraying traditionalist conceptions. The next subtheme to be discussed is handling diversity.

6.3.3 Handling diversity

Literature suggests that diversity in education implies an understanding that students are diverse in their learning abilities, experiences, conceptions, race, gender, socioeconomic background, language and culture (Roos 2017). However, in the context of my study, the diversity under consideration involved differences in mathematical abilities, experiences and conceptions. A student's learning ability is determined by their cognitive skills. If the cognitive skills are strong, learning is fast and easy, and if they are weak learning becomes a struggle (du Plessis 2013). If the cognitive skills are weak the students find mathematics (in this case) difficult and they become distressed because their cognitive skills will have failed to process mathematical concepts easily and effectively (Thoman, Arizaga, Smith, Story and Soncuya 2014). However, weak cognitive skills can be strengthened and normal cognitive skills enhanced to increase performance in learning, hence the need for effective handling of diversity during mathematics pedagogical practices (Lopez, Sosa, Langarica and Harris 2016). The students in my study passed O level mathematics with diverse symbols and after numerous attempts. Hence, the pedagogical practices in mathematics education required consideration of that diversity among the student teachers to enable adequate support and to enhance their mastery of mathematical concepts.

One student, ST1 at College A, commenting on their mathematics lecturer's handling of diversity, said in an FGD: *"... I was very poor in mathematics but he used to pay what we call individual attention, he used to give me lot of examples".* Given that this student teacher was one of those who had struggled to pass O level mathematics, their response reflected that the lecturer conceived that students had diverse abilities and those with weak cognitive abilities required exposure to plenty of examples, and the lecturer offered individual attention and scaffolding in mathematics pedagogical practices.

Contrary to the comments above by ST1 at College A, another participant ST6 at College B commented in an FGD: "*If you ask a question he would say: "you slow learners, you are naturally slow, you cannot do mathematics".* The lecturer conceived that those students who asked questions during pedagogical practices in mathematics were slow learners who would never understand mathematical concepts. From literature, good teachers provide positive encouragement and not such disparaging remarks (Heich 2014). I believe it is possible to show students the wonder of extracting a simple correct answer from a wrong response. Often, it is motivational for students to see that their teacher believes in their capability. Again, surveyed literature (Mukeredzi 2015) says the lecturer should be able to pay close attention to students' learning processes, analysing how they are learning and diagnosing issues that prevent understanding. Such labelling above affects the academic potential of the student, leading to failure (Boyle 2014). These labels follow the student teacher in their academic studies, making it difficult to perform as expected (Chodkiewicz and Boyle 2017). From the student teacher's response, the lecturer conceived that slow learners could not work mathematics problems out and would thus not succeed in the subject. In the same vein, during an FFI at College B, another student, ST2 said:

> *… He was someone who will never cater for the individual difference of learners, so he could, if teaching a concept, cater for those the fast learners. Once they get it then the lesson is over and the rest of us would remain asking from our friends how to work out problems.*

From the comment above, diversity was not given any attention in mathematics pedagogical practices. Learners who struggled were ignored and relied on asking friends for help. While the students should learn from and with their peers, it was possible that some students could conceive a concept incorrectly and then pass their misconception on to their peers. The student conceived mathematics pedagogical practices to be focused on fast learners. These fast learners then had a sense of achievement due to this inclusion during mathematics pedagogical practices. Inclusion is about being able to empower all students, as well as being able to accommodate human differences and creating meaningful participation in education (Krammer, Gasteiger-Klicpera, Holzinger and Wohlhart 2019). In a mathematics classroom, education should be for all of the students and pedagogical practices should suit the diverse backgrounds of the student teachers. All mathematics learning should aim at putting the student at the centre of the process, according to the socio-constructivist perspective (Vygotsky 1978; Dionne 1984; Torner and Grigutsch 1994; Kim 2001). Pedagogy thus plays a very important part of inclusion as inclusivity respects diversity and therefore no student should be excluded in the pedagogical practices in mathematics (Lambert 2020).

The students who struggled to pass mathematics conceived that they were excluded during the mathematics pedagogical practices. Exclusion can be seen as alienation because it involves not being a part of the 'whole' and not being able to get access to the 'whole' (Kollosche 2017), as was the case here. When a student teacher was excluded during mathematics learning they easily conceived that they were not a part of the whole and thus felt let down. Another student, ST10 in College C, revealed during an FGD:

> *I think we should be treated differently because we have different abilities, so they are really making it difficult for us to like the subject because they are combining us and to some extent they are moving with the pace of those intelligent ones and they don't care about the disabilities of those who wrote six times, seven times. And if you find that we learn with some elderly people here, I am not so sure if they can grasp those quadratic nonsense.*

From this response the student teacher's conceptions were that they needed to be treated differently because they had differences in mathematics cognitive skills and abilities, hence their poor academic performance at O level where they struggled to pass mathematics. ST10 also conceived mathematics as very difficult, which was supported by the traditional conception about mathematics (Skemp 1978; Lerman 1983; Toner and Grigutsch 1994).

The other conception was related to the pacing of the lecture during mathematics pedagogical practices. The lecturer was fast and maintained the same pace for both those with strong and those with weak mathematics cognitive skills. ST10 saw this as a lack of care and concern for diversity. When students went for mathematics education the aim was to learn, however, it seemed as if this student conceived that no learning took place for the weaker students. Considering the number of attempts quoted where students sat O level mathematics examinations many times, inclusion rather than exclusion was essential (Silva 2016). Another conception that ST10 held related to age as a dimension of diversity in mathematics pedagogical practices, which also needed to be considered. Oyelade (2019) concurs that younger students tend to perform better than mature students in a college setting. Thus, the student conceived that elderly students needed some consideration to help them understand the mathematics concepts. From the above response the conceptions reflected a lack of consideration for diversity during mathematics pedagogical practices, though student teachers conceived the knowledge of learners as a vital tool for the handling of diversity during mathematics pedagogical practices.

Concomitant to this, when I asked the lecturers whether their lectures were inclusive they gave these responses: Participant L1 at College A said in an FFI: "*Come again? Aaah, I don't, I don't really consider them otherwise it will give me problems. I just take those students at the same time and same level".* Another lecturer, L2 at College B, also said in their FFI: *Ahhh no, we just assume that since they passed mathematics they are just operating at the same level".* Similar sentiments were made by lecturer L3 at College C during their FFI: "*What do you mean by that? My lectures are not inclusive; I just treat them the same".* At College D participant L4 also mentioned during their FFI: "*A one and half hour lecture does not give me time to attend to slow learners".* All of the lecturers in the four teachers' colleges confirmed that their pedagogical practices in mathematics education did not accommodate diversity. They gave different reasons for this, as reflected in their responses. Conceptions that student teachers operated at the same cognitive level portrayed a traditionalistic conception about mathematics. When I observed L3 at

College C, the lecturer also used Shona (indigenous language) in many instances. While code-switching, which will also be referred to later as the language of communication, is permissible to enhance clarification and the understanding of concepts, this is often done without any consideration for the language diversity in the lecture room. There is no room for the mother tongue at tertiary level (Zimbabwe Language Policy 2018), let alone in mathematics where concepts are difficult to or cannot be explained in the vernacular; hence English is the official language of instruction and is mandatory in mathematics pedagogical practices. The exception is in the Foundation Phase where the language of instruction may be mother tongue, otherwise mathematics in Zimbabwe is taught and learnt in English (Zimbabwe Language Policy 2018). Literature reviewed has it that code-switching in the mathematics classroom refers to the use of more than one language, and it is used as a tool or strategy of communication to ensure mathematical knowledge (Nur Hafeezah and Masitah 2014).

To add on to that another participant, L4 at College D, said: *"Inclusive in what ways? My classes have no individual learner differences. I don't consider the number of times a learner wrote mathematics since a pass is enough for someone to do the subject at this level".* This lecturer's conceptions about mathematics pedagogical practices were that a pass in mathematics located all student teachers at the same level, notwithstanding the number of exam sittings nor the grades attained, and as such treatment had to be the same. Equating the learning capabilities of the student teachers and denying the learning differences was not expected of teachers, let alone lecturers. The lecturer confirmed that there was no consideration of the number of times a student teacher had written the mathematics exam in their pedagogical practices, as long as they eventually passed. These conceptions negated the issue that some students had weak mathematics cognitive levels. In any learning situation no learner should be left behind, therefore mathematics learning was no exception (Vygotsky 1978; Kim 2001). When I observed lectures across all of the colleges there was no consideration for the students' diversity, and all students were conceived as being at the same cognitive echelon. However, the lecturers' responses contradicted what ST1 at College A has said about a lecturer who conceived and attended to diversity during mathematics education lectures. It would appear that the student might have had this experience when he consulted the lecturer outside the lectures.

From the discussion above, notwithstanding that student teachers conceived handling diversity as an essential aspect of mathematics pedagogical practices, diversity was not considered by the lecturers studied. On the contrary, the lecturers conceived the handling of diversity during their pedagogical practices as insignificant for a variety of reasons. Student teachers also conceived remediation as an important component of pedagogical practices in mathematics. This is discussed in the next section.

6.3.4 Remediation

Responding to a question about conceptions related to effective mathematics pedagogical practices, remediation emerged as one of the sub-themes. Remediation generally refers to a process of taking corrective measures. According to the literature consulted, remediation is the effective re-teaching of material not previously mastered when it was originally taught (Brower, Woods, Jones, Park, Hu, Tandberg, Nix, Rahming and Martindale 2018). From a socio-constructivist stand point, remediation is a way of treating prior knowledge with great importance before a new concept is dealt with (Vygotsky 1978; Kim 2001). In the classroom the teacher carries out remedial work when a learner has not understood a concept. In the process the teacher places the learner at the centre, by being responsive to their mathematical needs and interests and bringing them to their ZPD; the same level as their peers.

Remediation was revealed when I asked students about good mathematics lecturers. ST4 at College A explained in an FGD: "*If we have any errors we should be given some remediation".* In the same vein another student, ST5 at College B said during their FFI: "*They should encourage us to do corrections and remediate us".* ST10 at College D revealed during an FGD: *"He should start by remedial work for us who failed previous work, and then teach us new work".*

Conceptions around remediation during pedagogical practices were that remediation was a critical teaching strategy. In any learning situation it is essential to link prior and new knowledge. According to literature reviewed, prior knowledge is important as it facilitates the learning of new concepts, providing ‘cushioning’ on which to lay new knowledge (Bringula 2016). Teaching should include diagnosis and remediation so that new work can be comprehended. New learning should not be done before or until wrong learning has been cancelled or corrected since new learning is constructed on prior knowledge, so the need for remediation cannot be overemphasised (Boatman 2018) during pedagogical practices in mathematics.

The student teachers' responses indicated that they conceived remediation as a worthwhile intervention which helped improve their learning skills and corrected the mathematical problems that these student teachers who had struggled to pass mathematics had. ST4 conceived that the correcting of one’s errors was vital in the learning of mathematics during pedagogical practices, as indicated by literature surveyed (Hinton and Flores 2019). This literature purports that the teacher in all learning situations acts as a collaborator and coach, and he or she provides scaffolding to lead learners to an increased understanding. Effective collaboration and coaching maximises student achievement and performance during mathematics pedagogical practices. Possession of content is discussed below. This emerged as vital during mathematics pedagogical practice.

6.3.5 Possession of content by the lecturer

Content refers to the subject matter that the teacher/lecturer should possess or what the learners/students are supposed to be taught during pedagogical practices. In this study, this referred to the possession of mathematical content knowledge. Content knowledge, according to Shulman (1987), includes knowledge of the subject and its organising structures; that is the knowledge that the student teacher should master during the lectures at college so that they in turn can teach it when they qualify as teachers. In other words, literature indicates that content knowledge is the facts, concepts, theories and principles that are taught and learnt in specific academic courses (Wheeldon 2017). Literature consulted indicates that if these student teachers who struggled to pass mathematics lack subject content knowledge, they will also lack the knowledge needed to help their future learners to learn the content (Nilsson 2019).

Talking about possession of content in relation to their conceptions of mathematics pedagogical practices, students were generally unanimous on this aspect. For example, participant ST3 in College A said in an FFI: "*A lecturer with mastery of content is very important in mathematics learning".* This was also revealed by student ST5 at College D in her FFI when she responded: "*… Would use a worked example from the textbook and then tell us to make sense of how other problems should be worked out".* In addition, in the FFI with ST10 at College A, while discussing the value of possession of content knowledge, this participant said: *"I also expected to learn more mathematics content so that… I will show content mastery during my lessons".* The conceptions revealed by the students' responses were that effective pedagogical practices which ensured that meaningful mathematics learning took place occurred when the lecturer had content mastery. Student teachers conceived knowledge of content as vital, given that it enabled the lecturer to use and organise learning more effectively for the learners to understand better. Literature reviewed (Leong, Chew and Rahim 2015; Mulwa 2015) indicates that the teacher can respond to the needs of any particular learner, recognising those who struggle, and can easily change the way in which concepts are presented to make them more comprehensible. In addition, a deep and flexible understanding of content knowledge enables teachers to help their learners to create useful cognitive maps, relate ideas and address their misconceptions (Worden 2015). With all this, teachers would see how ideas connected across fields and wthith everyday life. Literature surveyed (Mukeredzi 2019) shows that content knowledge is thus the vital knowledge that teachers need to carry out their teaching work, as this is the knowledge that they teach and which learners are expected to master. Hence teachers need relevant and appropriate content knowledge in order to teach effectively and make appropriate teaching decisions and choices (Mukeredzi 2019).

According to ST5's conceptions, the lecturer's use of a textbook and even the worked examples from the book portrayed a lack of content knowledge. The student teachers were denied clear explanations of how the problems were supposed to be worked out. They (student) conceived the use of a textbook and the lack of explanations of the mathematical problems during pedagogical practices as a reflection of a lack of content knowledge by their lecturer.

The conceptions about mathematics pedagogical practices that ST10 held were that they needed more exposure to mathematical content knowledge while at college so that they would be able to deliver lessons effectively in their own classrooms. Literature surveyed indicated that mathematics teacher educators should aim to facilitate and create interest in, and passion for, learning and teaching primary school mathematics in the student teachers (Vale and Livy 2013). Vale and Livy further indicated that the student teachers should gain a deep conceptual mastery of the subject, particularly if they struggled to pass mathematics in lower levels. Conceptions that played out in relation to pedagogical practices were that the student teachers expected to gain mathematical content whilst at college, which would equip them with the knowledge and skills to teach primary school children for understanding.

Explaining her experiences during TP where she struggled to teach a concept about time, ST5 at College B uttered during her FFI: *"I once delivered a topic on time…. I struggled to make learners understand even".* There is on-going concern that college graduates are not adequately equipped with the content knowledge that they need for teaching and that their integration of professional experience and theory needs to be improved (Grossman, Hammerness and McDonald 2009). So, this inadequate content knowledge would make the student a slave of the textbook and one who applied traditional methods of teaching and learning mathematics (Lerman 1983; Dionne 1984; Toner and Grigutsch 1994). It looked like the student teacher conceived struggling to teach mathematics as an indication of a lack of content knowledge.

The students' conceptions that emerged in relation to the possession of content knowledge during pedagogical practices in mathematics were that lack of content could manifest in one struggling to teach, when one used a textbook and also took all examples from the book to teach. Use of a textbook, according to conceptions about mathematics, is a traditional strategy which lacks diversity and portrays rigidity in the teaching of mathematics by a teacher or lecturer (Petocz et al. 2007; Jankvist and Jensen2018). Therefore, content mastery was conceived as essential for effective pedagogical practices in mathematics. Another theme that emerged around lecturer classroom practice is discussed next, namely student motivation.

6.4 Student motivation

One aspect of the student teacher's conceptions of pedagogical practices that they mentioned was student motivation by lecturers. Motivation is generally understood as giving encouragement to someone. Gilbert (2012) defines motivation as an element that pushes us to do something. Motivation can be verbal or by action, and can be either intrinsic or extrinsic. Extrinsic motivation emerged as a sub-theme of motivation and it comes in two forms; the positive and negative.

In an FGD at College C, participant ST1 said: "*... I think the lecturer must motivate the students"*. Similarly, in an FGD at College B, participant ST4 indicated: "*... If they motivate us a lot during mathematics lectures so that we like the subject a lot"*. In an FFI at College D, another student, ST8 said: "*... The way they talk and explain mathematics, eeeh… can help motivate us to like the subject and also their strategies"*. From these responses the student teachers conceived that motivation was critical in mathematics learning during mathematics pedagogical practices. Motivating the student teachers who struggled to pass mathematics in pedagogical practices would help them develop their own intrinsic motivation and confidence and thus impact positively on their learning of mathematics in college (Albrecht 2018; Garn and Morin 2021).

When I asked L2 at College B in an FFI how he reacted to questions asked by students, he explained: *"I will take this positively and I will answer in such a way that it motivates students"*. L2 conceived being positive about students' questions and motivating them during pedagogical practices as important. This reflected confidence in the learners' capability and encouraged them to ask questions and express their views. The lecturer could also motivate students through facilitation of their learning; creating a good rapport so that they engaged more and were not ashamed of asking questions or giving wrong answers.

During the lecture observation of participant L2 at College B, while a relaxed atmosphere prevailed in the lecture room, which was conducive to mathematics learning, students were not invited to ask questions to afford them a motivational experience. An effective mathematics lecturer, apart from motivating students, should create a classroom environment which is not intimidating but in itself motivational. Motivating students is another way of scaffolding learning which encourages them to learn according to socio-constructivism (Vygotsky 1978; Amineh 2015; Han and Yin 2016). It would appear that both student teachers and lecturers conceived motivation as an important aspect of pedagogical practices in the teaching and learning of mathematics. Motivation during mathematics pedagogical practices were conceived in two forms; positive and negative motivation, and these are discussed below:

6.4.1 Positive motivation

Positive motivation emerged as an important aspect of pedagogical practices, as highlighted by many students. For example, in an FGD at College A student ST2 commented on motivation, saying:

> *… Well as a teacher you have to be a good teacher, not like one which the learners are afraid to ask anything. It won't help, especially in mathematics because most people tend to think mathematics is a tough subject. So as a teacher you have to put an effort of erasing that thought in the learners' mind by being nice to them, by creating a friendly environment for them so that they won't hate the subject, they will actually like the subject mathematics.*

The student teacher here raised a number of conceptions about pedagogical practices in mathematics. The student conceived that the lecturer should be approachable to facilitate and assist the learning of mathematics since most students thought mathematics was difficult (Dionne 1984; Toner and Grigutsch 1994). Accessible, approachable and accommodative lecturers build a conducive learning atmosphere for their students and this is vital in mathematics pedagogy (Chiang and Lee 2016). The student also conceived that the classroom should be free from emotional frustration and physical intimidation during mathematics pedagogical practices so that students could ask for assistance and engage more in their work, which was supported by

Han (2016). The lecturer would then not be conceived as authoritative but as a resource person of mathematical knowledge. On the other hand, students should feel free to ask questions in order to erase the conception that mathematics is difficult. The socio-constructivist perspective believes positive motivation locates the learner centrally to their learning (Kim 2001). According to literature (Barr 2016), if students are positively motivated they can review their work and see what they have mastered and what they still need to master.

Another student, ST9 at College C revealed during an FFI that: *"… If we are motivated and encouraged we manage to understand mathematics since we once struggled with the subject…".* This student teacher conceived that through motivation and encouragement in pedagogical practices, concepts would be better understood. From a constructivist perspective, positive motivation was crucial for these student teachers so that they progressed to their ZPD (Vygotsky 1978; Kim 2001; Williams 2017).

From the discussion above, these student teachers conceived positive motivation as a vital element of classroom practice and pedagogical practices in mathematics education as a whole. Negative motivation also emerged as another aspect of the lecturers' pedagogical practices, which is discussed next.

6.4.2 Negative motivation

Concomitant to positive motivation, negative motivation was noted as an element of the pedagogical practices in mathematics education in the teachers' colleges explored. Negative motivation, when applied, can produce either positive or negative results. Like positive motivation, this kind of motivation could be verbal or action, in this case towards the student teachers. Negative motivation emerged in an FGD at College D when participant ST3 said: *"... Openly told us that mathematics is not for everyone and it is a subject which needs logical thinking and therefore it's not easy. This therefore demoralised me".* As a result of this comment, this student teacher who had written mathematics several times may have gotten confirmation that mathematics was for a special calibre of student. It was therefore unsurprising that some student teachers' conceptions about pedagogical practices in mathematics were that this subject was for a select few. The statement that *'mathematics is not for everyone'* reflected the traditional conception about mathematics that the lecturer held. Such pedagogical practices in mathematics education were often very detrimental to the academic performance of students. In the literature by Bosman and Schulze (2018), students' conceptions about mathematics were that lecturers who created a demoralising learning environment by being moody, unsupportive, impatient and by not giving adequate explanations to questions affected their confidence and performance.

These conceptions about negative motivation portrayed above were confirmed by L2 at College B during a lecture observation. During this observation, a student teacher was invited to give an answer to a problem, which she did well. The lecturer then enquired about her major, which was English main subject. The lecturer further asked how this student had come up with the correct answer, given that she was not doing mathematics major. He further asked the particular student to join the Mathematics Department because she appeared to be smart, judging by the response she had given. The conception portrayed by the lecturer was that it was only those student teachers doing mathematics major (a select few, the gifted ones) who could give correct answers and not those studying any other subject majors. This form of negative motivation could further confirm the conception of some of the student teachers that mathematics was not for everyone, giving rise to a lack of effort. It would appear that the student teachers conceived this type of pedagogical practice with negative motivation as yielding no positive effect on the learning of mathematics. Student teachers also revealed conceptions related to handling students' responses during pedagogical practices in mathematics.

6.4.3 Handling of students' responses

Handling students' responses refers to the way in which a lecturer responds to the answers given by students in a lesson; in this case in a lecture where the lecturer engages student teachers in a question and answer session. Handling students' responses is important in all teaching and learning situations as this is motivational and particularly vital during mathematics pedagogical practices.

In a FFI at College A, student ST3 said: *"... He was taking care of the brilliant ones and any wrong answers would remain unexplained".* In an FGD at College B, ST6 added: *"... He just picks the next student to provide an answer".* At College D in an FGD another student, ST9 also indicated that: *"... Only caters for those who raised their hands and if you happen to give a wrong answer he would not explain and we would ask other students".*

The response reflected the lecturers' conception that mathematics pedagogical practices should focus on smart students and any wrong answer from weak students should not be explained. According to literature reviewed (Fleming and Roell 2018), if lecturers explain clearly, and if they are also responsive to questions and wrong answers, this provides support for auditory learning during mathematics pedagogical practices. From the student, brilliant meant smart, intelligent, brilliant, talented, clever, genius and gifted. The student conceived that mathematics was only taught to the selected few; the brilliant ones.

When I asked the lecturers how they reacted to students' wrong answers, L1 at College A replied during the FFI: "*I throw it back to the other students to help give a correct response".* The lecturer tried to engage students in dialogue in the classroom so that students got the correct answers from their knowledgeable peers, which was a socio-constructivist perspective of interactive learning (Dewey 1938; Kim 2001; Vercellotti 2018). By throwing the question back to the students the lecturer's conceptions were that students learned more by verbalising and answering questions, and from explanations given by their peers. In so doing the lecturer would also get to understand what all the other students knew or did not know.

L2 at College B said in an FFI: "*… I attend to the wrong answers, in a diplomatic way or in a way that does not destroy the spirit of the student*". Diplomacy, according to Soden (2017), is defined as a tactful way of handling a situation. In this case the situation was the wrong answer being provided. The lecturer conceived that diplomacy was vital in handling students' incorrect answers in mathematics pedagogical practices. The lecturer briefly acknowledged the response without spending much time on it and then moved on to offer the correct answer. Therefore, the lecturer conceived answering questions in a subtle way as important during pedagogical practices.

On the contrary, during a lecture observation of L2 at College B a student teacher's incorrect answer was not attended to. The lecturer just proceeded to call upon the next student teacher to give the correct answer. The lecturer's conception displayed by his reaction was that only students who gave correct answers would be tolerated. According to socio-constructivism, students should move with the whole class as they must and should always benefit during pedagogical practices (Dewey 1938; Vygotsky 1978; Kim 2001). The lecturer did not give the student support, thereby creating a classroom culture where the student would not feel a part of the group. Literature reviewed revealed that the classroom environment should be a learning arena where questioning and deep thinking are valued during pedagogical practices (Rathmann, Herke, Heilmann, Kinnunen, Rimpelä, Hurrelmann and Richter 2018). Mistakes should be conceived as tools for learning and all students should participate, contribute and learn from their own errors during mathematics pedagogical practices. Literature also revealed that providing an incorrect answer offered a platform for clarity of any misconceptions and students learned through interaction with their teacher and peers (Palmer 2018). In any learning situation students provide correct or wrong answers, and the lecturer is expected to acknowledge the wrong answer given and help the student to turn their wrong answer into a correct one. Making comments on any answers provides strong motivation, which encourages students to put their hands up next time Makhubele, Nkhoma and Luneta (2015). Errors displayed by learners in the learning of grade 11 geometry. Proceedings of ISTE International Conference on Mathematics, Science and Technology Education, 26-44 (2014), when contemplating wrong answers, propounded that they should not be left unexplained as wrong answers reflect misconceptions and how the students are thinking. Through scaffolding the lecturer should lead the student teacher to a better understanding, guiding them into seeing how and why their answer was wrong and through the process, making them see the correct answer and thus locating the student at the centre of their learning. The error should be highlighted and clear explanations and demonstrations provided, to acknowledge the student's effort and thereby cultivating interactions in the classroom, as propounded by the socio-constructivist theorists (Vygotsky 1978; Kim 2001). The lecturer needed to be aware that some students were strugglers, therefore leaving a wrong answer with no explanations would have a negative effect on such students' performance.

Another participant, L3 at College C, said the following during an FFI in relation to wrong answers: *"I ask or rephrase my question".* The lecturer conceived that the wrong answer could have been due to a misunderstanding, hence the need to repeat or rephrase the question for clarity. Rephrasing during mathematics pedagogical practices would make the questions simpler; make students understand the question in order to extract the correct answer. On the reaction to a wrong answer, participant L4 at College D gave this response during their FFI: "*I indicate areas where the answer went wrong, then request for answer from other learners".* L4's response revealed a conception during pedagogical practices that the 'wrong' part of the answer would be identified, and clear explanations provided to correct any misconceptions and enable learning. L4 initiated a dialogue by indicating the areas of concern and calling upon the other student teachers to provide the correct answer. Dialoguing became reciprocal and the student teachers interactively learnt mathematics from knowledgeable 'others' (the lecturer/peers).

From the students' responses, conceptions around handling responses during pedagogical practices were that only those who put their hands up were engaged. Concerning wrong responses, students in College B conceived that wrong answers were left unexplained and students resorting to asking their peers for assistance. Contrary to what the students said, all of the lecturers in the four colleges said that they attended to the students' responses. However this was not evident, even during the mathematics pedagogical practices in the lecture observations, which confirmed the students' responses. L1's conception was that in the case of wrong answers, he threw the questions back to other students to answer. L2 conceived that wrong answers should be treated with diplomacy, which contradicted what took place during the lecture observation when a wrong answer was ignored. L3 viewed rephrasing for clarity as vital, while L4 conceived problem identification followed by explanations as the panacea for handling students' wrong answers. The next section discusses mathematics pedagogical practices around classroom communication.

6.4.4 Classroom communication

Other student teachers' conceptions of pedagogical practices in mathematics education were related to communication. Communication in this study was about the exchange of mathematical information between the lecturer and the students and also among the students in the lecture room. Communication was therefore about conveying or transmitting ideas, facts or knowledge through talking, writing or signs (Hudson, Henderson and Hudson 2015). Language of instruction emerged as a conception about mathematics pedagogical practices and is discussed below.

6.4.5 Language of instruction

The language of the classroom instruction is the official language of teaching and learning. Agirdag and Vanlaar (2018) propound that language is undoubtedly one of the most important areas of curriculum delivery. Zimbabwe adopted a British curriculum upon independence and had previously used English as the official language of instruction (Zimbabwe Language Policy 2018). As such English maintained its position as the language of instruction to this day. The use of the home language was revealed by ST2 at College B when he said in an FFI: "*... Someone is explaining, they will make sure that you understand difficult concepts, maybe even in your mother language so it makes it easy*". In the same vein, ST3 at College C added: *"At times lecturers should use our local language to emphasise mathematics concepts".* Similarly, ST7 at College C said: *"At times it is necessary to use the mother language in the mathematics lecture".* The use of code-switching was also confirmed by all of the lecturers studied. For example, L1 at college A indicated during their FFI: "*Yes, mother tongue helps them understand, so we have to use it every time to explain concepts".* The use of local languages was also evident during the lecture observations for all of the lecturers studied across the colleges. Contrary to policy and the general understanding that English was the language of instruction, particularly at college level, the student teachers' conception about pedagogical practices in mathematics education was that mathematical concepts could also be explained in one's mother language to enhance understanding.

It would appear that student teachers in some of the colleges conceived pedagogical practices in mathematics education as enhanced by using home languages, while in others students conceived that the official language of instruction had to be upheld. However, while there was always a bias towards the mother tongue more commonly spoken in the community surrounding the colleges, the practice in these institutions was contrary to the Zimbabwean Language Policy (2018). Lecture observations confirmed the use of mother language in three colleges: A, B and C. It was generally expected that the language used during mathematics pedagogical practices became a catalyst for mathematical understanding, especially for the students who struggled to pass mathematics. The conceptions around classroom interactions which also emerged in relation to mathematics pedagogical practice are discussed in the next section.

6.5 Classroom interactions

Communication and interaction are discussed separately because interaction generally involves verbal exchanges, whereas communication can be one-sided. For any meaningful mathematics learning to take place, pedagogical practices should embrace active classroom interactions between student teachers and lecturers, and between student teachers themselves. Conceptions about pedagogical practices around interaction emerged in relation to lecturer-to-student interaction.

6.5.1 Lecturer-to-student interaction

Lecturer-to-student interaction emerged when the student teachers discussed the worst mathematics education lecture that they had attended in the college. The worst lecturer was conceived as one who dictated notes to students. This teaching strategy was mentioned by all of the students in the four colleges. For example, ST8 at College C explained in an FGD:

It was difficult for me to understand. The lecturer dictated the notes a bit faster. He didn't even finish dictating the notes and he ended up saying we should copy notes from other groups and research alone. It was very difficult for me because I was waiting for an explanation.

The conception about the pedagogical practices in mathematics education suggested by the student teacher's comments above was that interaction was ineffective in this mathematics education lecture. The student teacher conceived that taking down notes was difficult because of the dictation speed and the notes were not explained, defeating the purpose of student learning. Chances were that these notes were wrongly captured, resulting in distortions, particularly for these students who had struggled to pass O level mathematics. As alluded to earlier, dictation could cause problems in pronunciation and spelling, among other pitfalls.

Interaction was vital as it enhanced thinking and understanding. From the socio-constructivist perspective which emphasised process-based teaching as opposed to result-oriented teaching, effective interaction was viewed as a necessity during pedagogical practices (Vygotsky 1978; Toner and Grigutsch 1994; Kim 2001). In the situation described by ST8 above, interaction was not effective as the student could not understand due to the lecturer's dictation speed and unexplained notes. The process-based learning could only be achieved through appropriate communication of the mathematical knowledge. The student teacher conceived interaction as key in classroom practice, specifically in mathematics pedagogical practices. On the other hand, the lecturer's conception seemed to have been that dictation effectively imparted mathematical knowledge. The dictation of notes, which was mentioned earlier, appeared to have been popular across all of the colleges studied, notwithstanding its ineffectiveness due to the errors that could occur. Student teachers often ended up listening and writing just to keep pace, without processing the information for comprehension.

Another dimension of dictation was raised by ST2 at College B when he explained in a FFI:

… They will be dictating from their heads, maybe saying this is important, this is not important, you can write this, you cannot write this. If it's a prepared lecture you

should come maybe with a note book or a diary, an I-pad or a tablet, to say take your pens and write this down because its important. But if they say you can choose to write or not to write, then those lectures are not as prepared as we think they are.

The pre-service teacher's conceptions were that the lecturer dictated notes from memory as he had no written material of any kind during the mathematics pedagogical practices. From the above response it appeared that the learner was not appropriately exposed to effective mathematics learning during pedagogical practices. Where interaction did not yield positive results learning was not likely to have taken place, rendering the mathematics pedagogical practices ineffective. From the literature consulted (Sukarni and Ulfah 2015), interaction was not about talking, and was not merely social and communicative. Rather, it was a tool for learning, but this was not the case with the lecturers explored. The conception that emerged from the response above suggested an absence of lecture preparation and consequently interaction, and thus no effective learning during pedagogical practices.

Thus, the conception around lecturer-to-student interaction during pedagogical practices was that ineffective interaction by the lecturers during mathematics pedagogical practices hindered mathematics learning. Other dimensions of interaction that emerged related to student-to-lecturer and student-to-student interactions during pedagogical practices.

6.5.2 Student-to-lecturer interaction

With regard to student-to-lecturer interaction during pedagogical practices, during an FGD at College B, participant ST2 revealed student-to-lecturer interaction when he said: "*... At college participation by students during lectures is low".* Another participant, ST10 at College C, said during their FFI: "*We get into a lecture room and sit and listen to what the lecturer has to say".* When student teachers were encouraged to participate this implied an interactive learning atmosphere in the lecture room. Mathematics lecturers in their pedagogical practices could assist struggling students to begin building their confidence by encouraging them to speak out when they did not understand, welcoming their questions and by giving them clear answers. When a lecturer created room for interaction through active participation by students, encouraging comments and questions, this illustrated the centrality of students in mathematics learning which is advocated for by socio-constructivists (Dewey 1938; Vygotsky 1978; Kim 2001).

ST10 on the other hand indicated a lecture room scenario wherein they were conceived as passive recipients of mathematical knowledge and student-to-lecturer interaction was minimal. Though the conception revealed by ST2 and ST10 about the pedagogical practices in mathematics education was that student-to-lecturer interaction was critical for effective learning and classroom practice, active interaction was not evident in any of the lectures that I observed across the colleges and this confirmed the responses by ST2 and ST10. Another conception that was revealed related to student-to-student interaction.

6.5.3 Student-to-student interaction

Students have to interact amongst themselves and this is important as they can then speak at the same echelon and can understand each other better. However, in all of the lecture observations at the different colleges there was no evidence of student-to-student interaction. A little student-to-student interaction occurred when students cross-checked notes with their peers after lagging behind or missing something in the dictation. Confirming the absence of student-to-student interaction, ST7 at College B pointed out in their FFI:

> *I think they should use the child-centred methods whereby the lecturers bring in work and, select a few students, instruct them to go and research. The students then bring in feedback for presentation in a lecture, then the lecturer adds on top if some points have been left out during the presentation.*

The student's response reflected that she conceived that student teachers were treated as passive recipients of knowledge, but they (students) needed active engagement in their learning, through

collaborative research, presentations and feedback. While it is generally understood that knowledge discovery through research fosters deep learning and knowledge retention, literature surveyed (Ali 2019) indicates that this kind of discovery learning that involves students researching on a specific topic on their own may not ensure the discovery of all of the key information. Hence, this student teacher made mention of the lecturer adding to (*adds on top*) an aspect when necessary and thus expanding knowledge, scaffolding and getting the student teachers to their ZPD (Vygotsky 1978; Kim 2001).
Lack of student-to-student interaction was further confirmed by lecturer L4 at College D, who said: "*They talk to each other only when I give them time to refresh, especially when content seems challenging to them".* In this response the lecturer's conception about pedagogical practices indicated that the student-teacher interactions were not a planned learning activity, and were only allowed for limited periods. The response clearly suggested an absence of student-to-student interactions during mathematics pedagogical practices. According to Leon, Medina-Garrido and Núñez (2017), effective mathematics lecturers during pedagogical practices in mathematics education are expected to foster student-to-student engagement, treating teaching and learning as a collaborative process, showing their students that their thoughts and opinions are valuable to each other and to the lecturer. Pedagogical practices that planned for student-to-student interaction could be good encouragement for students working with their peers and their lecturer, to develop their understanding of mathematics education. However, the conception about pedagogical practices in mathematics education displayed located student-to-student interaction as a non-important aspect, which pointed to a traditionalist conception.

Student-to-student interaction was also excluded by L1 at College A, who said: *"... Very rare, very rare, it's mostly lectures; the lectures are mostly lecturer focused".* From what the lecturer said, the conception about pedagogical practices in mathematics education was that interaction should be a one-way process from the lecturer to the students using the lecture method. This was contrary to the understanding that effective mathematics lecturers created busy, 'noisy' lecture rooms where they made their students talk to each other and learn mathematics together. But here the lecturer acted as the source of knowledge, displaying a traditionalist conception about mathematics. The evident lack of student-to-student interaction in the pedagogical practices in mathematics education contradicted the constructivist perspective which foregrounds collaborative learning in the lecturer's facilitative role (Dewey 1938; Vygotsky 1978; Toner and Grigutsch 1994; Kim 2001).

L2 at College B also responded: "*Yaa, I will give them some work to do, say in a group task".* The conception implied by this response was that student teachers interacted through group discussions. However, during the observation of this lecturer's lecture, while there was interaction (lecturer-students) through a brief question and answer session where L2 asked questions, no group tasks were given. The lecturer's conception about their pedagogical practice was seemingly that student- to-student interaction through engagement in cooperative learning was not important. Another participant, L3 at College C, also said: *"If I pose a question, I allow them to share ideas with friends and give feedback*". From L3's response, his conception was that during mathematics pedagogical practices student interaction was vital for sharing ideas. However, when I observed the lecture by L3, the only form of interaction evident was lecturer-to-student interaction which, as with L2 at College B was by means of a question and answer session.

From the discussion above, the lecturers across all of the colleges reflected conceptions that did not suggest student-to -student interaction. While L2 and L3 understood that student-to -student interaction was vital, they did not demonstrate that during their observed lectures. Student-to -student interaction was reported as non-existent in College D, where L4 conceived that students only needed to interact during relaxing breaks. These conceptions contradicted the constructivist perspective which advocated for collaborative learning.

During the mathematics pedagogical practices, student-to-lecturer interaction and student-to-student interactions were not evident, as revealed by the student teachers in Colleges B and C during their interviews when they indicated the non-existence of such interactions. Absence of these two types of interactions was also conspicuous during the lecture observations. The only forms of interaction in Colleges B and C were through lecturers either asking questions or dictating notes, thereby portraying the conception that the lecturer was the 'knower' while the students assumed a 'knowee' position.

Considering that student-to-student interaction forms an aspect of teaching for understanding, this is discussed in the next section.

6.6 Teaching for understanding

The data also revealed student teachers' conceptions as including teaching for understanding, which they regarded as the goal of all pedagogical practices in mathematics education. Teaching for understanding refers to teaching for comprehension of mathematical concepts so that they are retained in the student teacher's memory. According to the socio-constructivist perspective and conceptions about mathematics, teaching mathematics for understanding reduces memorisation and makes mathematics applicable in life (Skemp 1978; Dionne 1984; Toner and Grigutsch 1994). The student teachers made references to teaching for understanding during their lecturers' pedagogical practices in mathematics education when I asked whether they were going to teach in the way that they were being taught. One participant, ST5 at College A, said in an FFI: "*I want to be the best teacher, so I will teach for understanding".* From this response, the student teacher's conception about pedagogical practices in mathematics education was that a good teacher taught for understanding. Ideally effective teachers always teach for understanding and not only for passing examinations. Mathematical education with understanding should involve the active use of knowledge and skills which will be put into practice, unlike rote learning which breaches this perspective (Pepin 2017). Understanding goes beyond knowing since it is a long term, think-centred process and the knowledge gained should not be confined to the narrow circumstance of its initial acquisition (Trouche 2019). The students conceived that understanding mathematics involved teaching in such a way that mathematics knowledge learnt could be transferred from one context to another.

In an FGD, ST6 at College D posited that:

> *Teaching of mathematics at college should be such that lecturers are open to students when they deliver lectures, and they should go deep so that we can understand mathematics concepts.*

The student teacher implied that conceptions about mathematics pedagogical practices should promote the deep understanding of mathematics concepts. 'Deep' here suggested that the lecturer should explain all concepts starting with the basics for students to get an in-depth mastery of the concepts, hence engaging students in learning for understanding. In an FGD, ST9 at College B postulated that: *"Mathematics learning should be learning with understanding. That is how it should be taught at college".* Further to this, ST1 at College D also responded during their FFI: "*I think it is a good thing. Others may understand mathematics concepts when they hear the things in group".* While ST9 conceived that effective mathematics learning needed comprehension during mathematics pedagogical practices, ST1 conceived learning for understanding as being enhanced by group work learning with peers. In this regard, ST10 at College B also added during an FGD: "... *They should take us step-by-step at every concept where students seem to have challenges. I think that will be very good for us to understand".* The student conceived pedagogical practices in mathematics education as involving performance where a lecturer taught students slowly, especially those with challenges, so that they could understand the mathematics concepts.

In the same vein, ST9 at College B said in their FFI:

> *One thing that our lecturers should do is to ask whether we have understood, though maybe some might remain quiet. But we should be given that opportunity to ask, so that we don't proceed to the next step without understanding.*

From the response above the student teacher's conception about pedagogical practices in mathematics education revolved around teaching for understanding. Learning mathematics at an in-depth level during pedagogical practices implied that the student needed to understand the mathematical knowledge and develop skills so that they could retain them for later use. Traditional lessons often lacked teaching for conceptual understanding and the learners would only get a surface understanding of mathematics and not obtain a deep mastery of the subject (Bonsaken 2018), as propounded by ST5 at College A. This constructivist conception about mathematics confirmed the application of mathematics in real life (Dionne 1984; Toner and

Grigutsch 1994). This has also been confirmed by the constructivists who advocate for teaching for understanding, with their emphasis on the process as opposed to the end product.

When I asked lecturers what strategies they used to ensure understanding, L2 at College B said: "*I make sure I give them questions to go and work on after say, covering the aspect or concept, and ask them to find more information on the work taught".* L4 at College D explained: "… *Simple lecturing is used to enhance understanding for those who can".* L2 conceived that students' take-home tasks based on the previous lecture seemingly enhanced their concept mastery and enabled the lecturer's assessment of the students' understanding. The response by L4 reflected selective conceptions as the lecturer mentioned those *"who can"*. In other words, the lecturer conceived that those who could benefit and gain a deeper understanding of mathematics from his pedagogical practices would benefit, but others would not. Such a conception was exclusive, as it overlooked the students' diversity. This was contrary to the socio-constructivists who were all-embracing of students' diversity in knowledge construction. This lecturer's conceptions were thus aligned to traditionalist conceptions (Toner and Grigutsch 1994; Hudson, Henderson and Hudson 2015).

The students conceived that in mathematical pedagogical practices, effective teachers taught for understanding. They also conceived that their lecturers should teach mathematics concepts for understanding and retention through student engagement in cooperative work. L2, however, conceived that teaching for understanding mathematics involved further questioning and research by the students. Concomitant to this, L4 conceived that simple lecturing fostered the understanding of only some of the students, thereby implying exclusion during pedagogical practices and the belief that not all of the students were capable of understanding mathematics. Conceptions about mathematics pedagogical practices also emerged around teacher quality.

6.6.1 Teacher quality

Teacher quality is generally regarded as the most important school-related factor influencing student achievement, hence it is an important aspect of pedagogical practices in mathematics

education. Qualities of an effective teacher include: possession of content knowledge, pedagogical knowledge, classroom management and instructional skills, resourcefulness, compassion, determination, punctuality and knowledge of the theories of learning and child development (Sirait 2016). The conceptions about pedagogical practices in mathematics education that emerged around teacher quality in this study included patience, caring and friendliness. These are discussed below.
Teacher quality was revealed by ST8 in an FFI at College B:

> *Mathematics is just a difficult subject, so if you don't have patience you won't tolerate people. You won't tolerate your learners and you won't move with the pace of their abilities, so I think… I just think mathematics should be taught by someone with a lot of patience and then number two, someone who has got a motherly or a fatherly heart….*

This student teacher conceived that the most important quality of a mathematics lecturer was patience, and without this quality a classroom practitioner would not be able to handle the learners' diverse intellectual abilities. A patient lecturer would be accommodative and able to address the mathematical challenges faced by those students who struggled to pass mathematics, without getting annoyed. They would take the time to clarify any misconceptions held by the students. Another quality conceived by the student related to the tolerance displayed by a willingness to help students, and scaffolding their learning for them to reach their ZPD (Vygotsky 1978; Kim 2001; Ochagavia 2017). This kind of lecturer would assume a parental role (*loco parentis*) for the student. The *loco parentis* role would call on the lecturer to respond to the personal and emotional needs of their students while in contact with them in the absence of their family. The lecturer also had to be able to demonstrate the ability to develop a supportive and empowering environment for their students and respond to their educational needs. Students exposed to such a harmonious, adaptive, and non-intimidatory environment would learn freely for understanding during their pedagogical practices.

Teacher quality was also reflected in an FGD at College C, when student ST9 pointed out:

"*Lecturers should care for everyone… they should have patience, and also encourage us to work hard and to be patient"*. The response by ST9 reflected their conceptions about the qualities of an effective mathematics lecturer. The conceptions reflected above and the attributes mentioned cushioned the students in their learning. Being caring and encouraging would involve treating all of the students the same, with no favourites, viewing each student as capable and therefore scaffolding their mathematics learning during pedagogical practices.

Another student, ST1 at College D said during an FGD: *"Mathematics is a difficult subject therefore our lecturers should be approachable, creative to help us who struggle"*. The student's response indicated that students would benefit from a lecturer who was approachable, especially these students who had passed the subject after a struggle. The students would then use this quality to approach the lecturer and ask any questions, thus creating room for communication during mathematics pedagogical practices. The student also conceived that by being creative the lecturer would make learning more effective, exciting and interesting during mathematics education lectures. Student teachers therefore conceived that mathematics pedagogical practices required lecturers with qualities such as patience, being a source of encouragement, caring, tolerance, creativity, approachability and the ability to handle diversity. Research, which emerged as a third theme in addressing Question One, is discussed below.

6.6.2 Research

Research generally refers to an organised way of finding solutions to problems. The constructivist perspective believes that reality is drawn from a human inquiry; therefore, by engaging these student teachers in research the lecturers adopted a constructivist approach to learning mathematics (Boylan 2019). The aspect of research was mentioned by all students across all the research sites, for example student ST10 at College C said the following in an FGD: *"I think it's only about what we do, and then we have to research and work hard"*. Like ST10, conceptions related to research and hard work also came up at College A where student ST1 said in their FFI: *"I think mathematics is not a difficult subject. To my experience* *mathematics just needs you to work hard and you need to research more how you can work out and come out with the answer".* Similar sentiments that related to research also emerged in an FFI at College D, where ST2 said: "… *Lecturers should read widely and research so that they give their learners different approaches of solving a problem".* Another student, ST8 at College B suggested in their FFI: "… *Should give us work to go and research on whatever they want to deliver, then the students before the lecture starts, they are the ones to share with the class what they have prepared".*

Student teacher ST10 conceived mathematics pedagogical practices as involving research and hard work to gain mathematical knowledge. The hard work that the student referred to encompassed: effort, diligence, industriousness, self-drive, planning and sacrifices that they made to gain mathematics knowledge. The student conceived that though they had struggled with mathematics, through hard work they would be assured of good progress and getting a better understanding of the mathematics concepts. Research would enhance new knowledge acquisition and mastery of the mathematical concepts.

In addition, regarding research ST2 at College D raised conceptions related to lecturers' wide reading and students' exposure to different mathematics problem solving approaches as vital in mathematics pedagogical practices. Through wide reading these lecturers would then model inquiry-based learning and exploration for their students, prompting them to develop engagement and a deep understanding of mathematics concepts. With such pedagogical practices the primary goal of efficient mathematical teaching related to mathematical knowledge transfer could be achieved. ST8 at College B brought another dimension related to students' collaborative research and presentation. The student teacher's conception was that students should research and present on allocated topics during mathematics pedagogical practices. Collaborative research with peer discussion provides for knowledge retention. Presentations would thus offer learning space for both lecturers and students. Teachers studied by Mukeredzi (2009) confirmed that they acquired new ideas from their students' researched presentations.

From the responses above, conceptions related to research within pedagogical practices in mathematics education were expressed by students across all colleges. Research is valuable, not only for students to construct their own knowledge but also for developing learning independence and memory retention. Bruhwiler and Vogt (2020) indicates that research has a positive impact on students' learning by actively engaging them in doing mathematics and helping them to solve challenging problems. Thus, research gives rise to the active construction of knowledge. The collaborative research highlighted by ST8 at College B was central to constructivist theory. Socio-constructivists emphasise that learners make meaning in interaction with each other and with the context they live in (Lambert 2018). This makes knowledge socially and culturally constructed. In other words, the learning process does not just take place in a person's mind, nor is it a passive development of behaviours; rather it is shaped by external forces and occurs meaningfully through engagement in social activities and is then appropriated by individuals (Mukeredzi 2013). The lecturer would thus then assume the socio-constructivist facilitative role. This pedagogical practice which involves research often cultivates student-to-student and lecturer-to-student interaction which have been alluded to earlier. The student teachers conceived mathematics pedagogical practices as requiring students' research-based activities to promote their understanding of mathematics concepts. Reality according to socio-constructivism is a product of the human mind (Dewey 1938; Vygotsky1984; Kim 2001), therefore through research new mathematical knowledge would be created and attained by the students.

Lecturers also made references to research. This was reflected by L1 at College A, who revealed: *"Aaah, I can say… since they are adults I ask them to look for information on their own"*. Similarly, L3 at College C also said: *"I use no strategies except to ask them to research further"*. L4 at College D also said: *"… Ask them to look for sources in the library*".

The conceptions about mathematics pedagogical practices by L1 at College A were that student teachers were mature enough to search for information on their own, given that reality was a product of their own creation; each individual saw and interpreted the world and their experiences through their own personal belief systems. In other words, research located students centrally to construct their own meaning and understanding. While all the lecturers explored generally portrayed traditionalist conceptions about pedagogical practices in mathematics education, L1's conceptions about student teachers constructing their own knowledge reflected alignment with constructivism (Vygotsky 1978; Toner and Grigutsch 1994).

The learning context (the library) was central to the learning itself (Kim 2001; Schoenfeld 2016). As such, the learning context had to be designed to support and challenge the students' thinking. The critical goal here was to support the student teachers in becoming effective thinkers and practitioners who would be able to search for information on their own. This was, given that student teachers were not passive knowledge recipients but instead active players in the construction of their mathematics knowledge. L1 at College A and L3 at College C had similar conceptions about promoting students' engagement through research in the library. Literature reviewed (Arifin, Wahyudin and Herman 2020) indicates that research supports student learning, and promotes independent reading and individual exploration of mathematics knowledge.

From the responses above both student teachers and lecturers across the colleges generally conceived research as a vital aspect of mathematics pedagogical practices, given that it made both student teachers and lecturers more knowledgeable. Lecturers conceived it as a vital aspect of mathematics pedagogical practices as students could construct their own reality and minimise their dependence on their lecturers (Kim 2001; du Plessis 2013).

6.7 Chapter summary

The chapter analysed and discussed the findings around the student teachers' conceptions about pedagogical practices in mathematics education. The three major themes that emerged were conceptions about learning mathematics, conceptions about lecturers' classroom practices and conceptions about research. Regarding the conceptions about learning mathematics, all except two of the student teachers held strong traditionalist conceptions about mathematics, where the subject was conceived as detached from daily life and learnt through rote approaches to pass assessments. Other traditionalist conceptions regarding the subject were that it was a difficult subject where the answer was more important than the method. Thus, these students studied conceived the product and not the process of solving a mathematical problem as more vital. These participants also conceived mathematics as meant for a 'selected few', the gifted students who could understand the subject. All of these traditionalist conceptions of learning mathematics were also confirmed by all of the lecturers studied across the colleges.

Conceptions related to the lecturers' classroom practices were discussed by examining seven distinct aspects: teaching strategies; possession of content; motivation; handling students' responses; classroom communication and interaction; teaching for understanding; and teacher quality. Firstly, findings indicated that all student teachers explored conceived that teaching strategies like demonstrations, punctuated by clear explanations, and ample practice working out mathematics problems were vital for the effective acquisition of mathematical concepts. The findings also revealed that student teachers conceived cooperative learning as a vital teaching strategy during mathematics pedagogical practices. Further, other conceptions that were revealed related to teaching techniques and students conceived interactive teaching, student centrality, scaffolding and remediation of learning as critical for the mastery of mathematical knowledge in mathematics pedagogical practices. However, two students in Colleges A and B conceived cooperative learning as a waste of time and a deterrent to syllabus completion.

The findings also suggested that lecturers studied across all of the colleges conceived the lecture method as the ideal method of instruction during mathematics pedagogical practices, where they just dictated notes. Conversely, the conceptions of the student teachers studied were that this teaching strategy which centred on the dictation of notes was inappropriate for effective learning of mathematics. To add on, student teachers' conceptions were also that any mathematics misconceptions needed to be cleared before new knowledge was introduced. In addition, regarding practicing and working out of mathematical problems, students studied at Colleges A and C conceived a correct answer as more important than the method used to arrive at the answer, while the conceptions of those at College B and College D were that a correct method was more important. A few of the participants from these two colleges conceived that both method and answer were important.

The findings further suggested that the student teachers studied conceived that their lecturers' handling of their learning diversity was pivotal in mathematics pedagogical practices, given that many of the students had struggled to pass O level mathematics. Contrarily, the lecturers investigated across all of the colleges overlooked the students' diversity, viewing them all as being at the same cognitive level as they had all passed O level mathematics. This was notwithstanding their number of attempts to pass the O level mathematics examination.

Further, the majority of the student teachers and the lecturers explored across all of the colleges conceived that the use of their home language to enhance conceptual understanding was necessary during pedagogical practices in mathematics education. However, some of the students conceived that only the colleges' official language was to be used during pedagogical practices. Use of the official language of English during pedagogical practices would help all of the students, given the language diversity in some of the colleges. The use of code-switching also negated the fact that lecturers were expected to cater for learners' diversity, and were supposed to adopt inclusive language and pedagogical practices that catered for all of the students. Remediation was also conceived as vital, given that the lecturer in all learning situations was expected to act as collaborator and coach, where he or she provided scaffolding to drive students to their ZPD.

Secondly, with regard to the possession of content, all students studied conceived that they needed more mathematical content coverage than pedagogy to reduce their over reliance on mathematics textbooks in their teaching subsequent to graduation. One student at College B confirmed that a lack of content was detrimental during lesson delivery, drawing on her experiences of struggling to teach the concept of 'time' during TP. During the lecture observations in all four colleges, all of the lectures were on mathematics pedagogies.

Third, in relation to motivation, the student teachers studied in three colleges (B, C and D) conceived this as a vital classroom practice in mathematics pedagogical practices. Students conceived a good classroom environment as one that promoted positive motivation in pedagogical practices. Negative motivation also emerged at College B, where the lecturer did not expect the correct answers from students who were not mathematics majors, openly telling these non-mathematics majors that mathematics was only for a selected few. The students conceived that this negative motivation hindered their learning of mathematics during pedagogical practices.

All of the students studied conceived that all incorrect answers needed clear explanations so that they could correct their misconceptions. This was confirmed by the lecturers investigated across the four colleges who said that in the event of an incorrect answer they would rephrase a question, throw the question back to all of the students for them to answer it, analyse a misconception to get an accurate solution, or give the correct answer to the students. However, all of this contradicted the students' conceptions, particularly in Colleges A, D and C and also my lecture observations where the students' incorrect answers were ignored.

A fifth conception related to communication and interaction, where the students studied conceived that the lecturers explored across all of the colleges engaged in rushed dictation, making it difficult for students to understand during pedagogical practices. It also emerged that apart from these dictations, only brief lecturer-to-student questions offered interaction, as there was neither student-to-student nor student-to-lecturer interaction. Students conceived these interactions as critical for their effective learning during pedagogical practices. Lecturer L4 at College D only enabled informal student-to-student interaction during short breaks.

Sixth, all of the student teachers explored across all of the colleges conceived teaching for understanding as another vital aspect during mathematics pedagogical practices, as this yielded conceptual mastery and enabled relating knowledge gained to related higher order concepts. Unfortunately, the students explored did not experience any teaching for understanding, given the dominance of the lecture method. Notwithstanding the students' conceptions, some lecturers studied conceived the lecture method as effective for understanding mathematics.

Finally, regarding teacher quality, all of the students explored conceived good lecturer attributes as: patience to handle diversity; innovativeness and creativity; being friendly and approachable; being accommodative and accessible; and the ability to assume a parental role for students during mathematics pedagogical practices. However, these attributes were not experienced by any of the students. Research, one of the major themes that emerged from the study, was conceived by both the student teachers and the lecturers in this study as vital for understanding mathematics as it afforded opportunities for individually gaining, augmenting and understanding conceptual knowledge in mathematics pedagogical practices.

Having analysed and presented the findings around the student teachers' conceptions of pedagogical practices in mathematics education, in the next chapter I present and discuss the findings that address the second research question about the students' experiences.

CHAPTER 7

DATA PRESENTATION AND ANALYSIS: STUDENT TEACHER EXPERIENCES OF PEDAGOGICAL PRACTICES IN MATHEMATICS EDUCATION

7.1 Introduction

The previous chapter presented the analysis of the data for the first research question of this study - how the student teachers conceived pedagogical practices in mathematics education. In answer to this question, the conceptions that emerged about the pedagogical practices in mathematics were generally traditionalist, related to learning mathematics, lecturer classroom practice and research.

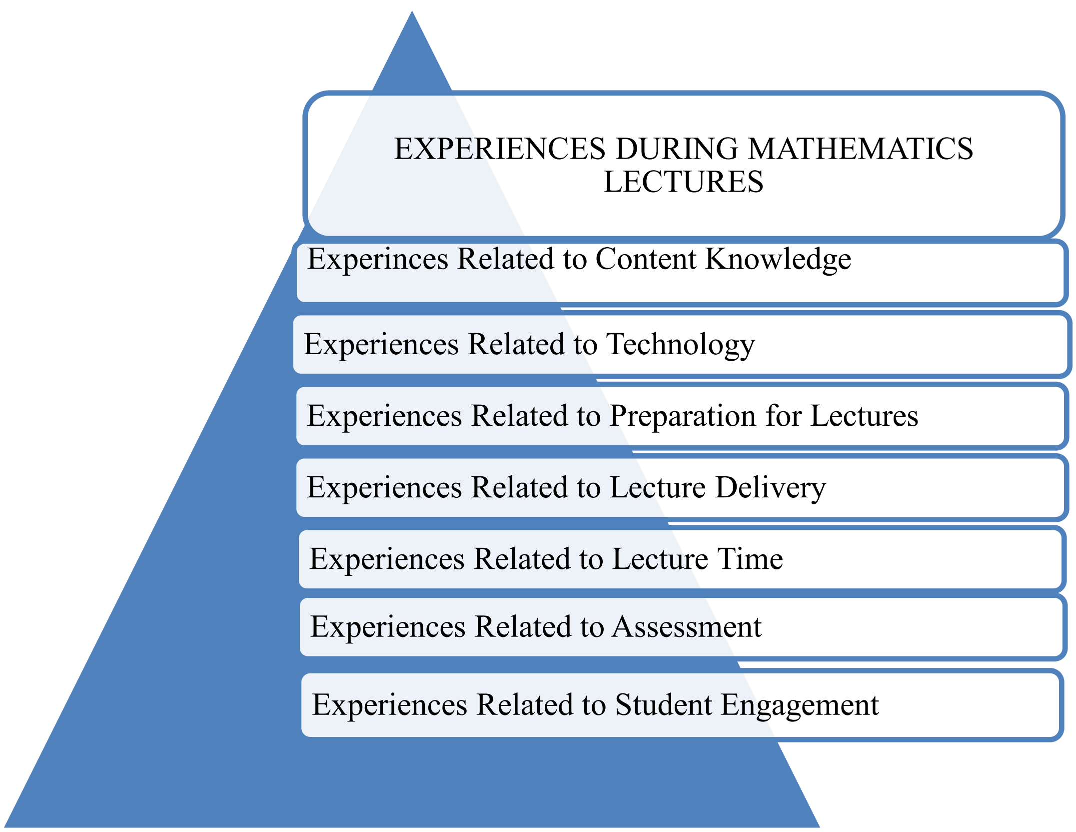
This chapter presents the analysis of the data for the second research question; the second of the three data presentation and analysis chapters. The data addressing this question was generated across all of the research sites using three data generation instruments; focus group discussions, individual interviews and lecture observations. This chapter addresses the question: *What are the student teachers' experiences during pedagogical practices in mathematics education?*

Surveyed literature (Mukeredzi 2009) reveals that experience is a process of doing, which does not necessarily require a teacher, but is a personal encounter, application and engagement in an action. It is the student teachers' personal encounters and engagements during mathematics pedagogical practices that are discussed in this chapter. In presenting and discussing the findings, data is aggregated and pooled across all of the participants and the data sources as the responses were generally similar. From the participants' responses, one major theme that emerged related to their experiences during the mathematics lectures. From this theme, seven sub-themes were also identified. The major theme is discussed using these subthemes. This chapter is therefore organised around this theme and the subthemes.

7.2 Experiences during mathematics lectures

Lecturer and student relationships are important aspects of lecture practice as their interactions lead to successful student learning. Therefore, experiences during lectures are what both lecturer and students go through during the teaching and learning process. In this context, the experiences during pedagogical practices were the experiences of the student teachers in the lecture room and in the context of this study, those students who had struggled to pass mathematics at O level. The sub-themes that emerged under experiences during lectures related to: content knowledge, technology, preparation for lectures, lecture delivery, lecture time, assessment and student engagement. The theme – the experiences during mathematics lectures and its subthemes are reflected in Figure 7.1 below.

Figure 7.1: Experiences of pedagogical practices in mathematics education related to mathematics lectures



Source: Researcher (2021)

7.2.1 Experiences related to learning content knowledge

As reflected in the previous chapter, content knowledge is the subject matter that students should learn and what the lecturer should teach in mathematics education. In this case, on one hand mathematical knowledge was what the lecturers needed to know to enable them to teach student teachers, and on the other hand, it was the knowledge that the students needed to learn in mathematics (Dreher, Lindmeier, Heinze and Niemand 2018). During Professional Studies Mathematics Syllabus B (Mathematics PSB) which is specifically a methods course, students were exposed to the teaching of mathematics (methods) and what to teach (mathematics content). Student teachers also learned content-specific pedagogy that addressed how the teacher was supposed to teach, particular content, management, motivation, planning, scheming, assessment, and handling the diverse needs of students (Mukeredzi 2013). This type of knowledge is referred to as pedagogical content knowledge (Shulman 1987; Grieser and Hendricks 2018). Furthermore, Shulman (1987) propounds that pedagogical content knowledge (PCK) is the integration of content and pedagogical knowledge. In this study content knowledge came up as students described their experiences regarding their feelings towards their preparation for primary school teaching of mathematics.

In an FGD at College D, participant ST3 said: *"… We did not deal with mathematics content in-depth so that we can be confident to teach the primary school child".* From this response the student teacher did not experience adequate exposure to mathematical content during mathematics pedagogical practice to develop the confidence to teach primary school mathematics. This experience contradicted Can (2019) who indicated that a successful mathematics teacher is one who has extensive knowledge of mathematics content. This was not the case in this college, as reflected by ST3 above.
Again, in an FGD at College A, another student ST6 revealed:

> *In college there is not much mathematics, it's more about how to teach mathematics but they are not giving us the real concepts of which I think they have to go back to each topic covered in Primary, discussing every concept. They are mainly focusing*

> *on how to plan, how to scheme and teach, and they are not concentrating on the mathematics concepts that were difficult for us. That is all I can say.*

From the quote the student teacher gained pedagogical knowledge during mathematics pedagogical practices but not much mathematics content. The student teacher, like all of the other students in this study, expected to gain more content knowledge which covered all of the areas in the primary school mathematics syllabus and not only the methods of teaching in the primary school classroom. According to Shulman (1987), adequate content knowledge leads to high quality instruction. Literature consulted also indicates that student teachers do not develop adequate expertise in content knowledge during training to enable them to teach for conceptual understanding (Nilsson and Karlsson 2019; Toropova, Johansson and Myrberg 2019). Such a situation would impact negatively on their performance as teachers and the learners that they taught. The experiences of students in my study seemed to be in line with what literature indicated; that students were exposed to mathematics pedagogies at the expense of mathematical content knowledge during their mathematics pedagogical practices (Nilsson and Karlsson 2019).

In an FGD at College B, the issue of content knowledge was also raised by student ST9 who said: *"I expected not only to learn how to scheme, plan, but also to learn more of mathematical content…".* The response reflected that students' experiences in pedagogical practices in mathematics education apparently did not meet their expectations and needs regarding the learning of mathematical content; instead students were exposed more to pedagogy. Hill and Chin (2018) concurred with this student teacher on the need to have adequate content knowledge when he said: teachers with a greater understanding of content asked higher order questions, whereas teachers who did not know the material tended to dominate the classroom discussions. The aspect of domination is a traditionalistic approach of lesson execution, according to conceptions about mathematics (Lerman 1983; Ernest 1991; Torner and Grigutsch 1994) and often reflects a lack of content knowledge. According to Skemp (1978), lack of content knowledge leads to instrumental teaching which gives learners temporary success, thereby leading learners to memorising mathematical facts.

In an FFI at College C, another participant ST1 revealed that: *"I have experienced less work on mathematics content, considering that we struggled to pass mathematics. Mathematics content, therefore, needs beefing up so that when we go for TP we teach what we know"*. From the response the student teacher experienced less learning of mathematics content during mathematics pedagogical practices, contrary to their expectations and desires given their struggles to pass O level mathematics. From the perspective of this student, their content knowledge needed to be strengthened and made more effective, probably by giving them more practice, more support, and more scaffolding.

From the comments above, all of the student teachers across all of the colleges studied experienced adequate learning of methods, but not of mathematical content during their pedagogical practices. This was confirmed in the lectures observed where all of the colleges were teaching pedagogy. When the teacher has a strong base of content knowledge (Shulman 1987) he/she does not continually hold onto the textbook, or check the answer from an answer book (Grieser and Hendricks 2018). According to Stacy, Guarino and Wooldridge (2018), lack or abundance of content knowledge (mathematical knowledge) is contagious and can easily be transmitted to the students.

Given that some of these student teachers struggled to pass mathematics, they expected to experience more mathematical content to become effective teachers who would confidently teach the primary school child. Possession of content would also help them move from the traditionalistic teaching of dominating during lesson execution (Skemp 1978; Hudson, Rivera and Grady 2015) to constructivist teaching approaches. The experiences highlighted by the student teachers above that there was limited exposure to content knowledge are aligned to surveyed literature (Howells 2012) which indicates that the curriculum for teacher preparation covers more about teaching methods than the content knowledge of the subjects to be taught. The next section discusses the experiences related to technology.

7.2.2 Experiences related to technology

From both students and lecturers, the issue of technology emerged as another area which offered students some experiences during mathematics pedagogical practices. Literature revealed that technology is the use of scientific knowledge for practical purposes or applications, whether in industry or in our everyday lives (Harrell and Bynum 2018). Technology can also be used to accomplish various tasks in the classroom, thereby producing effective learning environments. According to Higgins, Huscroft-D'Angelo and Crawford (2019), using technological tools and equipment in mathematics education offers great assistance in teaching and learning in order to obtain good results. Technology has challenged traditional lecture rooms by promoting individual learning where students discover content on their own, as propounded by the socio-constructivists and constructivist conceptions about mathematics (Dewey 1938; Torner and Grigutsch 1994; Kim 2001).

Student teachers made references to experiencing technology related to the use of the Internet. For example, in an FFI at College A, ST10 revealed: *"… We are told to use the library and the Internet to make personal notes…".* This participant experienced mathematics pedagogical practices where they were referred to the library and the Internet for additional information. The use of the Internet plays a key role in any learning situation, since learning cannot all be accomplished in the classroom. It was therefore necessary for these students to visit websites to research and find additional or new knowledge to plug any of their learning gaps and to clear up any misconceptions and doubts which would probably have emanated from the pedagogical practices. Technology thus promoted individual learning and provided students the opportunity to experience and initiate searches independently, which is supported by the constructivist perspective where the learner takes responsibility for their learning. Also, ST8 at College A in an FFI said: "*Our college timetable is packed. We do not have time to go into the library, but we use the Internet where we research in our spare time".* This participant's response implied that though the college timetable did not have free periods for them to work in the library, they used the Internet for research as Internet facilities were available during other times outside lectures.

Thus, they utilised their free time effectively by undertaking self-directed learning activities to gain mathematical knowledge. In an FFI at College D, ST2 also responded: "*I think I am geared to teach mathematics, since at college I was taught how to make teaching notes using textbooks and technology".* ST2 revealed that she was now ready to teach primary school mathematics, given her exposure to textbooks and technology.

However, ST6 in an FGD at College B responded: "*During learning I will face difficulties because of lack of Internet and technology at this college",* and ST10 in an FGD at College C made similar sentiments when he said: *"We do not have the Internet to look for notes".* These responses indicated that the students were not well supported with regards to technological facilities. This was likely to have been detrimental to their academic performance considering these students had struggled to pass mathematics. Thus, the students did not experience technology dependent research and most probably produced assignments that lacked depth. This lack of technological experience hindered the constructivist aspect of student teacher learning through discovery (Vygotsky 1978; Hegedus, Dalton and Tapper 2015).

Lecturers also revealed how student teachers experienced technology during mathematics pedagogical practices. In an FFI, L1 at College A said: "*Maybe technology… we just use overhead projectors or slides and the like. That's the main thing that we use".* L2 at College B also responded: *"I mainly use notes, hard copies on PowerPoint otherwise … it will be a lecture, students taking down notes. Yeah, it will be students taking notes".* The lecturer (L1) declared that he used Power Point during pedagogical practices, as such, the students in College A experienced the use of overhead projectors or PowerPoint slides during their pedagogical practices in mathematics education. PowerPoint slides are often an effective and convenient way of teaching in mathematics pedagogical practices as students can see the work and listen to the pronunciation of the terms. The presentation often presents neatly typed notes and the lecturer can deliver more information as compared to the traditional lecture method. A well-prepared PowerPoint presentation could have systematic, precise mathematical content which would enhance accurate mathematical comprehension. Literature reviewed indicates that technology strengthens mathematics pedagogy, which increases student motivation and interest (Hegedus

2017). While L1 reported using PowerPoint technology, this was contrary to the lecture observation that I made where I did not see the use of any kind of technology. L2 at College B also pointed out that he used hard copy PowerPoint notes in his mathematics pedagogical practices, however during the lecture observation he used handwritten notes. Infusing technology in pedagogical practices in mathematics education often minimises the memorisation of formulae and mathematical rules. In this regard, student teachers may experience a paradigm shift from traditional conceptions to a hands-on approach to learning mathematics.

Lecturers in their FFIs also indicated how these students experienced technology during their pedagogical practices, for example L4 at College D said: "*I prepare typed notes and produce both hard and soft copies for students".* This response by L4 reflected that the student teachers experienced lectures which had been prepared with the use of technology during their pedagogical practices. Often it was the lecturers who, concerned about their effectiveness in lecture delivery, spent time on lecture preparation - preparing lecture notes using technology, and researching more on how to teach the subject matter (Spitzer and Aronson 2015). All of this planning, according to L4, involved the use of technology to research and prepare for the teaching of mathematics. Therefore, the student teachers in College D also experienced the use of technology during mathematics pedagogical practices through soft copies of typed notes.

While the lecturers explored in the four colleges indicated that they used technology in the form of PowerPoint presentations, the interactive board also emerged as another piece of technology that lecturers used, as evidenced by their responses. For example, L1 at College A said: *"I sometimes use the interactive board".* Similarly, L4 at College D also said: *"When electricity is available an interactive board is used to give notes".* The conceptions shown by the lecturers were that they used this form of technology, depending on the availability of electricity. It appeared that the economic situation in Zimbabwe during the time of this study was impacting negatively on the pedagogical practices in relation to the use of electronic media, as indicated by L4. The interactive whiteboards referred to by L1 and L4 are different from the ordinary white boards. To use the interactive board, one needed to connect it to a projector or computer with a display that could be manipulated by a stylus, mouse, or touch screen. Such gadgets were slowly replacing traditional blackboards in lecture rooms. When employing the interactive whiteboards, lecturers would be able to create lessons that included videos and moving diagrams. It would also be possible to access online mathematical content that would help explain difficult concepts. These processes would promote student engagement during pedagogical practices. While the use of the interactive whiteboards was commendable as a vital tool in mathematics pedagogical practices, at other colleges lecturers (L2 and L3, at Colleges B and C) continued using the traditional blackboards. Not only could lecturers use the whiteboards discussed above, but students could also interact with these boards in many ways; writing on them, manipulating objects and engaging in problem solving activities using hand-held devices. All this would convert the rigid traditional lecture room into an active constructivist classroom (Dewey 1938; Kim 2001; Ochagavia 2017). Technological tools such as the interactive board supported the learning of mathematical procedures and skills as well as the development of advanced mathematical proficiencies, such as problem solving and reasoning (Sadeghi 2019). This piece of technology which promoted research and access to new information was consistent with the socio-constructivists and constructivist conceptions where mathematics knowledge is viewed as dynamic (Torner and Grigutsch 1994; Kim 2001; Vintere 2018).

To conclude this section on the experiences related to technology, responses from all of the data sources suggested that the student teachers in Colleges A and D experienced the use of technology during their pedagogical practices in mathematics education in the form of overhead projectors, PowerPoint presentations, interactive boards, electronic storage devices and white boards. Participants also experienced use of the Internet through library Internet searches. However, during lecture observations the only form of technology L4 used was a soft copy given to the students. Use of technology, as indicated in literature (Hoyles 2018), helps in simple calculations and the conception of mathematics situations and relationships, thereby allowing a deep conceptual understanding of mathematics.
Preparation for lectures was another important aspect of classroom practice.

7.2.3 Experiences related to lecture preparation

Thoughtful mathematics lecture preparation often leads to a successful lecture. Such a lecture will usually be effective and beneficial, particularly to student teachers who struggled to pass mathematics. Discussing their experiences regarding preparation for lectures, ST10 in an FGD at College D intimated that: "*... The lecturer had an electronic storage device and asked for the group representative. And the representative raised his hand, and he said 'I want you to write these notes from the electronic storage device"*. In an FFI, ST7 at College A responded: "*Our lecturers when they want, they use PowerPoint presentations and overhead projectors and at times it helps us in taking down notes during a lecture"*. ST3 at College A also said in an FGD: "*… The lecturer just beamed his notes on the PowerPoint which we used during the lesson and he kept on moving the slides very fast"*. A slide show, as revealed by ST3, is an exposition of a series of slides or images on an electronic device or on a projected screen which makes pedagogical practices powerful and flexible to support learning (Casey 2013). But from ST3, the PowerPoint presentation was less effective, given the speed with which the lecturer moved through the slides. However, the availability of the slides indicated by ST3 was a sign of lecture preparedness by the lecturer. ST8 in their FFI at College C said: "*These lecturers, when they lecture they have their lecture notes in hand"*. ST8's response reflected lecturer preparation for pedagogical practices. From the above discussion the students experienced well prepared lectures where some lecturers prepared notes for PowerPoint presentations and used electronic storage devices and printed notes.

To confirm what the students experienced, L1 at College A said: *"Yes, I do I research. I make use of pdf and the like to come up with something good to present to students"*. L1's response reflected commitment to planning and the use of the portable document format (pdf) in order to come up with lecture notes to draw on during the pedagogical practices in mathematics education. A portable document format is a file format used to present documents, including text formatting and images, which can be viewed, navigated, printed or shared with others. The response suggested that student teachers in College A experienced well researched information during mathematics pedagogical practices. L2 at College B also had this to say on lecture preparation during their FFI: *"True, we prepare work in advance and give them lecture notes".* L2 also portrayed some commitment to students' learning of mathematics by planning in advance and giving students lecture notes during the mathematics pedagogical practices.

Notwithstanding the issue of giving them notes and not enabling students to develop their own notes, one could still conclude that as in College A, College B students also experienced well prepared lectures during mathematics pedagogical practices. The act of adequate preparation of lecture notes would aid in effective lecture presentation. The lecturer would thus be aware of all grey areas and landmarks that needed emphasis during the lecture. This would probably give rise to effective learning on the part of the student teachers. One could also view this as suggesting that student learning took precedence, which was fore-grounded by socio-constructivism (Dewey 1938; Kim 2001; Ochagavia 2017; Vintere 2018). However, the mention of giving the students typed notes suggested spoon feeding, which was aligned to traditionalist conceptions.

L3 at College C had a different approach to preparation, commenting: *"I go for an archive. That is, I visit old notes".* The lecturer's response implied that the same notes were used again and again. The implication here was that the student teachers experienced teaching from the same old, recycled notes and that these were possibly used year after year. With this situation, I was inclined to think that no up-to-date knowledge was added or experienced by the student teachers in the mathematics pedagogic practices, contrary to the dynamic nature of mathematics knowledge. Knowledge was assumed to be static, thereby reflecting the traditional conceptions about mathematics pedagogical practices that the lecturer held. From the conceptions about mathematics, a lecturer who conceived knowledge as static was a traditionalist (Skemp 1978; Lerman 1983; Yang, Leung and Zhang 2019). A socio-constructivist lecturer conceives knowledge as dynamic, as new ideas are constantly discovered (Vygotsky 1978; Torner and Grigutsch 1994; Kim 2001). It appears that L3's conceptions were contrary to this understanding.

During his FFI, L2 at College B indicated advance preparation and that he gave his students notes, but contrarily student ST7 at the same college disputed this lecturer's comments during the FGD there when he revealed: *"Sometimes the lecturer would come and say, 'sorry I wasn't prepared for this lecture', and he would come and he would be struggling to deliver the lesson to us".* This lack of lecture preparation most probably led to ineffective lecture delivery and ineffective students' learning. The response above also suggested that the student teachers at College B experienced poorly or unprepared lectures during mathematics pedagogical practices, contrary to what the lecturer had said. Advance preparation often provides a picture of how the lecture will proceed and enables pre-playing and rehearsing of the lecture to identify any areas that will require emphasis (Mukeredzi 2009). Showing signs of unpreparedness breeds a lack of confidence in the lecturer by the students.

From the discussion above, responses from both students and lecturers revealed that students in Colleges A, B and D experienced learning from well prepared lecture notes, contrary to the experiences of students in College C where L3 used and exposed students to archived notes, suggesting a static nature of mathematics knowledge. Well prepared notes for any lecture foster students' understanding of mathematics content, and the opposite is true for poorly prepared lectures. The student teachers also confirmed well prepared notes as soft copies on electronic storage devices (memory sticks). This was also evident during one lecture observation where student teachers collected notes on an electronic storage device. Literature indicates that electronic storage devices are portable data storage media accessible on computer which can be edited, and can also be sent by email (Montrieux and Schellens 2015).
Following lecture preparation was lecture delivery, which is discussed next.

7.3 Experiences during lecture delivery

Lecture delivery, that is the execution of a planned lecture presentation, was another area in which students experienced mathematics pedagogical practices. This aspect is discussed under the following sections: lecture introduction, teaching strategies, handling students' questions, use of manipulatives and lecture conclusions.

7.3.1 Lecture introduction

In mathematics lectures, an introduction at the beginning of the lecture enables the lecturer to capture attention and interest, and motivate students. Literature reviewed (Liang 2013) indicates that an introduction focuses students' attention on the lesson and its purposes and convinces students that they will benefit from it. This stage therefore marks the success or smooth flow of a lecture. Discussing their experiences regarding lecture introductions, ST9 at College B said in the FFI: "*When the lecturer enters the lecture room he greets us and then writes the topic on the board for us to copy".* ST3 in an FGD at College C also responded: "*The lecturer just tells us what we are going to cover in that lecture".* Another student, ST7 at College D added during an FFI: "*... The mathematics lecturers start the lecture by introducing the topic to be covered".* In the same vein ST4 at College A said during their FFI: "*The lecturer just tells us what we want to cover in that lecture*". From the students' responses above the students across all of the colleges experienced introductions where generally the lecture's objectives or the topic under discussion was highlighted without a recap of the previous lecture, and thereafter the lecturers figuratively "*jumped*" into the lecture without linking it to the previous one. This lack of connection with the previous lecture undermined the constructivist perspective of prior knowledge (Vygotsky 1978; Kim 2001). The absence of links with previous lectures reflected traditionalist conceptions about mathematics (Dionne 1984).

Describing how they welcomed student teachers before the lecture, all lecturers across the four colleges explored indicated that they greeted them. For example L1 at College A said*: "I just simply say, 'morning' if its morning or, 'afternoon' if its afternoon. That's enough",* and L2 at College B also explained: *"OK, for my students I simply say in terms of when I am in a lecture, I will address them as 'morning or afternoon my students'".* Thus, from the lecturers' responses it was clear that the students in all of the colleges experienced a formal greeting from their lecturers during pedagogical practices. This was a contradiction of the students' responses as only the students in College B received a formal greeting. A greeting is always essential because it helps to build a warm relationship with students, shows that they are welcome, relaxes them, and portrays care which can be used as a motivational strategy. Literature points out that the student teacher will feel welcome at the lecture, and will want to participate and become a part of the lecture room environment as they may develop a sense of belonging (Boyd 2018). While it was evident from all four lecturers' responses that student teachers in all four colleges experienced these greetings in mathematics pedagogical practices before every lecture, student teachers may just have overlooked that aspect in their responses, given that I witnessed greetings during the lecture observations.

In addition, L1 at College A also said in their FFI: *"Normally I introduce by recapping what we were doing yesterday or some time ago, just trying to pick related things".* The response implied that the lecturer engaged students by provoking assumed knowledge during the pedagogical practices in mathematics. On the contrary, however, ST4 from the same college as L1 and the other students in the other colleges quoted above did not mention a recap at the beginning of their lectures. Thus, not all of the students across all of the colleges experienced this vital intervention which was useful, especially for these students who had struggled to pass mathematics, as it would help them to relate their previous knowledge with the new knowledge to be learnt. Prior knowledge was vital to learning new information as it created a context for the new knowledge. From the constructivist perspective, prior knowledge is vital in the teaching and learning of mathematics as a learner does not come to school empty headed (Vygotsky 1978; Kim 2001; Sloat, Sherman, Christou, Hirschkorn, Kristmanson, Lemisko and Sears 2014). Such knowledge could therefore enable or obstruct learning if it was incorrect, and when new knowledge was added, it would lead to further misconceptions. Thus, recapping provided an opportunity for the lecturer to correct misconceptions while creating a context for learning new knowledge. However, this was not experienced during the mathematics education lectures in these colleges. From the literature reviewed, if misconceptions are curbed before new knowledge, this can lead to effective mathematics learning during the mathematics pedagogical practices (Mohyuddin and Khalil 2016). There is often an overlap of new and old knowledge for a deeper understanding of mathematics. Consequently, during the mathematics pedagogical practices student teachers seemingly did not experience these summaries of previous lectures during the lecture introductions.

L3 at College C, also commenting on lecture introduction, said: "*I highlight what is to be covered in the day's lecture".* The comment by L3 confirmed what the student teachers had highlighted. According to L3, these student teachers did not experience recapping of the previous learning during the introduction of the new lecture during mathematics pedagogical practices. Thus, no link was provided between new work and the previous work. This response was confirmed during the lecture observation when L3 wrote the topic on the board and went on with the new lesson. Contrary to what he had said about highlighting the goals of the day's lecture, there was no outline made or indication of the day's lecture outcomes. Thus, the absence of a recap of the previous work for synthesis and enhancement of understanding was overlooked and the students were not informed about the lecture's objectives, as had been intimated by their lecturer during his FFI.

Similarly, L4 at College D also said: *"By telling them the business of the day that is the topic for coverage"*. This response confirmed what students at this college had intimated. Just like L3 at College C, this lecturer also did not recap the previous knowledge to link the old and the new information. Consequently, these lecturers treated lectures in isolation and the student teachers did not experience lectures that were introduced by making linkages with previous ones through recapping. As has already been alluded to earlier, a recap created space in the students' minds for new knowledge through connections between prior learning and new learning, thereby ensuring continuity. Literature reviewed indicates that this boosts confidence, memory and morale among students (Mukeredzi, Bertram and Christiansen 2018). Contrary to this, other research consulted Karaali (2015) supports L3 and L4's approach of not recapping; pointing out that prior knowledge may confuse students and affect the lecturer's presentation of an effective lecture as students may distort the new information learnt. Notwithstanding the literature against recapping, there is always a need for students to link the information already acquired with the new information they are going to learn as this provides a framework for smooth assimilation or accommodation of information during mathematics pedagogical practices.

Thus, only students at College B experienced a formal greeting. Students in Colleges C and D were exposed to details about the focus of the lecture as a way of introduction. However, L1 indicated that students at College A experienced a recapping of the previous lectures, while the y students at this college indicated that they were informed about the goals of the new lecture in the introduction and did not experience any recapping. ST4 at College A's utterances were also confirmed during the lecture observation for L1, as the lecturer only spelt out the objectives and no recap was done. From the findings, students at Colleges B, C and D also did not experience recapping during the pedagogical practices in mathematics. Lecture observations at these Colleges B, C and D further confirmed that lecturers did not recap previous work but went straight into new work without provoking assumed knowledge. L3 and L4's responses concurred with their students' responses; that of outlining the aim of the lecture.

Teaching strategies also emerged as another vital aspect under lecture delivery.

7.3.2 Experiences related to teaching strategies

Teaching strategies are generally an important aspect of lecture delivery. The students in all of the colleges, when explaining the teaching strategies used, confirmed that their experiences of mathematics pedagogical practices were confined to the lecture method. For example, in an FFI at College B, student ST3 commented: *"The lecture method, where the lecturer just comes, delivers information and bounces back. No clarification, no individual attendances".* Another student, ST6 at College A, indicated in an FGD the prevalence of the lecture method in their mathematics pedagogical practices, complaining that: "*I also strongly feel that the lecture method and mathematics do not correlate, and it is the only method used".* Both ST3 and ST6 confirmed experiencing the lecture method during pedagogical practices. ST6 further highlighted that this mode of instruction was unsuitable for mathematics learning. This may have been because mathematics required practice, where students worked out mathematical problems.

Studies consulted revealed that the lecture method involves one authoritative figure that has full control of the direction of the lesson and the tone of the classroom (Paris 2014). Adult learning, in particular in mathematics, usually requires student-centred approaches where the lecturer is a facilitator rather than exposition during pedagogical practices. Effective mathematics learning and teaching needed to be stimulating to cater for the different students' learning styles and capabilities and to expose them to experiences of mathematics learning from a knowledgeable other, as propounded by the socio-constructivists (Kim 2001; Ochagavia 2017; Yang et al. 2019). The use of this lecturer-centred approach, a one-way mode of instruction (the lecture method) was confirmed during the lecture observations that I carried out in all of the colleges.

During an FFI L2 at College B explained the students' reactions to his teaching strategies and mentioned: *"Some are very eager to answer, but some students… you know students, some will not respond to the questions".* However, this was not the case when I observed his lecture. L2 only picked on those students who raised their hands; consequently, not all students participated in this lecture. Students experienced a situation where, if they did not put their hand up, they were not picked to respond during the pedagogical practices, even though they may have known the correct answer. Often the fact that these student teachers did not put their hands up was not necessarily because they did not know the answers. This could have been because of low self-efficacy. Literature (Erath, Prediger, Quasthoff and Heller 2018) indicates that raising hands during pedagogical practices is a way to stress individuality. Hence, every student benefits from being given a chance to express themselves or to answer questions asked during lectures, whether they raise their hands or not. Klette and Blikstad-Balas (2018), however, disagrees and states that those who raise their hands often listen and engage in the lesson more than those that do not put their hands up as their attention may have drifted away from the lesson.

On the same issue of strategies, L3 at College C said in an FFI: *"I encourage students to always give feedback after they have consulted the Internet".* The students experienced Internet research. L4 at College D also revealed in an FFI: *"I summarise the main points of the content and give remarks".* While L3 encouraged Internet research, L4's response revealed that he was the source of knowledge during the mathematics pedagogical practices. From L3's response, students researched and provided feedback during mathematics pedagogical practices. The feedback implied in this response was based on a research task for discussion during the mathematics pedagogical practice. However, at College D the students experienced the lecturer's summaries of the key points of the lecture during their pedagogical practice in mathematics. L4 suggested that the lecturer had full control of the direction of the lecture, while absorption of this information was done by the students. Though lecturing made the lecturer the gatekeeper of the knowledge (Hudson 2018), in this case the lecturer was expected to ensure that the student teachers captured the key points. Thus, as revealed by L4, discussing the main points of the lecture and providing concluding remarks may not have been such a bad idea. However, such traditionalistic approaches could be viewed as implying spoon-feeding of the students (Torner and Grigutsch 1994; Kim 2001; Hudson and Hudson 2018).

Generally, what emerged with regards to the teaching strategies was that the students revealed that the lecture method was the only mode of instruction and no other teaching strategies were employed during mathematics pedagogical practices. This lecturer-centred strategy was contrary to the constructivist perspective which aligned with the active acquisition of mathematical knowledge where the student took the centre stage in their learning (Vygotsky 1978; Lerman 1983; Kim 2001).

7.3.3 Experiences related to handling students' questions

Discussing the handling of the student teachers' questions; at College A ST3 responded during their FFI: "… *He did not give us time to ask questions".* In an FGD at College B ST1also said: *"In a lecture we are just writing the notes and lecturers ask questions".* At College C ST4 intimated during an FGD: *"I had to move around, asking other colleagues how to do it".* In addition, ST6 at College D also said during their FFI: "*I would have wanted a situation where we are grouped according to ability, and when we operate within the same level one will not feel shy to ask questions which may appear to be silly to the gifted".* Responses from the students in all of the colleges studied indicated that they were not afforded an opportunity to ask questions during mathematics pedagogical practices as only lecturers asked the questions (ST1) and some students ended up consulting peers for the required information as a result of this. Asking helped to fill knowledge gaps and resolve any mathematical errors. McAninch (2015) indicates that questioning is the most frequently used instructional tool and a process which allows learners to articulate their current understanding of a topic, to make connections with other ideas, and also to become aware of what they do or do not know. Other students like ST6 revealed a lack of confidence which prevented them from asking questions. The lack of confidence may have emanated from their previous struggles to pass O level mathematics. The constructivist stance of interaction and learning from a knowledgeable other would probably enable them to ask their peers questions. On the same issue of handling students' questions; all of the lecturers generally indicated that they responded to students' questions with explanations, as exemplified by the following quotations: *"I do provide clear explanations but in a normal classroom some will struggle to get what I want them to do or to understand what I want them to understand"* (L1 College A, FFI); *"I try my level best to give clear explanations by even demonstrating some concepts on the board"* (L3 College C, FFI); and *"I try by all means to provide clear explanations to their questions and that is sometimes through questioning them for better understanding"* (L4 College D, FFI).

An explanation is a series of statements that are intended to clarify; in this context any mathematics concepts during mathematics pedagogical practices. From the lecturers' comments, the students experienced clear explanations in answer to their questions during pedagogical practices in mathematics. The *'normal'* referred to by L1 referred to an ideal classroom situation where the students had diverse cognitive abilities – below average, average and above average performers. Clear explanations during mathematics pedagogical practices would scaffold learning and understanding, particularly for those students who struggled to comprehend some mathematics concepts. The above responses suggested that lecturers attempted to promote students' accurate conceptual understandings and experiences of effective learning through the provision of clear explanations and answers to questions asked during the pedagogical practices. The adequate and clear explanations that lecturers indicated could have been a reflection of deep mastery of the content knowledge (Shulman 1987; Grieser and Hendricks 2018). It was only when a lecturer knew the answers that he/she could explain because they could not explain what they did not know.

In the same vein, during another FFI lecturer L2 at College B responded to the question about handling students' questions by saying: "*Yah, sure we give them question time and they will address their questions".* Affording students question time promoted interaction, particularly when peers were allowed to answer the questions. By answering their peer's questions, students were able to verbalise their thoughts. In the case of any misconceptions, this would offer the lecturer an opportunity to correct the misconceptions and also to make additions to the responses during the mathematics pedagogical practices. Again, asking questions and receiving answers stimulated a two-way communication which supported the constructivist perspective which believed that mathematics concepts should be interactively acquired from knowledgeable 'others', in this case the lecturer (Torner and Grigutsch 1994; Kim 2001; Ochagavia 2017; Yang et al. 2019). Contrary to this, however, in L2's lecture which I observed, this lecturer did not invite any questions from the students, and there was no question and answer session. Some brief questions were asked by the lecturer himself.

I also asked the lecturers whether the questions that they asked called for critical thinking during the pedagogical practices. L1 at College A responded: "*... Whatever remains, we ask them to go and research".* This response did not show clearly the students' experiences related to critical thinking. However, this aspect of the research pointed to constructivist approaches where students took responsibility for their own meaning-making. On the other hand, this response could also be viewed as traditionalist, given the lack of exposure to critical thinking. L2 at College B responded as follows regarding critical thinking: "*Yah, somehow sure yes. Haa! Sure yes, they call for critical thinking".* The hesitance in the response and the use of the word "*somehow"* did not confirm clearly that the questions asked promoted critical thinking. During the lecture observation, L2 posed questions that required simple recall only. L3 at College C said outright: "*No, I don't because of time".* This lecturer's response was loud and clear that during mathematics pedagogical practices student teachers did not experience questions which demanded critical thinking on their part.

Only L4 at College D implied asking critical thinking questions when he said: *"My questions are normally ones that require immediate responses so students give responses to questions that require final figures or suggestions for the next step. Questions that require critical thinking are* *left as homework".* According to L4, students experienced critical thinking questions as take home written work, probably because this gave them adequate time to think critically and to work the problems out.

While L2 at College B appeared hesitant about whether or not he asked critical thinking questions during his lectures, contrary to this L4 at College D indicated that his students did experience critical thinking questions in mathematics pedagogical practices in their individual take home assignment work. Generally, what emerged was that none of the lecturers observed exposed the student teachers to questions that demanded critical thinking, and this aligned their mathematics pedagogical practices with traditionalist conceptions. Furthermore, students were not afforded the opportunity to ask questions during the mathematics pedagogical practices. Mukeredzi (2015) suggests that asking questions that demand critical thinking enables students to view their thoughts and experiences from new perspectives. In the context of this study, this means that the students would be empowered to think through problems and would experience mathematics pedagogical practice in all of its complexities. If this occurred, they would experience positive results while gaining a conceptual understanding of mathematics. Further, in addition to converting the traditionalistic nature of the lecture, critical thinking questions facilitate discussion, thereby creating a constructivist classroom (Santoso, Yuanita and Erman 2018; Yang et al. 2019). This in a way would scaffold the students' knowledge construction, while discouraging memorisation and recall. The process thus reflects whether or not student teachers would have understood the concepts. However, in my observation of the four lectures, the questions asked were few and simple and demanded the recall of facts, thus negating the benefits of critical thinking raised above. From the data gathered from the lecturers, none of the student teachers in this study experienced questions that demanded critical thinking on their part, except possibly the students in College D who apparently had more in-depth take home assignments.

Manipulatives also emerged in relation to the teaching strategies in the mathematics lectures.

7.3.4 Experiences related to manipulatives

Manipulatives are practical objects used in the classroom as teaching aids for a hands-on approach to the learning of mathematics (Carbonneau, Marley and Selig 2013). In mathematics education, the use of manipulatives in mathematics teaching is critical as they increase students' conceptual knowledge and help improve their attitudes towards mathematics learning. Many researchers suggest that the use of manipulatives in solving mathematics problems (Cockett and Kilgour 2015; Lafay, Osana and Valat 2019) has positive learning effects on all students, and in particular on struggling students.

In relation to manipulatives, ST5 in an FFI at College A said: "*I am going to apply what I have learnt on planning and media. I am going to use it though I did not experience media use in our lectures".* Similarly, at College C in their FFI, ST9 also responded:

> *I thought our lecturers would prepare a model lesson plan, prepare media for that particular topic and then they teach so that we really have an idea of the lesson steps, since some of us had never taught in our life.*

Along the same lines, ST2 at College D also said during their FFI: *"Lectures at college teach differently, however the best approach to learning mathematics is through the use of relevant and adequate media".* Manipulatives not only allow students to construct their own cognitive models for abstract mathematical ideas and processes, they also provide a common language with which to communicate these models to the teacher and to other students (Golafshani 2013). In any learning situation the primary goal is to improve and extend learning for students and the use of manipulatives helps in boosting critical thinking and building problem solving skills. However, from the responses of the students they did not experience the use of this vital aspect during their mathematics lectures.

Discussing the use of manipulatives, the lecturers explored confirmed what the students had indicated; that they did not use any manipulatives in their pedagogical practices. As such student teachers missed out on those experiences during mathematics pedagogical practices. For example: L1 at College A pointed out: *"Aah, not necessarily".* L3 at College C responded thus: *"I don't use any manipulatives".* In the same vein L4 also said: *"I don't use manipulatives*". The lecturers openly declared non-use of media in their mathematics pedagogical practices. The conception of mathematics pedagogical practices that was implied by these responses was that the use of manipulatives was irrelevant for mathematics pedagogical practices in Colleges A, C, and D. Consequently, the student teachers in the said colleges did not experience the use of manipulatives during their mathematics lectures. Manipulatives help remove the abstract nature of mathematics learning, enhance interaction and liven the classroom atmosphere. The student teachers in this study who had struggled to pass mathematics would benefit greatly from the use of manipulatives, given that they often found mathematics too abstract, and the use of manipulatives would foster their understanding of the abstract mathematics concepts. This is confirmed by consulted literature (Furner 2017) which indicates that manipulatives eliminate the abstract nature of mathematics during mathematics pedagogical practices. If used in the classroom, manipulatives often bring in the aspect of interaction and active learning of mathematics which helps in the retention of concepts. Manipulatives that involved these student teachers manipulating tools themselves would locate them at the centre of their learning, as understood from the socio-constructivist theorists and constructivist conceptions about mathematics (Ochagavia 2017; Vintere and Ozola 2020).

Contrary to what the lecturers said, in an FFI at College B student ST4 commented as follows about manipulatives:

> *... Yes, it had a lot of media. For the lesson of fractions there was something like that in the lecture. He came with some media and he used fruits, he came with matohwe (indigenous fruit). He shared the media so that we were all able to understand.*

From the above response the students at College B experienced the use of manipulatives to enhance their comprehension during mathematics pedagogical practices. From reviewed literature, interaction with manipulatives helps student teachers to grasp mathematics concepts easily (Cockett and Kilgour 2015). The idea of bringing an indigenous fruit (*Matohwe*) into the lecture room was ideal as the local environment is often an effective mathematics laboratory. This therefore reveals that mathematics need not be confined to the four walls of the classroom; it should also encompass resources within the local context. This links with the constructivist conception about mathematics and manipulating the context (Torner and Grigutsch 1994; Ochagavia 2017; Yang et al. 2019). Further, by using manipulatives the student teachers' cognition and deduction of mathematics takes precedence given the interaction created, which is in line with socio-constructivist theory (Kim 2001; Vintere and Ozola 2018). Student teachers at College B were thus exposed to learning experiences with hands-on strategies through the use of manipulated objects which apparently stimulated their learning (Raj and Subramanian 2019).

With respect to manipulatives, generally what emerged from the responses of both students and lecturers was that the students in Colleges A, C and D experienced the non-use of manipulatives during their pedagogical practices in mathematics. Contrarily, from ST4's response it was apparent that the student teachers at College B experienced the use of manipulatives during their mathematics pedagogical practices. However, when I observed L2's lecture at College B there were no manipulatives used during the mathematics pedagogical practices, making it difficult to understand whether ST4 experienced the use of manipulatives at this college or somewhere else.

Another aspect of lecture delivery that emerged related to concluding the lecture, which is discussed below.

7.3.5 Experiences related to lecture conclusions

The purpose of lecture conclusions during mathematics pedagogical practices is to reinforce important concepts learnt during the lecture. ST5 at College C said in their FFI: "*There was no time for us as students to really ask and have things clarified, and so the lecture just ended like that"*. Similarly, in the FGD ST2 at College D replied: "*In some lectures we have little time so lecturers end up giving us notes and just leave"*. From the students' responses they were left "*hanging*" with no conclusions to their lectures. The lecturers in Colleges C and D failed to capitalise on the chance to effectively tie the lecture threads together to benefit students' learning of mathematics during mathematics pedagogical practices.

With regard to conclusions to lectures, in an FFI L1 at College A said: "*Aaah, (he laughs). I just stop when the material that I have prepared is finished… Aah no, this is a lecture, my dear".* When I asked whether or not he concluded his lectures or make any closing remarks, he added: "*No, this is just a lecture".* From this lecturer's response, a lecture should just be ended abruptly during pedagogical practices in mathematics education. From his response, the conclusion was not necessary since all that needed saying would have been said. A conclusion to a lecture is generally regarded as important given its ties to the introduction and it summarises the main points of the lecture highlighted in the introduction. Further, a conclusion affords the lecturer an opportunity to synthesise the material, enhances the students' understanding of what has been taught and also points to the worthiness of the lecture. From research, concluding the lecture is another strategy of engaging students interactively through questions and answers, checking whether they have understood or acquired knowledge since the main aim of learning is to acquire knowledge (Jackson, Garrison, Wilson, Gibbons, and Shahan 2013).

L1 at College A also reacted to concluding strategies by saying: "*I haven't seen anything fishy, they just stand up and go away".* From the lecturer's response, students experienced no formal conclusion to their lectures during mathematics education pedagogical practices. Apparently the students just left when he stopped talking. What was disconcerting here was that he was a teacher educator, and a trained teacher. It would be unsurprising to see such student teachers also not concluding their lessons when they moved out into the school environment, given that most of what teachers do or do not do reflects their prior learning experiences (Mukeredzi 2013). Commenting on concluding remarks to a lecture, L3 at College C revealed: "*I just stop when it's time for the next lecture. They will be rushing for the next lecture and won't listen to any concluding remarks"*. In the same vein L4 at College D indicated: "*Sometimes time will be up and so they may not take remarks seriously*".

The responses by L3 and L4 suggested that these students experienced an abrupt end to their lectures during pedagogical practices, purportedly because they would not listen even if the lecturer wanted to tie up the lecture. This issue of time referred to suggested weaknesses or oversights in lecture preparation, given that planning would enable lecture pre-playing and rehearsal which would point to the time requirements for appropriate and adequate coverage of all stages of the lecture. The reasons given by both lecturers also tended to point towards disciplinary issues, among others things. Given that discipline is not control from the outside but rather order from within, exposing the student teachers to the lecturer's expectations and practicing them would influence the students to wait until the final aspect of the lecture was completed. From literature reviewed (Hacat 2018), a lecture's conclusion is regularly overlooked, notwithstanding its ability to strengthen the student teachers' learning of mathematical knowledge and shed light on any conceptual misconceptions. Lectures are expected to have a planned end in the form of a summary of the main points. This, as alluded to above offers the students a *"take home message"* to remember and use. Thus, the student teachers at three of the four colleges explored (Colleges A, C and D) did not experience these concluding remarks which were essential for the reinforcement of their learning of mathematical content and helping to clarify their misconceptions during the pedagogical practices. L2 at College B indicated in an FFI:

> *I will ask the questions from the aspects that we have covered during the lecture, in order to check whether the students have understood the content that we have covered. … Haa! The technique, it's quite motivating and they will also try to motivate others.*

From the lecturer's response the students in College B experienced lectures that were concluded with a summary of the major points covered in the lecture. Such an approach promoted the retention of information as the main points were highlighted as something to be taken away from the lecture. From L2's quote, this lecturer reported having adopted concluding his lectures by emphasising the main points during the pedagogical practices, and this was motivational. The students at College B thus seemed to have been exposed to lecture summaries during their mathematics pedagogical practices, whereas at Colleges A, C and D students did not experience lectures where conclusions or summaries were provided. When I observed the mathematics education lectures across all of the colleges no lecture conclusions were made to wrap the lectures up by picking on key points. This contradicted what L2 had said about concluding his lectures, but the absence confirmed what L1, L3 and L4 had said.

To conclude this section on lecture delivery, from the students' responses only the students at College B experienced a greeting from their lecturer, while the students in the other colleges experienced an outline of the lectures' objectives. However, the lecturers had concurred that they welcomed their students to the lectures and greeted them. The recap indicated by L1was vital as it addressed the key points from the previous lesson to create connections with the new content to be learnt. This was, however, disputed by the students across all of the colleges who indicated that lectures were treated in isolation as there were no recaps.

With regard to teaching strategies, generally all of the student teachers indicated experiencing the lecture method during pedagogical practices, which some of the students felt was unsuitable for mathematics learning. However, the lecturers themselves revealed that they varied strategies as they included students' research and report backs, which was contrary to what the students had said. It also emerged that during mathematics pedagogical practices none of the students in any of the colleges were given a chance to ask questions. Instead it was the lecturers who asked simple recall questions. In addition, when the lecturers asked questions they generally picked on the students who raised their hands. This is against the socio-constructivist perspective which is all-embracing and does not leave any learner behind, instead scaffolding their learning to help them reach their ZPD (Vygotsky 1978; Kim 2001). It also emerged that some of the students relied on their peers to clear any misconceptions as they lacked the confidence to ask questions during the lectures. From the findings, none of the lecturers studied except the one at College D asked the students critical thinking questions. At this one college, critical thinking questions where assigned as homework.

Regarding media use during mathematics pedagogical practices, both students and lecturers in Colleges A, C and D concurred that the use manipulatives was not experienced by the students, notwithstanding their effectiveness. From the data it was only students at College B who experienced media usage during their mathematics lectures. However, during the lecture observation for L2 at College B, no media was used. Generally, what seemed to emerge was that no students across any of the colleges experienced the use of media during mathematics pedagogical practices.

Regarding lecture conclusions, the findings revealed that students experienced an abrupt end to their lectures. This was also confirmed in the lecture observations that I made as no lecture conclusions were forthcoming. This was despite the fact that the lecturers explored had indicated prior to the lecture observations that their students experienced lecture conclusions in the form of summaries. A lecture conclusion is valuable as it acts as the closure of the lecture and reminds students of the key aspects of the lecture.
Experiences during mathematics pedagogical practices also emerged around lecture time, which is discussed in the next section.

7.3.6 Experiences related to lecture time

Lecture time surfaced in the students' responses, for example ST10 in an FGD at College C said: "*The problem is, more time is needed for the lectures, and they just read out notes and have no time to explain"*. Similarly, another participant ST3 from College B further highlighted similar sentiments by saying in their FGD: "*I expected to have more time to study mathematics and practice calculations"*. Also, in relation to time another participant, ST7 at College D, indicated in their FGD: "*... Should have covered more if there was time"*. Talking about time in relation to lecture experiences another student, ST10 from College A, added in their FFI: *"I feel mathematics should appear a greater number of times on the timetable, like what we have at secondary level"*.

From these comments the student teachers revealed that there was limited time for mathematics learning during pedagogical practices, and that they thus experienced time constraints. The issue of just writing notes dictated without conceptual understanding and the need for more time to cover more content came up again. This related to what Skemp (1978), on the topic mathematics algorithms, indicated: Students simply copied mathematical procedures without comprehension. Given that the students studied across all of the colleges complained about the limited lecture time, when coupled with the limited exposure to content knowledge that was discussed earlier, I wondered whether they would have mastered adequate content knowledge by the time they graduated so that they could teach primary school mathematics effectively. Educators and students generally operate with the philosophy that more lecture time enables them to broaden and deepen the curriculum content to address the learning needs of the individual students, and builds opportunities that enrich the students' educational experiences (Roehl, Reddy, and Shannon 2013). In the context of this study, in mathematics education the development of content competencies seemed to have been minimal in pedagogical practice due to the limited amount of lecture time. Literature surveyed (Anderson 2016) shows that students in other countries excel in mathematics because they have longer school years and thus more instructional time, which enhances their effective learning of mathematics.

Limited lecture time was also confirmed by the lecturers studied, for example L1 at College A said in an FFI: *"No, we do not have enough time. We treat them the same… due to time. Look, these lectures are timetabled and we won't finish the syllabus".* This was also raised by another lecturer at College D, L4 who said: *"Given ample time I get to basics and direct the students towards solutions. Sometimes when they fail I end up giving the solution myself".* From these lecturers' responses time seemed to have been so limited that both students and lecturers were affected during mathematics pedagogical practices. L1 also focused on completion of the syllabus; in other words, preparation of the students for examinations. If the learning focus was syllabus completion and it was examination oriented, it portrayed traditionalistic conceptions which also negated the production of holistic teachers at the end of the course. More time was also needed to cover the basics of the various mathematics concepts. Covering the basics would assist students, particularly the struggling students, to better understand the basic concepts. Due to limited time during mathematics pedagogical practices, some lecturers sometimes provided the solutions to problems, making the students recipients of the mathematical knowledge as propounded by traditionalist conceptions about mathematics (Ochagavia 2017; Yang et al. 2019), as opposed to being active players in their knowledge construction process.

Both the student teachers and the lecturers lamented the limited contact time for mathematics pedagogical practices. I also noted the limited lecture times during the lecture observations. For example, at College D time was up before completion of the lecture, forcing L4 to give the students notes on a memory stick.

Further discussing their experiences of mathematics pedagogical practices, the student teachers and lecturers also revealed experiences related to assessment.

7.3.7 Experiences related to assessment

Assessment in this case referred to evaluation of the student teachers' ability in mathematics. It was a way in which the lecturer could measure whether course objectives were being achieved and whether the student teachers understood the work covered during pedagogical practices. From literature (Black and Wiliam 2018) assessment is also about collecting and discussing empirical data in order to develop a deep understanding of students' knowledge and how well they can apply their knowledge. The student teachers in my study experienced different forms of assessment during their mathematics pedagogical practices, namely tests and assignments. In an FFI at College B, student ST9 said:

> *To tell the truth, at one time we were given a mathematics test on primary school mathematics. We performed dismally. One really fails to understand what we are going to teach the primary school child.*

What emerged from the response above was the experience of failing a primary school level mathematics test and a fear of inadequacy as a mathematics teacher. This finding was similar to research findings by Tswanya and Hlati (2019) where South African Grade Six teachers wrote a Grade Six mathematics test and some performed below average as they struggled with the questions set for their own students. From the response above and the performance of the South African mathematics teachers, one could conclude that neither these teachers nor ST9 possessed adequate mathematics content knowledge. Furthermore, this could be a pointer to the inadequacy of the initial teacher training programmes, which could be detrimental to learners' performance and the performance of the education system as a whole. The experience of student ST9 above probably provided their lecturer with pointers on where and how they could assist their students. In another FFI, participant ST8 at College A said:

> *When we wrote our promotion and demotion tests there were some mathematical problems in the test. I was shocked to find mathematical problems in the test. I had just thought we were going to find questions on how to scheme and plan.*

Promotion and demotion tests determined whether a student could move to the next level of study along with their peers after mastering the academic competencies expected at their current level of study (Reschly and Christencon 2013; Damopolii and Rahman 2019). Student teachers experienced these assessment procedures, and demotion meant remaining in the same year group during the next stage of their pedagogical practices in mathematics. Retained student teachers would be given another chance to pass, with adequate resource support including direct student-to-lecturer contact to enhance their concept mastery during mathematics pedagogical practices.

From the above response, ST8 in College A concurred with ST9 in College B that assessment was experienced through written tests during pedagogical practices in mathematics education. Assessment in mathematics pedagogical practices was also experienced by means of assignments and tasks given to the student teachers. Assignments are academic tasks given to students to check what they know, understand and are able to do, thereby ensuring achievement of their course objectives (Arneback and Blasjo 2017). This form of assessment experienced by the student teachers required them to adequately research for, develop and submit the work for marking. In an FGD at College A, assessment through assignments was also mentioned by student ST2 when he pointed out: "*At college you are given enough time for research for assignments and you get to understand more*". Assignments are a critical teaching tool using individual research to obtain answers and receiving feedback on assessed scripts. The main purpose of mathematics teaching and learning is understanding and the transfer of knowledge to new contexts (Ormond 2018), hence the need to give students assignments to check their ability to apply what they have learnt. From the socio-constructivist perspective and the constructivist conceptions about mathematics, research in assignment writing creates space for students to engage in their own meaning-making (Kim 2001; Ochagavia 2017; Yang et al. 2019). Thus, this process of assignment writing offered the student teachers opportunities to experience individual learning and understand more through tackling these assignments.

Assessment experiences through assignments were also confirmed by the lecturers. For example, L1 at College A when he said: *"Aaah, since it is mathematics we deal with, and we just give some assignments that they should write during their time away from college"*. L2 at College B also indicated in an FFI: *"Simply essay type of assignments. For example, for our finalists, we give them one test and two assignments"*.

And when I asked whether assignments contained mathematical content, L2 at College B revealed: *"Somehow, but it will be less than 30% of the stuff…. It will be below O level stuff"*. L3 at College C also added: *"Due to large numbers I don't give much, but I just give two assignments, a distance and residential assignment"*. L4 at College D also said concerning assessment: *"I give one residential and distance assignment. At the end of each topic, I give a worksheet, especially if I am not going to give a test. My assignments are just straightforward"*. The student teachers in the three years of teacher training have residential college and non-residential sessions, as explained in Chapter One. It is during these periods that they experience writing these different assignments. Assignments written during the non-residential periods are the distance assignments (de Souza, Franco and Costa 2016; Zuhairi, Karthikeyan and Priyadarshana 2019). The lecturers explored in the four colleges confirmed that students experienced assessment through tests and/or assignments in the mathematics pedagogical practices. From the responses above the depth, content and coverage of the assignments varied by college. College D also added worksheets to the assignments.

The lecturers and student teachers in all four colleges concurred that pedagogical practices in mathematics education enabled student teacher experiences through assessment tests and assignments. In College A the tests were also given for promotion and demotion purposes and College D added assessment worksheets.

Other students' experiences during pedagogical practices in mathematics education were around student engagement.

7.3.8 Experiences Related to Student Engagement

Student engagement refers to the student's degree of attention, optimism, willingness, curiosity, desire, passion, and need shown when partaking in and succeeding in a learning process (Holmes 2018). It extends to the level of motivation that they have to learn and progress in their education (Davis, Kelley, Kim, Tang and Hicks 2016). Lecturers should therefore plan activities that nurture student engagement during pedagogical practices in mathematics. Student engagement, in other words, means a student's active participation in their learning.

Mathematics academics are often faced with poorly prepared students, many of whom do not want to know how to learn mathematics. This could be due to their self-conception of their ability and the difficulty of higher-level mathematics (Abramovich, Grinshpan and Milligan 2019). This may limit their engagement, especially for those who may have struggled with the subject, like the participants in this study. This is supported by Jankvist and Jensen (2018) who says that some student teachers who enroll in colleges have a poor mathematics understanding and background so they suffer from anxiety and lack of confidence in their mathematics ability, and this negatively impacts their class engagement.

Student engagement was revealed in an FFI by ST9 at College C when he said: "*I did not value the subject during mathematics time. I would just sleep in the lesson and I would not write the work".* The student teacher conceived mathematics as not having any value, and as such did not experience much engagement. L2 at College B confirmed the lack of student engagement in an FFI when he said: "*Some will sleep".* And when I asked what he did with those who slept he replied: *"Aah, will say… I will… I will… what can I say? I will ask the student to stand up and then ask her to sit"*. L2's response suggested negative student engagement.

During the lecture observations of L2 at College B and L3 at College C, some of the student teachers actually fell asleep during the pedagogical practices. Many factors may have contributed to these students dozing off in class. For example, the lecturer may only have concentrated on those who raised their hands, which has emerged in this study. The students may have lacked interest in and/or motivation for the subject, as ST9 above indicated. The students' desks may have been too far away from the lecturer, or the lecture might have been boring. Further, drawing on the comments made by ST9 above, some students experienced limited participation or engagement due to lack of a high regard for mathematics. Student engagement of that nature could impact negatively on the student teachers' learning experiences and mastery of mathematics concepts (Collaco 2017) considering that some of these students had sat for the O level mathematics examination more than once.
Lack of student engagement was also noted when I observed L2 at College B. In the mass lecture some of the students were seated about 50 metres away from the lecturer in the lecture hall. The distance between the lecturer and the students had a great effect as there was minimal eye contact and interaction between them during the pedagogical practices, leading to a rigid or formal classroom atmosphere. A lecturer can reduce the distance in such instances by walking around and maintaining constant eye contact with each student (Bambaeeroo and Shokrpour 2017) but this did not happen here. The great distance observed between the lecturer and the students was very likely a major contributor to the little or no engagement experienced by the students in College B. In addition to this some of the students' views were blocked by pillars in the lecture theatre which prevented them from seeing what was written on the chalkboard.

Reviewed literature suggests that students should choose a seating position with a viewing angle which is physically comfortable (Amasuomo and Amasuomo 2016). Uffler, Bartier and Pelaccia (2017) also propounds that a good classroom environment allows students to be physically positioned to hear any audible presentation, and is free from noises, blockages, distortions and hindrances so that students can see everything presented. When I observed L3's lecture in

College C, the lecture theatre was packed and many students fell asleep. This environment was probably the reason why the students had fallen asleep. Larger gestures and high voice projection often make up for the distance between the lecturer and the student teachers (Bambaeeroo and Shokrpour 2017) as these students need to hear every word clearly.

L2 at College B did not use a public address system to promote audibility during his lecture. Verbal communication is often meant to communicate knowledge, thus given this learning environment some students probably missed concepts or could not hear the lecturer, leading to their lack of engagement. When observing L2, animated gestures were used and these were effective for motivating and capturing the students' attention. Notwithstanding the one or two students who dozed off during this lecture, L2's use of animated gestures seemingly created positive experiences which impacted on the students' learning.

Still on this issue of mass lectures, ST6 at College B explained in an FGD: "*Imagine talking to 300 people, teaching them a simple concept in mathematics. Umm, in our case the general course comprises of 319 students".* This was confirmed during the lecture observation at the same college where L2 had about 400 student teachers in the mass lecture. In such situations, as the size of the audience grows it becomes increasingly difficult to ensure that students are actively engaged and comprehend the material being taught (Paris 2014). Non-verbal behaviours like facial expressions and eye contact convince student teachers to believe and trust the lecturer that the information being dispensed is authentic, however, this was apparently not possible with such large numbers, giving rise to a lack of student engagement.

From the discussion above on student engagement, the lack of it manifested in some student teachers falling asleep. This was broadly due to a lack of interest or motivation in the subject, seating arrangements, the distance from the lecturer, and pillars which obstructed the students' view of the lecturer and the chalkboard in the lecture theatre. These aspects gave rise to limited experiences of engagement during mathematics pedagogical practices in some colleges (Colleges B and C). Research reviewed indicates that most of these tertiary lectures are more than an hour long therefore students tend to get tired and doze off to sleep during the sessions (Buehl and Beck 2015). When one is not actively engaged for a long time, this often leads to drowsiness during mathematics pedagogical practices. Medina (2018) says that most instructors overlook the learning process and instructional theory since their lectures lack variety. In the observed lectures, teaching was a one-way communication process (lecture method) therefore the students probably lost focus and slept during these pedagogical practices.

Having discussed the experiences of the students during the mathematics lectures, the next section ties this chapter up with a conclusion.

7.4 Chapter summary

This chapter presented an analysis of the data addressing the student teachers' experiences of pedagogical practices. The major theme and sub-themes were discussed.

With regard to mathematics content knowledge, the student teachers studied across all of the colleges indicated that they had experienced more pedagogical knowledge than subject matter knowledge during their mathematics pedagogical practices. This was contrary to their expectations and needs. As these student teachers had struggled with passing the national O level mathematics examinations, they had hoped to learn a lot of both content and pedagogy.

In Colleges A and D, the student teachers studied experienced lectures where technological artefacts such as data projectors, PowerPoint presentations, interactive boards, electronic storage devices and the Internet were used to enhance learning during pedagogical practices. The use of technology was confirmed during the mathematics lecture observation in College D. Generally, all of the students experienced well prepared lectures but in College C they experienced re-cycled notes from previous years.

It also emerged that during mathematics pedagogical practices the students investigated experienced lecture introductions where the objectives or the lecture topic were highlighted. During the lecture observations only one lecturer welcomed the student teachers into the lecture, whereas the others simply wrote the lecture topic on the board and proceeded without outlining the goals of the day's lecture. L1 indicated that he recapped his last lecture in the introduction of the new lecture; however, this contradicted what the students in all of the colleges including his own said. Generally, what emerged was that the students did not experience any recapping of previous lectures during mathematics pedagogical practices.

With regard to teaching strategies, as highlighted earlier the students explored across all of the colleges experienced being taught using the lecture method. Thus, the student teachers in the colleges studied experienced the traditional approach to learning mathematics which some viewed as unsuitable for mathematics learning and mastery during pedagogical practices, given that understanding mathematics demanded lots of practice and calculations.

Regarding handling students' questions, the student participants revealed that they were not given an opportunity to ask questions during the pedagogical practices. In addition, the lecturers studied did not ask the students questions that required critical thinking, attributing this to limited lecture time or a desire to use such questions as take-home assignments. As such the students in this study did not experience answering questions requiring critical thinking, and this absence was confirmed during the lecture observations.
Regarding the use of manipulatives, the student teachers studied in Colleges A, C and D did not experience the use of such media during their mathematics lectures. It was only College B's student teachers who confirmed experiences of using manipulatives during mathematics pedagogical practices. Contrarily, however, no manipulatives were used during the lecture observation at this college. In their interviews the lecturers were quite clear on the non-use of manipulatives; therefore, one could conclude that no media were used during pedagogical practices. Further, none of the students studied experienced lecture conclusions. While the lecturer at College B indicated that he concluded his lectures with question and answer sessions, the absence of conclusions was also evident during the lecture observations in the selected colleges.

The time allocated for mathematics education was reported as insufficient for mathematics education by both student teachers and lecturers in this study. These time limitations were confirmed during the lecture observation at College D, when the end of the lecture arrived before the planned content was covered. Findings from all of the student teachers and lecturers explored also confirmed that students experienced assessment tests and assignments during their pedagogical practices in mathematics education.

In relation to student engagement, this study revealed that in Colleges B and C the students explored did not generally experience active engagement during mathematics pedagogical practices and some ended up dozing off. This was also evident during one lecture observation where about ten student teachers were captured asleep by the video recorder. Supporting pillars inside the lecture hall at College B, the distance between the lecturer and the students, the absence of a PA system, and unsuitable seating positions in the lecture room all contributed to the lack of student engagement. Lack of engagement was further confirmed by one lecturer in this study who clearly pointed out that some students slept during his lectures.

Having analysed and presented the findings on the student teachers' experiences of pedagogical practices in mathematics education, in the next chapter I present and discuss the findings addressing how conceptions and experiences influenced the student teachers' learning during mathematics pedagogical practice.

CHAPTER 8

DATA PRESENTATION AND ANALYSIS: INFLUENCE OF CONCEPTIONS AND EXPERIENCES ON STUDENT TEACHER LEARNING DURING MATHEMATICS EDUCATION

8.1 Introduction

The aim of the study was to understand the conceptions and experiences of student teachers about pedagogical practices in mathematics education in four teachers' colleges. As pointed out in previous chapters, the student teachers explored had struggled to pass O level mathematics. They wrote the National Mathematics Examination more than once before getting a pass. The previous chapter presented the analysis of the data for the second research question: – "*What are the student teachers' experiences of pedagogical practices in mathematics education?"* In answer to this question, experiences that emerged about pedagogical practices in mathematics were around content knowledge, technology, lecture preparation, lecture delivery, assessment, and lecture time for mathematics education and student engagement.

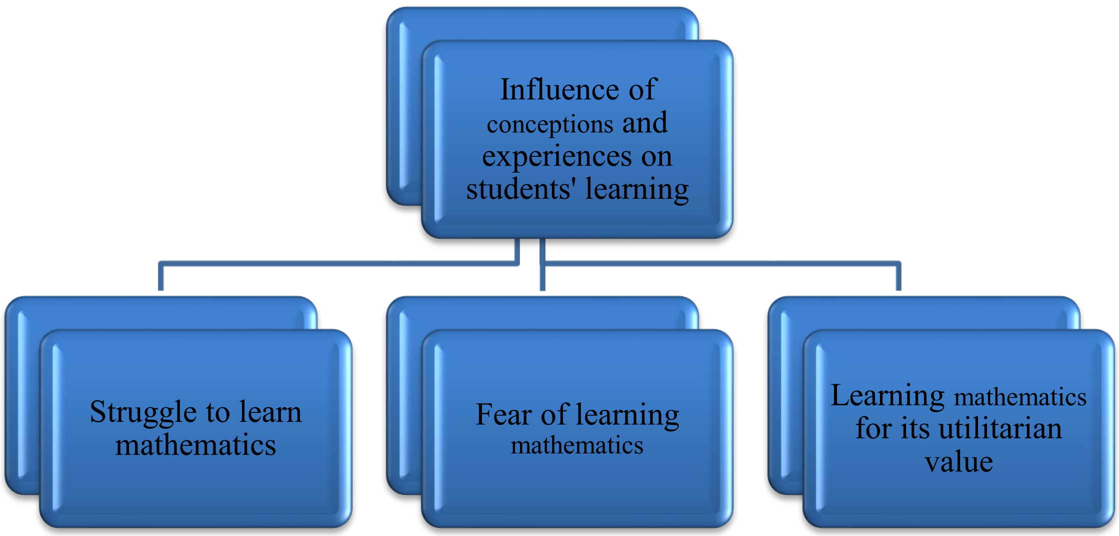
This chapter discusses question three: *In what ways do the conceptions and experiences influence their (student teacher) learning in mathematics education?* In presenting and discussing the findings, like in the other data presentation and analysis chapters, all of the data from the focus group discussions, face-to-face interviews and observations of lectures is discussed together.

8.2 Themes that emerged on influence of conceptions and experiences on student teachers' learning

In answer to this question, three themes emerged: struggle to learn mathematics, fear of learning mathematics and learning mathematics for its utilitarian value. These themes which frame this chapter are discussed in turn in the chapter.

The ways in which the conceptions and experiences influenced the student teachers' learning during pedagogical practices in mathematics education are reflected in Figure 8.1.

Figure 8.1: Influence of conceptions and experiences on students' learning



Source: Researcher (2021)

8.2.1 Struggle to learn mathematics

Struggling to learn mathematics emerged as one of the influences of the conceptions and experiences on student teachers' learning during mathematics pedagogical practices. As these students had struggled to pass mathematics at O level, their earlier experiences and conceptions seemingly gave rise to difficulties in learning mathematics during mathematics pedagogical practices in the colleges.

To illustrate this, participant ST5 said in an FGD at College D in answer to a question on the influence of conceptions and experiences on mathematics learning: "*What I know is that one's bad conceptions affect experiences and they have a bad effect in anything that one wants to do because I struggled with mathematics and I am struggling more in college".* Another student, ST9 at College C also said in an FGD: *"It affects me in a negative way because I did not expect to come across any difficult mathematics in college which will lead to struggling in the learning* *of mathematics. I was expecting to deal with simple numbers in those simple ways, but its complex and I have problems"*. Similarly, ST2 at College B also said in their FGD: *"My greatest challenge is doing the subject that I passed after a struggle; I am struggling with this subject again."* From the responses provided by the students, their conceptions and experiences of mathematics impacted negatively on their learning during pedagogical practices in college.

"*Negative"* implied in the response was an indication that learning was hindered by their conceptions of mathematics, giving rise to feelings of struggling with the subject during mathematics pedagogical practices. The findings were supported by reviewed literature (Mohyuddin and Khalil 2016) which indicates that errors and misconceptions that students develop during previous classes or which they bring to the learning context can create barriers in the on-going learning of mathematical concepts, which may then lead to failure in mathematics. This appears to have been the case in this context. The students' past experiences with mathematics, where they struggled to pass, led to conceptions that they would experience challenges in learning the same subject in college since college mathematics proved to be difficult (*complex*) for them. When a student approaches a learning situation anticipating failure or struggle, they are likely to fail or struggle. Thus, students in this study apparently envisioned that since they had struggled and experienced problems with the subject in order to enter teacher education, further mathematics learning during college pedagogical practices would be another struggle. This was supported by reviewed literature (Jenkins 2002: 53) which propounds that, "*If students struggle to learn something, it follows that this thing is for some reason difficult for them to learn"*.

The quotation by ST9 on the other hand suggested that during pedagogical practices in mathematics education, the student expected to experience simple mathematics; however this was not the case. The student probably anticipated simple mathematics because they were training to be primary school teachers or because they had eventually passed the subject at O level. The type of mathematics that the student experienced during pedagogical practices was difficult, in other words it was beyond their cognitive ability and they had to transcend the mathematics they would teach the primary school child. These negative conceptions towards,

and expectations to study simple mathematics seemingly hindered their motivation to learning challenging mathematics. The students in their responses thus also portrayed traditionalist conceptions about mathematics; that mathematics was difficult (Vintere 2018).
ST2 openly admitted that during mathematics pedagogical practices prior conceptions and experiences influenced him to struggle to learn mathematics, as it was the same subject he had struggled to pass at O level. Literature surveyed also revealed that the conceptions students have of a particular subject they are studying affect their approach to studying it as well as learning of that subject (Pilegard and Mayer 2015). From the responses by ST5, ST9 and ST2 it was clear that prior experiences and conceptions shaped their learning of the subject of mathematics, and this was likely to have a lasting influence on their learning. Literature consulted revealed that in such situations it becomes difficult to accept new concepts which are unfamiliar and different from prior experiences and conceptions (Heckler and Mikula 2016). Therefore, students' conceptions about mathematics and their past experiences in mathematics appeared to be an impediment to their learning of mathematics in mathematics education pedagogical practices.

Also describing how their conceptions and experiences impacted on their learning, in an FFI another student, ST2 at College B said: *"... I struggled to pass this subject and I struggled to make my learners understand when I was on teaching practice. I have a hard time with mathematics at college. I still struggle".* Struggling to learn was also mentioned by another student, ST8 at College D in their FFI when they revealed: *"... Mathematics since I struggled with this subject, I again struggle with my studies at college. Mathematics is difficult".* Another participant, ST1 at College A, also revealed struggling to learn mathematics when they indicated during their FFI: "*Your view will greatly affect your learning and your learners… since I wrote mathematics thrice. I just feel bad about it. I just struggle to pass it".* The struggle to learn also came up in an FFI at College C, when student ST4 said: *"I did mention earlier that I passed mathematics after re-writing and so I have that feeling of saying I am not mathematics…. I am not mathematically competent, therefore am struggling with the subject…."*

Quotes from the students in both FDGs and FFIs indicated that during mathematics pedagogical practices they struggled with mathematics as their conceptions and experiences with the subject related to failure. ST2 conceived that since she struggled to pass mathematics, and experienced difficulties in delivering mathematics lessons during teaching practice and thus failed to make her own learners understand the subject's concepts, she still struggled with mathematics in college. According to this student's conceptions, she was experiencing further problems with the subject. This therefore implied that the problem of low mathematics proficiency would continue during mathematics pedagogical practices in college, given that low achievement in the early schooling often affected students' abilities, making it more difficult for them to succeed in higher level mathematics courses. This finding was supported by literature consulted (Maciejewski and Merchant 2016) where a negative mentality, as highlighted by ST2, ST8, ST1 and ST4 above, can result in loss of confidence, motivation and unsatisfactory learning, instead of pleasurable lasting practices and philosophies that may promote a rich mathematical understanding. Student teacher ST8 clearly conceived that it was a struggle to pass O level mathematics and such conceptions influenced this student to anticipate further struggles with the subject during pedagogical practices. The response reflected another conception about mathematics held by this student teacher about a continuous struggle with mathematics at college, given their earlier encounters with the subject. Thus, students in this study who struggled to pass mathematics generally found the subject difficult during mathematics pedagogical practices. From the above responses, it was evident that the students reflected traditionalistic conceptions about mathematics; that it was a difficult subject (Yuanita, Ibrahim and Isnawati 2018).

As mathematics became more advanced and challenging, such students often experienced problems since they needed to work harder and practice more in order to understand the more advanced mathematics concepts. Therefore, during mathematics pedagogical practices such student teachers would likely struggle with learning. ST4 declared that he was not cognitively capable of working out the college mathematics during pedagogical practices after previously experiencing struggles with the subject. This lack of zeal to learn mathematics impacted his mathematics learning during pedagogical practices, leading to further struggling with the subject.

Commenting on the struggle to learn mathematics in an FFI, another student, ST9 at College B indicated that:

> *… Given that choice, I wouldn't have to teach it since I struggle. But for the sake of learners and for the sake of this unending change of this world, I will teach them for the sake of their future. But if it didn't have an impact on their careers, I wouldn't.*

Drawing from the response above the student teacher conceived that teaching of mathematics would be done as a duty, otherwise given the choice they would not teach the subject at all. A teacher with such conceptions would definitely be negatively affected during pedagogical practices in mathematics (Chiou and Liang 2012). The student was aware of the importance of mathematics in the world around her and in her career, therefore had no choice except to teach the young learners. This implied teaching as a duty. Reviewed literature (Boyd 2018) indicates that to some teachers, mathematics is not a priority because they lack confidence and so they would rather teach other curriculum subjects instead of mathematics. From the response by ST9 at College B, mathematics learning had been a struggle before entering teacher education and would continue to be a struggle during pedagogical practices in teacher education.

On the same issue of struggling to learn, student ST9 at College C also said during their FFI: *"Yes, it affects me because when I chose my main subject I put mathematics as the last choice but they chose mathematics for me. I am doing environmental studies; I changed from mathematics because I did not want to struggle anymore".* ST9 had this strong conviction and conception that studying mathematics would be a struggle and as such had not chosen mathematics as their subject of specialisation. This finding was supported by literature consulted (Mensah 2013) which says that such conceptions are detrimental and they may cause the student to experience a negative influence on their learning of mathematics, thereby affecting their performance in the subject. In primary teachers' colleges students are required to choose a major study area or specialisation, which they will study in depth in college and then teach in a primary school. From the response, mathematics was indicated as their last choice of specialisation, but the college ignored their preference and assigned them to specialise in mathematics anyway.

This was not acceptable to the student, who consequently changed to environmental studies as their major subject.

Students are expected to choose to major in mathematics, with the anticipation of enjoying the subject during pedagogical practices. The conceived rigour and difficulty of mathematics as a result of these students having to struggle to pass it at O level could give rise to further struggles during mathematics pedagogical practices. From the literature reviewed (Hiebert 2013), a struggle takes place when a student does a task or problem that seems beyond their potential. This rejection of mathematics as the major subject for specialisation was aligned to the traditionalist conceptions that mathematics is for a selected few people (Skemp 1978; Lerman 1983; Dionne 1984; Yang et al. 2019).

Contrary to the above, some students who had previously struggled with the subject benefitted from those struggles, as illustrated by one student. Student ST7 at College B, who stated during an FGD: "*Though I once struggled with mathematics, it never affected me in any way… I even wanted to do mathematics as my main subject but they put me where I had the best passes".* ST7 conceived that despite their struggle to pass O level mathematics, they were still prepared for further mathematics studies during mathematics pedagogical practices. It would appear that the continuous struggle with mathematics was beneficial to the student, since it led the student to being motivated towards studying the subject further during pedagogical practices. That familiarity with mathematics helped this student to move on with confidence and the previous stumble or fall did not deter them from their desire to pursue mathematics during pedagogical practices.

The other conception around the student teacher's response was that he had selected mathematics as his first choice of subject for major study. This student did not anticipate any further struggles with mathematics during mathematics pedagogical practices after struggling with it at O level, given his choice of mathematics as his main study area. When student teachers chose their subject for specialisation, their conceptions of learning it were elevated and readiness was stimulated during pedagogical practices. However, when subjects were imposed on them by their colleges, learning was undertaken as a mandate and they were not necessarily comfortable with the imposition of the subject. This student's response could imply that they had reached their ZPD (Vygotsky 1978; Kim 2001; Vintere 2018) by studying and re-sitting the national mathematic examination and were thus prepared for further mathematics study during mathematics pedagogical practices. This was likely to have given rise to effective learning during mathematics pedagogical practices. The student teacher conceived that their past academic experiences and conceptions had not influenced their current mathematics studies during mathematics pedagogical practices. In other words, student teachers' conceptions and earlier experiences of mathematics did not always influence their learning negatively during pedagogical practices.

The question about influences was also posed to lecturers. Three out of the four lecturers felt that conceptions and past experiences had a negative influence on mathematics learning during pedagogical practices. For example, mathematics lecturer L1 at College A said in an FFI: "*If one does something again and again to no avail one gets demoralised, so these students definitely hate the subject. ... Their prior experiences affect their learning adversely"*. According to L1, their experiences of continuous failure negatively influenced their mathematics studies during pedagogical practices in college. This "*doing something over and over again"* according to L1 eventually led to hatred of the subject, thus influencing in a bad way their learning of mathematics during mathematics pedagogical practices. Consulted literature (Lurea 2015) indicates that experiences of failure can lead to serious consequences, given that students who fail become discouraged, decrease efforts, lose self-confidence, and are more likely to fail again. This related to what L1 in this study referred to when he said that students' negative experiences in mathematics impacted negatively on their later learning of mathematics during pedagogical practices. L1 used the word *'adversely*', portraying the gravity of the influence of conceptions and experiences on students' learning of mathematics at college. Literature reviewed (Doabler and Fien 2013) further indicates that student teachers conceive the subject as demotivating because they struggled with it at a lower level and anticipate further struggling at tertiary level. These students studied experienced failure and struggled to pass O level mathematics, thus their conceptions and experiences brought about further struggle to learn at college level during mathematics pedagogical practices and this negatively affected their learning. The lecturer's response was in line with the traditionalist conceptions where mathematics is conceived as difficult, and will always be difficult hence the conception that mathematics is not for everyone (Vintere 2018; Ochagavia 2019).

Responding to how conceptions and experiences influence students' mathematics learning, another lecturer, L2 at College B, further added during their FFI:

> *It greatly affects because once you consider a subject to be difficult, then your mindset is in such a way that this is a very difficult thing to do. Then at the end everything that is done is always a struggle.*

L2's response implied that once mathematics was conceived as difficult it would be a struggle to study and master it during mathematics pedagogical practices. This finding was supported by literature consulted (Bates, Latham and Kim 2013) which as highlighted above indicates that the student teacher's past experiences will affect and influence further studies in mathematics, leading to lack of confidence in their teaching and learning ability, teaching methods and content knowledge. L2's responses conclusively reflected that a student's conceptions and experiences influenced further learning during pedagogical practices. The lecturer's comments implied that the student teachers' personal conceptions about mathematics and previous experience of schooling were a strong influence alongside any formal higher education experience of mathematics they gained during the teacher education programme. The lecturers from the three colleges anticipated that students who struggled to pass O level mathematics would struggle; they apparently did not leave room for any exceptions, which conveyed traditionalist conceptions of mathematics. As lecturers were expected to demystify negative conceptions about subjects, these lecturers' conceptions displayed above did not help in turning the students' conceptions around.

While lecturers at Colleges A, B and C confirmed that conceptions and experiences influenced learning during pedagogical practices, contrary to this L4 at College D, when asked about the influence of conceptions and experiences on student learning during their FFI, replied:

They regard mathematics as very important despite the number of times they wrote the subject. In fact, they work hard and do not struggle with the subject; most of them feel they should take it to higher levels since this time they get to understand better.

Notwithstanding that some students had struggled to pass mathematics, L4 conceived that they viewed it in high regard and wanted to take the subject further. It was the value attached to mathematics that meant that some students still wanted to pursue the subject, despite their previous experiences and conceptions. Such students were therefore not intimidated by the complexity of mathematics during the mathematics pedagogical practices and worked hard to understand the subject. Thus, the conceptions and experiences of this category of students seemingly did not have any negative influence on their mathematics learning. L4 also added: "*They are likely to take the subject further if they get financially stable. Their hope is that this is a starting point".* The lecturer conceived that, funds permitting, these student teachers would advance in mathematics studies after teacher training. Prior struggles with mathematics seemingly taught these students that failure was a way of learning from their errors, since life was full of second chances. Thus, previous failure need not influence current or future mathematics learning during pedagogical practices. Such students probably benefitted from repeating mathematics and may have gained confidence and significant understanding of the concepts to be used as tools during mathematics pedagogical practices. In other words, according to L4, these other students' conceptions and experiences of mathematics education exerted a positive influence on their learning. L4's conceptions were that there had been a paradigm shift in conceptions since these students had outgrown their previous conceptions and their previous experience might have helped in the change of these conceptions (Golding 2017).

From the above discussion on the influence of the conceptions and experiences on students' learning, 39 students in the study revealed that they struggled to learn mathematics during mathematics pedagogical practices. For example, ST9 at College C clearly showed that conceptions and experiences influenced his learning as he changed from mathematics as his major subject (which had been allocated to him) to environmental studies, evading further struggles in mathematics. However, one of the students explored (ST7 at College B) conceived that conceptions and past experiences had no influence on his mathematics learning during pedagogical practices and he was prepared to major in mathematics, albeit that he was given another subject for specialisation. Generally, lecturers at Colleges A, B and C confirmed that conceptions and experiences had a negative influence on the student teachers' learning during pedagogical practices. L1 added that something should be done with strugglers since they should not become mathematics specialists. He further revealed that once a student struggled with mathematics, they were likely to continue struggling to learn mathematics at a higher education level and that this would then carry over into their teaching. The lecturers' traditionalist conceptions were contrary to socio-constructivist conceptions. According to the socio-constructivist theory, the students who struggled during mathematics lectures should be scaffolded with clear directions, using methods that allowed them to reach their ZPD (Vygotsky 1978; Kim 2001). The assumption was that mathematics learning for retention was done in stages and students learned skills gradually through instruction, practice and apprenticeship. Contrary to what L1, L2 and L3 said above, L4 at College D revealed that some of the students were enthusiastic and were prepared to pursue further studies in mathematics, even up to degree level. All except one student indicated that their conceptions and prior experiences of mathematics education brought about struggles in learning mathematics. These aspects gave rise to fear of learning the subject of mathematics. This fear is discussed next.

8.2.2 Fear of learning mathematics

Students in learning situations tended to be intimidated by mathematics or felt that they were not mathematics competent. Some conceived mathematics as a difficult subject, which could not be learnt by everyone and this brought about fear of the subject. Literature reviewed (Chinn 2012) indicates that students conceive mathematics as the most disliked, dry and boring subject and in most cases, mathematics stimulates feelings of stress; anxiety and fear. In Zimbabwe mathematics was generally conceived as a filter that hindered many students from pursuing career aspirations since it was a pre-requisite in most civil professions, including tertiary institutions.

In this study, fear of mathematics generally referred to being afraid of manipulating numbers, which created tensions that influenced learning during mathematics pedagogical practices. According to Whyte and Anthony (2012: 4), "Mathematics fear or phobia produces a negative response specific to the learning or doing of mathematics activities that interfere with performance". The student teachers in this study wrote and re-wrote mathematics to gain entry in teachers' colleges. This phobia while in college could have emanated from those earlier experiences of failure. Surveyed literature (Zambo and Zambo 2006: 15) indicates that: "If mathematics makes a student fearful, the learning and teaching of mathematics will be marked with negative emotions and bodily sensations and these may have a powerful and long-lasting effect on the learning of mathematics". Drawing on this literature, the struggle to pass O level mathematics may have developed this fear of mathematics, as revealed in the FGDs and FFIs that I held with the students who participated in this study.

Fear was mentioned in an FGD at College C by student ST9, who said:

> *The way he taught us gave us fear that if you don't pass this subject you are nothing, so by experiencing fear during learning we thought that when we don't know mathematics we are nothing. She didn't encourage us to work hard, but we became fearful….*

Asked about the great challenge of learning mathematics, participant ST10 at College D also said in an FGD: *"… The subject mathematics which I struggled to pass. I fear to fail again; this is my greatest challenge"*. From the responses above, students' conceptions and experiences brought about fear of learning mathematics during pedagogical practices. ST9's conceptions and experiences led him to being fearful of learning mathematics, which was worsened by the lecturer's negative, intimidating and demoralising comments which further affected his mathematics learning during pedagogical practices. Again, what the lecturer portrayed here were traditionalist conceptions whereby mathematics was conceived as a subject for a selected few. ST9's response was in line with literature reviewed (O' Leary, Fitzpatrick and Hallett 2017) which indicates that fear is strongly linked to poor mathematics learning and teaching and is brought about by past and current experiences. Fear of mathematics led to underachievement, and the traditional lecture rooms which were apparently dominant in these teachers' colleges were unhelpful in eradicating this fear. This finding was supported by literature (Schmidt 2016); that fear of mathematics leads to under-performing in the subject, and can make learning of that subject a daily struggle for student teachers during mathematics pedagogical practices. Further literature (Firdaus 2017) indicates that the traditionalist conceptions about mathematics which employ direct and deductive mathematical approaches to mathematics teaching result in having students anxious and fearful to the extent of avoiding the study of mathematics.

From the above responses the students clearly reported fear during pedagogical practices and this fear had a negative influence on their learning. Student teachers in both the FGDs and FFIs further indicated how they had fearful experiences during pedagogical practices. For example, another participant, ST7 at College C, said in an FGD: *"I think the people (parents or grandparents) who wrote mathematics first and failed it thought the subject was very hard, so children grow up with the fear of mathematics and this affects learning of mathematics in later life".* According to ST7, society carried this myth that mathematics was difficult; a traditionalist conception about mathematics. Society was another source of fear, which was passed through generations and subsequent generations grew up with that fear of mathematics. ST7 conceived that the fear of mathematics experienced by their forefathers had filtered through to the current generation to influence and build fear in them, and this fear manifested during mathematics pedagogical practices.

In an FGD at College C, fear of mathematics was also revealed when another participant, ST10, said: *"I was a little frightened and became fearful when I saw mathematics on my timetable"*. Another student ST2, at College B said during their FGD: *"When I met challenging topics at college I feared…. I have got the fear of failing the subject".* In further relation to fear, another participant, ST5 at College A also indicated in their FFI that: "*Writing O level mathematics examinations made me fear this subject, therefore writing mathematics tests in college is my greatest challenge. I fear that I will fail".*

The findings from ST10 were that he became fearful upon discovering that further studies were required in mathematics when he started at the college. Such a mismatch between a student's expectation and reality often potentially influenced their learning during mathematics pedagogical practices. These findings were also supported by further literature which stated (Hacking 2014) that students who highly feared mathematics were less prepared for mathematics classes.

The findings also revealed that ST2 feared challenging topics which would influence their performance and lead to their failure during pedagogical practices in mathematics. ST5 at College A indicated that the fear of writing mathematics tests influenced his mathematics learning during pedagogical practices. This finding related to reviewed literature (Sa'ad, Adamu and Sadiq 2014) where written tests elevated the student teachers' fear or anxiety. Fear generally influences concentration when preparing for tests and examinations, since students will be afraid that the test will determine their fate. However, Mukeredzi (2016) notes that fear is not always bad after all, as it heightens one's awareness of things that need attention. This fear could therefore be of tremendous advantage as it pointed out what could go wrong, so that students could prepare themselves for any obstacles which arose. In this case fear could give the students energy, excitement and anxiety, all of which could be channeled into motivation or alternatively dislike (Bekdemir 2010), as was the case in this study.

In addition to the students' comments about fear of mathematics, the lecturers also revealed students' fear of learning mathematics. For example, L2 at College B said in an FFI: "*They are full of struggle to learn mathematics, and full of fear and anxiety*". L2's response revealed that students strove to learn mathematics but were afraid and anxious to learn the subject.

Findings revealed that the student teachers were afraid of mathematics due to their conceptions and earlier experiences which triggered their fear and this fear influenced their learning during mathematics pedagogical practices. Two students in the study had not anticipated studying mathematics in college, while three did not expect any challenging mathematics topics at college level. While lecturers, for example L2 at College B, generally felt that students' conceptions and experiences gave rise to their fear of mathematics during pedagogical practices, their conceptions were that of expectation of fear in the students. Other students revealed that their conceptions and experiences made them study mathematics for its utilitarian value and this subtheme is discussed next.

8.2.3 Learning mathematics for its utilitarian value

For a nation to be well developed economically, politically, technologically and scientifically (engineering) there is a need to put great emphasis on mathematics teaching and learning. This is supported by surveyed literature (Walshaw 2012) which indicates that mathematics plays a central role in shaping how individuals deal with various spheres of private, economic, social and civil life. As revealed by the data, the students who participated in this study studied mathematics as a last option, repeatedly wrote mathematics in order to qualify to enter teacher training and further studied mathematics in college in order to qualify as teachers.

Learning mathematics for its utilitarian value was indicated by participant, ST7 at College D who said in an FGD:

> *I was only forced to write mathematics, again and again, to gain entry into a teachers' college. If it was not for that, I would not have studied mathematics after failing it the first time.*

In the same vein, another student said in an FFI at College B:

> *In mathematics, especially when you want to become primary school teachers, you do studies in mathematics at college, because you still need mathematics in the teaching and learning of the learner. That is, mathematics is a requirement* (ST10).

ST10 added:

> *You know, some of us just studied mathematics because it was a requirement to get a place at college and I am studying the subject at college for me to become a teacher, otherwise I should not have bothered myself with the subject. I tell you, I hate the subject! I hate the subject! I know I will fail my final examinations. I have failed before…*

The participants quoted above indicated that their conceptions and experiences influenced them to view studying mathematics as a requirement; a pre-requisite for entry into teacher training and also mandatory for primary school teachers. It appeared as if, had mathematics not been a requirement, these student teachers would probably not have been studying mathematics at all. ST7's conception was that he was influenced to write mathematics several times in order to get a place for teacher training. Such a student, according to constructivist conceptions, is not process oriented but is concerned rather about the result; a pass in mathematics (Skemp 1978; Lerman 1983; Dionne 1984; Ernest 1988; Toner and Grigutsch 1994). Davies, Hersh and Marchisotto (2011) conceived mathematics as a vital subject, not only for getting an academic qualification at school or college or to be studied as a requirement, but also for its value. ST10 wanted to join teacher training therefore the situation forced this student to study and obtain a pass in O level mathematics. Mathematics should not be studied with the view of it as a last resort but rather as a necessity since all everyday activities revolve around the subject. Negative dispositions displayed by ST10 induced tendencies of fear, anxiety and stress thus influenced their learning of the subject during mathematics pedagogical practices.

Conceptions during pedagogical practices influenced mathematics learning and the subject was only studied because it was mandatory. The sentiments expressed by ST10 were supported by reviewed literature (Larkin and Jorgensen 2016) which indicates that student teachers who have negative conceptions will say things like: *"Mathematics is my enemy"*, and *"Mathematics is something that I hate"* (ST 10), and such conceptions will influence students' learning if they are exposed to further mathematics studies during pedagogical practices. This student only studied mathematics for its utilitarian value to enter teacher education and to qualify as a teacher.

From the discussion above, findings revealed that student teachers in two of the colleges studied conceived that their conceptions and experiences influenced them to study mathematics for its immediate utilitarian value - entry into teacher education and obtaining a teaching qualification. ST10 at College B showed outright distaste for mathematics and this clearly reflected that she only studied mathematics for its functional purpose, which possibly influenced her mathematics learning during pedagogical practices. According to the constructivist conceptions about mathematics, learning should be a fun and meaningful experience for students where problems are introduced within contexts and the teacher then acts as a facilitator to help them solve these contextual issues (Yuanita, Ibrahim and Isnawati 2018). Mathematics therefore needed not to be learnt for its utilitarian value during mathematics pedagogical practices but rather for in-depth concept mastery and application in daily life.

8.3 Chapter summary

The chapter analysed and discussed the findings around the influence of conceptions and experiences on students' learning during pedagogical practices in mathematics education. The ways in which conceptions and experiences influenced student teacher learning emerged around three aspects: struggle to learn mathematics; fear of learning mathematics; and learning mathematics for its utilitarian value.

To begin with, the study discovered that all except one student conceived that conceptions and past experiences had influenced them to struggle to learn mathematics during pedagogical practices. If students lacked sufficient mathematical skill and understanding this affected their ability to pursue further mathematics studies, thereby leading to them struggling during mathematics pedagogical studies. According to the conceptions about mathematics, a student teacher's conceptions are key factors that shape their autonomy in the lecture room during training and the classroom when they qualify, and thus they have a significant impact on any learning (Ernest 1989; Vintere 2018). These conceptions and past experiences appeared to be strong enough to either facilitate or inhibit learning during mathematics pedagogical practices.

Generally, in relation to struggling to learn, three lecturers at Colleges A, B and C confirmed that conceptions and prior experiences negatively impacted on student teachers' learning during pedagogical practices. One of the lecturers added that these strugglers should not be allowed to train as mathematics specialists. This was supported by surveyed literature (Beilock and Maloney 2015) which indicated that there has been renewed emphasis and research regarding struggling in learning mathematics and one thing that seems to be certain is that students who struggle in mathematics in their early years remain struggling in their later years. The lecturers also added that once a student struggled with mathematics at a lower level, chances were that the student would struggle to learn mathematics at a higher level. According to these lecturers' conceptions, a student's conceptions and experiences had an influence on further mathematics learning during their pedagogical practices. Contrarily, L4 at College D revealed that some students, for example one in this study who had struggled, were prepared to pursue further studies in mathematics. Such students who once struggled with mathematics could possibly have learnt to turn their insecurities in mathematics into positive conceptions. Thus, the struggle could have pushed them to reach their ZPD (Kim 2001).

Secondly, it emerged that all of the students across all of the colleges experienced fear during mathematics pedagogical practices, which emanated from their conceptions and prior experiences. Findings also revealed that this fear affected their performance during tests, and learning challenging topics. While four students had not anticipated learning mathematics at college, they also expected to learn simple primary school mathematics and not difficult mathematics during mathematics pedagogical practices. Reviewed literature (Nolting 2011) which indicates that fear produces negative responses specific to learning or doing mathematical activities that interfere with performance. A lecturer studied at College B also confirmed that students' conceptions and experiences brought about fear of mathematics during pedagogical practices.

Further, from the findings in this study, all of the students in teachers' colleges B and D, and about six student teachers in each of the other two colleges, had conceptions and experiences that influenced them to study mathematics for its utilitarian value only. This was consistent with traditionalist conceptions which conceive that mathematics is learnt for utilitarian purposes only (Vintere 2018). In Zimbabwe teaching was the only profession where on course completion the students were assured of a job. Therefore, although students hated mathematics, as was revealed above, they were forced to write and rewrite the subject in order to join teacher training. During mathematics pedagogical practices these students were being prepared to teach mathematics in the primary school environment, forcing them to continue studying the subject that they had previously struggled to pass. Thus, from the findings, students had to learn mathematics as it was a requirement.

Having analysed and presented the findings on the influence of conceptions and experiences on students' learning during pedagogical practices in mathematics education, in the next chapter I synthesise the findings and discuss the conclusions and implications for teacher development in Zimbabwe.

CHAPTER 9

DISCUSSIONS, CONCLUSIONS AND SYNTHESIS

9.1 Introduction

This study sought to investigate student teachers' conceptions and experiences of pedagogical practices in mathematics education in four selected teachers' colleges. A definition by Jong, Hodges, Royal and Welder (2015) views conceptions as specific meanings attached to phenomena which then mediate the response to situations involving those phenomena. These are psychologically held propositions or understandings about the world that are conceived to be true. In this study, conceptions are therefore understood as the specific meanings attached to the phenomenon - the pedagogical practices in mathematics education. In other words, conceptions in this study represent specific meanings that student teachers attached to the teaching and learning of mathematics during mathematics education lectures. As conceptions are formed of virtually every aspect of our perceived world, in so doing, those abstract representations are used to delimit something from, and relate it to, other aspects of our world (Jong et al. 2015). Conceptions then mediate the student teachers' views of mathematics pedagogical practices in mathematics education, and how they respond to their learning context (Canbay and Beceren 2012).

Mathematics is vital for: the development of technology and society as a whole, scientific research, electrical and mechanical engineering, computer programming, and company management or finance since these fields require a significant amount of mathematics (Hallstrom and Schonborn 2019). For a mathematically literate citizenry, mathematics teacher education is expected to be aimed at the development of mathematics teacher competencies, adequate mathematics subject knowledge, appropriate attitudes and dispositions towards mathematics teaching, as well as proficiencies that empower the mathematics teacher to meet the demands of the subject and its challenges (Tang 2017).

In Zimbabwe, at the time of this study, teaching was the only source of employment on successful accomplishment of the teacher education programme due to a national economic collapse. Given that situation, O and A level graduates were left with no option but to enter teacher education. However, these student teachers in teacher training colleges were a combination of those who had passed O level (equivalent Grade 11) mathematics at first sitting, and those who had passed mathematics after more than one sitting. Due to the fact that mathematics was a pre-requisite for entry into teacher education and other formal professions (Zimbabwe Education Policy 2017), these students had to write and re-write the mathematics national examinations until they obtained a pass at Grade C (50%) or better in the subject. With this mixed bag of student teachers (with one sitting and multiple sittings), teacher education had to ‘stew’ and develop these cadres into competent mathematics practitioners notwithstanding that some of them had struggled to pass the subject.

Reviewed literature (Canbay and Beceren 2012; Mukeredzi 2013; Jong et al. 2015) sums up the value of conceptions by pointing out that teacher conceptions and teacher practice are intimately related as conceptions shape teachers’ instructional behaviour and students’ learning in particular regarding the choice of pedagogies, teaching materials and learner activities. Further literature surveyed (Vettori 2018) indicates that student teachers’ conceptions and experiences about mathematics impact the way they learn and approach mathematics. Mathematics teacher education equips student teachers with sound mathematics pedagogical theory, teaching skills, mathematics content knowledge, and mathematics pedagogical content knowledge (Darling-Hammond 2006; Mills and Goos 2017; Odalen, Brommesson, Erlingsson, Schaffer and Fogelgren 2019). Therefore, for effective mathematics teaching, in addition to the highlighted knowledge domains, student teachers’ conceptions are viewed as critical contributors to children’s meaningful learning and acquisition of mathematical knowledge and eventually their achievement and education quality. Barber and Mourshed (2007) indicate that: to achieve a quality education, first of all there should be quality teachers. Quality mathematics teachers are only possible through quality mathematics learning prior to and during teacher education. Teacher education is therefore challenged to produce mathematics teachers with appropriate knowledge, skills, aptitudes and conceptions.

Given that the student participants in this study had struggled to pass O level mathematics, and given all of the above, developing an understanding of their conceptions and experiences and how these influenced their learning during pedagogical practices in mathematics education was worthwhile. As these student teachers investigated in my study represented student teachers in Initial Teacher Education (ITE), studying them located this enquiry within wider discourses on teacher development.

Four research sites (two government and two missionary teachers' colleges) were involved. The study sought to answer one major research question: What are the student teachers' conceptions and experiences of pedagogical practices in mathematics teacher education in selected teacher training colleges in Zimbabwe? To answer this key question, it was vital to unpack it into three subsidiary questions which the study had to address:

1. How do student teachers conceive pedagogical practices in mathematics education?
2. What are the student teachers' experiences of pedagogical practices in mathematics education?
3. In what ways do the conceptions and experiences influence their learning?

Answers to these questions would then enable the study to explain the student teachers' conceptions and experiences of pedagogical practices in mathematics education in the selected teachers' training colleges. The three previous chapters presented the findings addressing these research questions. This chapter discusses, concludes and synthesises these findings, explaining how the student teachers who struggled to pass O level mathematics conceived and experienced, as well as how these conceptions and experiences influenced their learning during pedagogical practices in mathematics education in teacher development.

Drawing on the findings in Chapters Six, Seven and Eight of this thesis, this chapter attempts to explain the student teachers' conceptions and experiences and how these influenced their learning during pedagogical practices in mathematics education. This chapter will also extract some implications for teacher development in Zimbabwean teachers' colleges in general, and the student teachers studied in particular.

In discussing, concluding and synthesising the research findings in answer to the student teachers' conceptions and experiences of pedagogical practices in mathematics education in the four selected teachers' colleges in Zimbabwe, the chapter is organised into five sections. I first outline my methodological reflections of this study. I then offer a review of the study where I briefly summarise what is contained in each of the nine chapters of the thesis. Subsequent to that, I discuss the findings of the study under each research question. The chapter further presents the implications of the study's findings for the Ministry of Higher and Tertiary Education Science and Technology Development (MHTESTD), teachers' colleges, mathematics teacher educators, and student teachers. Finally, the implications for research are presented.

9.2 Methodological reflections on the study

My study was located in the interpretive paradigm and used a multiple site case study design (Yin 2013; Alpi and Evans 2019) which involved four primary teachers' training colleges to obtain a detailed and in-depth understanding of student teachers' conceptions and experiences of pedagogical practices in mathematics education. Albeit that travelling to these sites was expensive, it was beneficial in developing a deep understanding of the differences and similarities between the cases, and to enable analysing the data both within each case and across cases. Also, as I reflect on it, this made it possible to augur either contrasting or similar results in the study (Yin 2013). Often when case studies are compared, the researcher can provide rich findings from the contrasts and similarities, making the findings strong and trustworthy (Yin 2013, 2014). Thus, the multiple site case study design allowed me wider scope for exploration of the research questions as well as theoretical evolution.

Three of the colleges were in the same provincial authority, two of them being private colleges but under different church governance. These two were also located in different rural settings, while the third which was a government owned college was located in an urban setting. The fourth college, another government run institution, was in a different town and province approximately 300km from my home location. However, like any research of this magnitude, I encountered some challenges with one college (College C), where I made several visits in order to obtain gatekeeper consent to conduct research with their student teachers and staff. This was notwithstanding that the same Head of Institution had offered me verbal consent when I submitted my permission request letter. Consent was eventually granted. As I reflect on this, I realise that I should have started requesting consent at this private institution earlier than I did. I also learnt that I should not always assume that if the Head of an Institution has a PhD, consent will be granted easily.

As alluded to in Chapter Four - the methodology chapter, due to different college activities like TP, workshops, vacation leave and lectures across the colleges, at the time of my data generation, it became impossible to conduct focus group discussions with lecturers as they were never available on campus as a group. So, I was forced to make some adjustments. Instead of the focus group discussions, I then held individual face-to-face interviews with these lecturers before the lecture observations. However, this change did not have any negative impact on the quality and amount of the data that was generated.

I used open coding to manually analyse the data generated. I transcribed the data, coded it, categorised it and then clustered the categories into themes and interpreted the data. The manual analysis enabled me to conduct the data analysis in a precise, consistent and exhaustive manner which helped me to engage with and analyse the data in great depth. This step-by-step approach offered an opportunity for deep immersion in my data, which promoted the production of insightful findings. Trustworthiness was ensured through triangulation, and accurate and appropriate analysis of the research findings.

9.3 Review of the study

This section provides a summary of the key points in the chapters contained in this thesis, before drawing and discussing conclusions.

Chapter One provided a background to the study, to set the scene for the investigation. The chapter also discussed the focus of the study, and provided a personal context and motivation for the study, including the rationale for undertaking this study. The research questions were spelt out, followed by a discussion on global, regional and national contexts of teacher education to contextualise my study. Internationally teachers' training colleges are required to produce high quality teachers who enhance students' achievements and eventually the quality of education (Darling-Hammond 2017). The world education policy agenda has been closely monitored by the World Bank to ensure quality Education for All (EFA). Therefore, an understanding of student teacher conceptions and experiences was critical, given the influence of conceptions on teachers' instructional conduct, pedagogical choices and learner activities. The chapter then traced the history of teacher education in Zimbabwe before and after liberation, including the efforts to address EFA through massification across all levels of the education system. The consequences of massification of education and the many models of teacher education tried were also discussed. Notwithstanding the numerous teacher education models tried, entry requirements into teacher education and other civic professionals of 5 O level subjects that included English and mathematics remained unchanged. It was this entry requirement that forced participants in this study to write and re-write mathematics to gain entry into teacher education (Zimbabwe Education Policy 2017). The chapter concluded by discussing the structure and organisation of the thesis.

Chapter Two presented reviewed literature which was arranged conceptually following a funnel approach, starting with global debates, followed by regional and finally local debates on student teacher conceptions of pedagogical practices. Locally there seemed to be no studies on conceptions about mathematics (Nyaumwe 2004). Literature reviewed across all contexts generally indicated that mathematics pedagogical practices needs interactive teaching (Badu-Nyarko and Torto 2014; Van Dat 2016), use of manipulatives (Golafshani 2013) and handling of learning diversity (Vintere 2018). Although literature revealed that much has been done on conceptions about mathematics elsewhere, it appeared that not much had been done on the conceptions and experiences of mathematics education of student teachers in teachers' colleges, particularly on those who struggled to pass mathematics before entering primary school teacher education.

In Chapter Three the two theoretical frameworks: conceptions about mathematics (Dionne 1984) and socio-constructivism (Vygotsky 1978; Kim 2001) that underpinned my study were discussed. These theoretical frameworks complimented each other and helped in unpacking, analysing and explaining pedagogical practices, particularly understanding the variations in pedagogical practices in mathematics education. The chapter's first section discussed the conceptions about mathematics, of which the principles are hinged on three types of conceptions: traditionalist, formalist and constructivist. The chapter then traced the historical development of both theories and also highlighted their weaknesses and how in the study I attempted to minimise their impact on my findings. The key tenets of socio-constructivist theory which advocates for learner centrality in their learning, the learning context and culture, learner diversity, the value of prior knowledge, human activity in knowledge construction, the value of language, the facilitative role of the teacher and the ZPD (Kim 2001; Vintere 2018) were also discussed. The discussions of the key constructs of the theories were linked to the study to illustrate their relevance and applicability.

Chapter Four discussed the methodology and design of the study. The interpretive paradigm, multiple-site case study design, and qualitative approach which were adopted were defined, justified and discussed. Data generation tools, namely focus group discussions, individual face-to-face interviews and non-participant lecture observations employed in the study, as well as the moves and choices that I made were defined and justified. Following this, the chapter also discussed the population, sample and sampling techniques employed. Issues of rigour under the four aspects of trustworthiness, namely credibility, transferability, confirmability and auditability were also discussed, illustrating the ways in which each aspect was enhanced. This section also covered the ethical aspects, demonstrating that the research was undertaken with conscious consideration of ethical practices.

In **Chapter Five** the four research sites were discussed. Discussing these sites was vital for ensuring a clearer understanding of the context from where the data was generated, analysed and explained. The chapter briefly highlighted that teacher education in Zimbabwe was located in the teachers' colleges and universities under the MHTESTD (Mukeredzi 2013). The chapter also highlighted that the four sites were affiliated to the University of Zimbabwe and the Department of Teacher Education (DTE), and that all of them trained primary school teachers (Ministry of Higher Education Department Policy 1957). The broad similarities in the core educational foundation modules (psychology, sociology and philosophy), the other core modules of mathematics and mathematics education, as well as all other subjects in the primary school curriculum and TP were highlighted. How student teachers selected areas of specialisation from the curriculum subjects was also covered. The chapter further discussed the common teacher training model 2-5-2 followed by all of the sites studied and highlighted their enrolment figures.

Chapters Six, **Seven** and **Eight** presented and analysed the data that addressed the three research questions set out in Chapter One to be answered by the study. Data analysis was informed by the theoretical frameworks to unpack and explain the findings, and also drew on literature to show how the findings related to existing research. Research findings from the three chapters are discussed in detail in the next section.

9.4 Discussion of findings

This section discusses the research findings addressing the student teachers' conceptions and experiences of mathematics pedagogical practices in mathematics education in the four selected teacher training colleges in Zimbabwe, and how these aspects influenced their learning. The discussion is organised and presented according to the research questions. The following section discusses the findings addressing how the student teachers conceived pedagogical practices in mathematics education.

How do Student Teachers Conceive Pedagogical Practices in Mathematics Education?

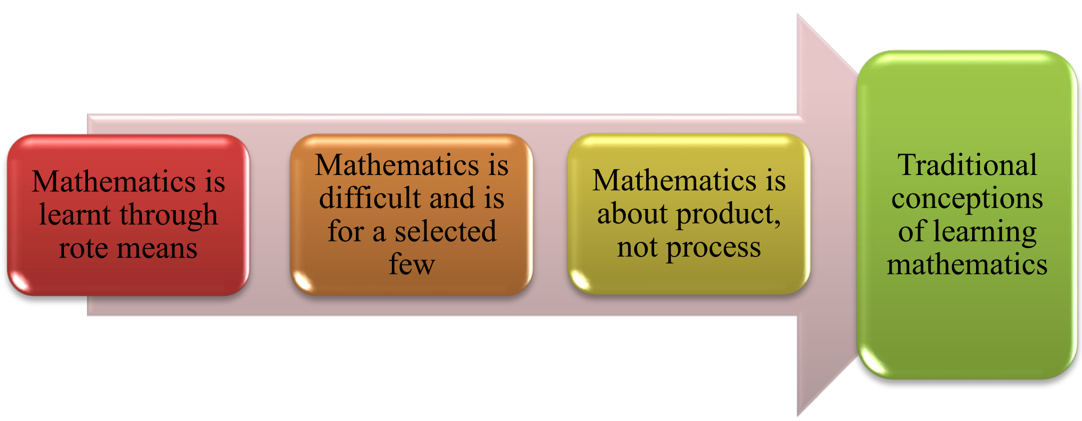
Student teachers' conceptions of pedagogical practices in mathematics education emerged around three aspects:

- Conceptions about learning mathematics;
- Conceptions about pedagogical practices in mathematics education related to the classroom; and
- Conceptions about pedagogical practices in mathematics education related to research.

9.4.1 Conceptions about Learning Mathematics

In this discussion, the classroom represents the lecture room. With regard to student teachers' conceptions about learning mathematics, findings across all of the colleges explored revealed that all except two participants held strong traditionalist conceptions about mathematics learning. Words and phrases that student teachers used to describe their learning in mathematics pedagogical practices, which reflected traditional conceptions were: *"drilling; cramming; memorising; repetitive means (over and over again); regurgitation of facts; rote learning; mathematics is difficult; and mathematics is for the selected and gifted few".* Informed by the conceptions about mathematics theory (Skemp 1978; Dionne 1984; Grady 2013), these words were indicators of traditionalistic conceptions about mathematics. These are summarised diagrammatically in Figure 9.1 below.

Figure 9.1: Traditional conceptions about mathematics



Source: Researcher (2021)

These students indicated that their learning of mathematics was by rote means. Carr (2012) from surveyed literature states that many students prefer to memorise formulas and steps to solve mathematical problems provided, without comprehending the actual concepts. This was the case in this study. As these students had struggled to pass O level mathematics, the easy way for them to get through the subject was to cram, regurgitate facts and learn mathematics by rote means. These conceptions revealed by the student teachers studied portrayed examination focus, where structured knowledge was imparted and transmitted. These traditionalist conceptions portrayed by the students did not promote conceptual understanding but rather temporary mastery of the mathematical concepts (Dionne 1984; Grady 2013). This was contrary to the constructivist facilitative approach which foregrounds understanding and conceptual and intellectual development (Kim 2001; Vintere 2018).

Students in all of the colleges studied also indicated that they conceived mathematics as a difficult subject, further revealing another pointer to traditionalist conceptions. Literature reviewed (Fritz, Haase and Rasanen 2019) indicated that mathematics is commonly perceived to be difficult. Fritz et al. (2019) further indicated that such students believe that not everyone can be good in mathematics. The struggle to pass mathematics at O level could have brought about such conceptions where they would conceive mathematics as a subject for a certain category of students.

Again, with regard to working out problems in mathematics pedagogical practices, all of the participants from Colleges A and C and some from the other two colleges further reflected traditionalist conceptions when they revealed that they conceived the product - the correct answer, as more valuable than the process. Literature surveyed (Boaler and Zoido 2016) has it that students who approach mathematics where they conceive the product as more valuable than the process are lower achieving than those who approach it as a subject of ideas that they can think about deeply. One could conclude that those student teachers who struggled to pass O level mathematics held traditional conceptions about mathematics and its learning. Findings also revealed the student teachers' conceptions about mathematics education in relation to classroom practice, which is discussed below.

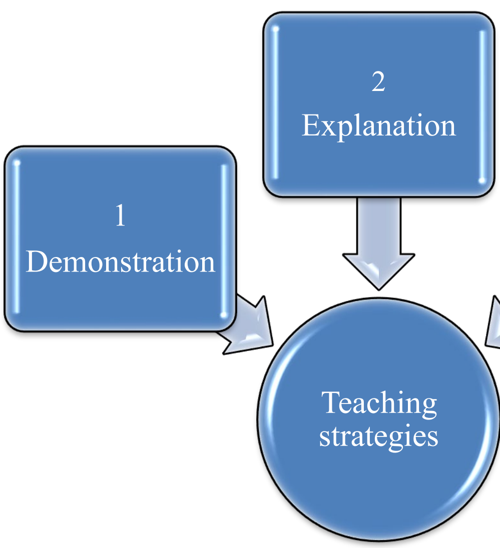
9.4.2 Student teachers' conceptions about pedagogical practices in mathematics education related to classroom practice

Seven distinct aspects depicting student teachers' conceptions related to classroom practice emerged around: teaching strategies; possession of content; motivation; handling students' responses; classroom communication and interaction; teaching for understanding, and teacher quality.

9.4.2.1 Teaching Strategies

Student teachers' conceptions of teaching strategies are discussed under: demonstrations, explanations and cooperative learning, and reflected in Figure 9.2 below. Concomitant to strategies, other conceptions that emerged within these strategies were interactive teaching, student centrality, scaffolding and remediation.

Figure 9.2: Student teachers' conceptions about teaching strategies in mathematics



Source: Researcher (2021)

9.4.2.2 Demonstration

First of all, from the findings the student teachers' conceptions across the four colleges studied were that clear demonstrations offered a systematic and effective teaching strategy during pedagogical practices in mathematics education. Student teachers conceived that demonstration as a teaching strategy communicated mathematical ideas and concepts through clear and understandable step-by-step processes during mathematics pedagogical practices. Demonstration was conceived as a way of enhancing students' understanding of mathematical concepts as it was motivational and helped in clarifying mathematics concepts, thereby helping improve students' learning efficiency (Sweeder and Jeffery 2013). Drawing on the theoretical frameworks, demonstrations promoted scaffolding thereby leading students to their ZPD, as advocated by the socio-constructivist perspective (Vygotsky 1978; Vintere 2018). Albeit that the demonstrations appeared dictatorial given the limited hands-on opportunities for students, learning was often permanent as students become motivated into active participation (looking, thinking, answering questions) and consequently related what they saw to what they heard from their lecturers' explanations. Thus, while student teachers' conceptions of pedagogical practices in mathematics education were that clear demonstrations were effective in teaching/learning of mathematics; this was rarely practiced as the lecture method was dominant in the four selected teachers' training colleges. Findings also revealed that student teachers conceived explanations of mathematics concepts as critical for mastery of mathematical knowledge in mathematics pedagogical practices in mathematics education.

9.4.2.3 Explanation

From the findings, further conceptions that students, particularly those from Colleges A and B, indicated were that while they conceived demonstrations as effective during pedagogical practices in mathematics education, they were not to be staged in isolation and needed to incorporate and be punctuated by clear explanations to communicate mathematical knowledge. Clear explanations provided by the mathematics lecturers were conceived as essential for ensuring mastery of mathematical knowledge and skills in preparation for their classroom practice following course completion.

Further, apart from intermittent explanations during demonstrations, explanation as a teaching strategy was conceived as one of the effective instructional approaches for teaching students at the risk of mathematics difficulties, like those explored in this study who had struggled to pass mathematics at O level. Surveyed literature (Schneider and Preckel 2017) indicates that students should be exposed to sufficient explanations before being allowed to work independently. The students also conceived explanations as vital for scaffolding their learning for them to reach their ZPD, as suggested by the socio-constructivist theory (Kim 2001; Vintere 2018). In addition, from the findings the students' conceptions were that explanations engaged them and enhanced mastery of concepts by providing corrective feedback and addressing any misconceptions, thereby promoting effective mathematics learning during mathematics pedagogical practices. Though students' conceptions were related to clear explanations during my lecture observations at College B, some wrong answers which students provided during the mathematics pedagogical practice should have been clarified, however this was not done. Other important students' conceptions were around cooperative learning.

9.4.2.4 Cooperative Learning

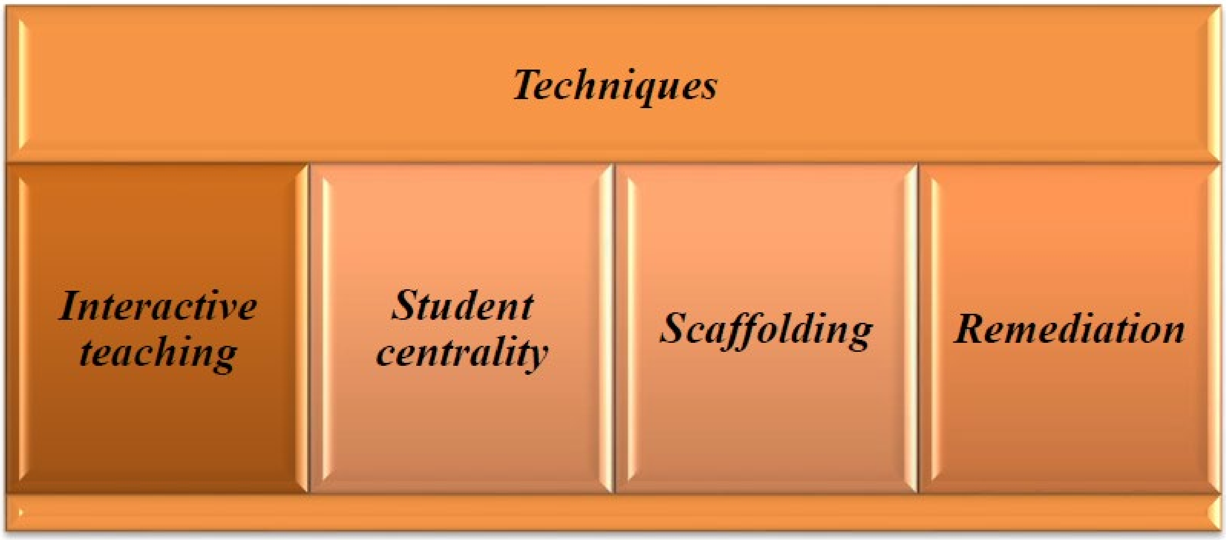
Drawing on the findings, all of the student teachers except two conceived that cooperative learning was critical during mathematics pedagogical practices. From the reviewed literature (Baloche and Brody 2017), cooperative learning is an instructional strategy which uses small groups and allows students to work together, learning with and from one another and maximising their own and each other's learning. Students' conceptions were based on the effectiveness of this teaching strategy in enabling the exchange of ideas with peers, for example in solving a multi-step mathematics problem, or a difficult mathematical algorithm during pedagogical practices. Their conceptions were that the lecturer should not be the sole source of mathematical knowledge during mathematics pedagogical practices, but should allow students to interact and learn from and with their peers (Mukeredzi 2018). Thus, students' conceptions of mathematics pedagogical practices in relation to classroom practice were that mathematical knowledge should be socially constructed, which was aligned to socio-constructivist theory and conceptions about mathematics which locates students at the centre of their learning (Dionne 1984; Kim 2001; Vintere 2018).

Surveyed literature (Baloche and Brody 2017; Mukeredzi 2019) concurred with this research finding as cooperative learning strategies are viewed as effective in raising the level of tertiary students' achievements and attitudes. However, the two student teachers (mentioned above) from Colleges A and B who were against collaborative learning conceived that cooperative learning in mathematics pedagogical practices was a waste of time and a hindrance to syllabus coverage. The focus on syllabus completion suggested traditional conceptions (Martin and Gourley-Delaney 2014) which target the product and not the process when working out mathematical problems in order to accomplish a task.

Thus, what generally emerged from this study was that these student teachers who had struggled with O level mathematics conceived demonstrations, explanations and cooperative learning as vital teaching strategies that promoted conceptual mastery during mathematics pedagogical practices. However, during the lecture observations that I carried out, the three vital strategies were missing during mathematics pedagogical practices as the lecturers dictated notes as per the lecture method.

In addition to teaching strategies, students' conceptions also emerged related to techniques employed within these strategies, namely interactive teaching, student centrality, scaffolding and remediation, which are illustrated in Figure 9.3 and discussed in turn below.

Figure 9.3: Student teachers' conception about teaching techniques in mathematics



Source: Researcher (2021)

9.4.2.5 Interactive Teaching

First of all, from the findings the student teachers from all of the teachers' colleges studied conceived interactive teaching as effective in mathematics pedagogical practices as it ensured active student engagement and consequently concept mastery. Senthamarai (2018) views interactive teaching as a dynamic and communicative teaching technique which constitutes motivational elements for students to develop a critical position about content taught, which enhances knowledge retention and satisfaction. An interactive learning atmosphere during pedagogical practices often promotes student collaboration with knowledgeable 'others' in knowledge construction. Interactive knowledge construction is aligned to the socio-constructivist theory and constructivist conceptions about mathematics (Dionne 1984; Kim 2001; Vintere 2018). Students conceived that interactive knowledge construction in mathematics pedagogical practices promoted concept comprehension and retention, however students did not experience this technique as lecturing took precedence as was evident during my lecture observations. The constructivist theory (Vygotsky 1978; Kim 2001; Vintere 2018) suggests that interactive knowledge construction fosters students' enjoyment of various learning styles and teaching strategies through opportunities for addressing individual learning needs, thereby elevating them to their ZPD.

9.4.2.6 Student Centrality

Secondly, the findings also suggested that student teachers across all of the colleges studied conceived student centrality as essential in mathematics pedagogical practices. When all learning is centred on the student, this implies that the student takes responsibility for his or her learning and the lecturer assumes a facilitative role during mathematics pedagogical practices. Li and Guo (2015) indicate that traditional pedagogy is teacher-centred while constructivist pedagogy is student-centred. Students in the constructivist classroom generally perform better than those in a traditionalist classroom who are often treated as passive recipients of mathematical knowledge during pedagogical practices. From the socio-constructivist theory standpoint (Dewey 1938; Vygotsky 1978; Kim 2001; Vintere 2018) good mathematics learning is learning that leads to development, which requires mediation or structured guidance, within the ZPD. Students' conceptions also revealed that in any learning situation learner centrality was paramount during mathematics pedagogical practices. Concomitant to student centrality, participants also conceived scaffolding as vital during pedagogical practices.

9.4.2.7 Scaffolding

Thirdly, from the findings across all of the colleges, student teachers' conceptions of mathematics pedagogical practices were also that scaffolding student learning was vital for effective learning in mathematics pedagogical practices. Scaffolding enhanced learning and assisted in mastery of mathematics concepts. The lecturer could systematically build on students' knowledge and experiences as they learned new mathematical skills. Vygotsky's (1978) socio-constructivist theory provided the theoretical basis for scaffolding through to the ZPD.

Scaffolding provides a special type of help that assists students to move towards new concepts, skills or new understandings, in particular students with mathematics learning problems such as those in my study who had struggled to pass mathematics. Scaffolding ensures the smooth transition from teacher demonstration of a skill to performing the skill independently, and offers students an opportunity to learn more from a knowledgeable other to achieve targeted learning outcomes. According to Ormond (2016), scaffolding serves as some form of feedback about accuracy in trying to curb misconceptions by sorting out doubts that may spread through the assessment process. Thus, student teachers in this study conceived that if interactive teaching, student centrality and scaffolding were employed with teaching strategies during pedagogical practices, this would foster and promote their mathematics learning and understanding. When I observed the mathematics lectures these vital teaching techniques were not included across all of the colleges studied. Student teachers in this study also held conceptions related to handling diversity with regard to remediation, which is discussed below.

9.4.2.8 Remediation

As the findings suggested, student teachers' conceptions of mathematics in pedagogical practices that related to remediation were that this process was vital for enhancing understanding, closing mathematical knowledge gaps and bringing students to the level of their peers. Students from three Colleges A, B and D mentioned remediation as an important teaching technique during mathematics pedagogical practices. Thus, the lecturer by remediating students would be taking a constructivist stance of considering prior knowledge as vital. And once prior knowledge was taken care of through remedial activities it would be easier for students, particularly those who had struggled to pass mathematics, to understand new mathematical concepts. Surveyed literature (Brower et al 2018) shows that remedial activities are usually carried out to give additional help to those students who, for one reason or another, may have fallen behind the rest of the class. The participants in this study had struggled to pass O level mathematics, hence there were likely to be students who needed this additional help during pedagogical practices.

Again, students did not all operate at the same cognitive levels, and these diverse cognitive levels could be catered for through remediation which has a direct impact on their content mastery and performance during mathematics pedagogical practices. While student teachers conceived remediation in mathematics pedagogical practices as vital for getting them back on track so that they could continue on the mathematics continuum, the practice was overlooked, as revealed by the students. Remediation locates the learner centrally (as the student is afforded one-on-one interaction with the lecturer) to their learning, which is in tandem with the socio-constructivist perspective (Vygotsky 1978; Kim 2001; Vintere 2018). It was therefore through remediation that student teachers in need of help were scaffolded and moved to their ZPD, as advocated for by socio-constructivism.

What the above discussion suggests is that student teachers conceived that mathematics learning during pedagogical practices would be enhanced by employing strategies, techniques and approaches like clear demonstrations, explanations and cooperative learning, coupled by techniques like interactive teaching, learner centrality, scaffolding, and remediation. Another conception that also emerged relating to lecture room practice was around content knowledge.

9.4.2.9 Need for Content Knowledge

Content knowledge refers to the facts, concepts, theories, and principles that are taught and learned (Grieser and Hendricks 2018), in this case in mathematics content. From the research findings in all of the colleges, the student teachers' conceptions about pedagogical practices in mathematics education were that they should be exposed to more mathematics content, contrary to the limited content that they were exposed to. Equipping the student teachers with mathematics content knowledge would prepare them to teach the subject effectively. Literature surveyed (Libeskind 2011) emphasises that more attention should be given to helping student teachers to develop adequate mathematics content knowledge during training. Student teachers' conceptions were that broad and in-depth mathematics content coverage during mathematics pedagogical practices would enhance their effectiveness when they got into the teaching field.

Their conceptions about the need for broad and in-depth mathematical content knowledge were in tandem with literature surveyed (Reid and Reid 2017) which emphasises that student teachers should have a deep understanding of mathematical concepts before taking any methods courses. It appeared that the student teachers who had struggled to pass O level mathematics conceived that pedagogical practices in mathematics education should expose them to more mathematics content, probably to cover the mathematics content gaps and misconceptions created in high school. However, from the findings, this was not the case. During lecture observations in the four teachers' training colleges that were studied, lectures covered work on mathematics pedagogies and not content. Findings also revealed that student teachers in this study conceived motivation as another critical aspect in mathematics pedagogical practices.

9.4.2.10 Motivation

From the findings, conceptions also emerged around motivation. Students in Colleges B, C and D conceived that during mathematics pedagogical practices motivation in the lecture room would act as a catalyst for mathematics learning, thereby maximising performance. This aspect was likely to have a positive impact on the conceptions about mathematical ability, especially for the students who struggled to pass mathematics. The findings suggested that these student teachers conceived collaboration as a strong motivational ingredient for their interest in mathematics and conceptual mastery. Student teachers conceived that through an encouraging, positive and supportive environment they would develop confidence in mathematics and be energised to tackle difficult problems during mathematics pedagogical practices. Reviewed literature (Nguyen and Goodin 2016) says that an increase in motivation fosters a positive classroom environment, and reduces uneasiness during mathematics lectures for all students whether they struggled to pass it earlier or not. Motivation is adaptive and lecturers can apply positive motivation to influence student learning and performance in the classroom, particularly where there is cognitive diversity, as was the case in the mathematics education classes in this study. However, motivation was reported lacking in all except one of the colleges studied.

Through motivation the lecturer locates the student at the centre of their mathematics learning, thus aligning with the socio-constructivist perspective (Vintere 2018). When students are motivated they take risks and may choose more difficult mathematical tasks to work on, and therefore increase their learning during pedagogical practices. Results from this study also revealed that these student teachers who struggled to pass mathematics, conceived that they needed motivation and encouragement in order to reach their potential, and achieve their goals and dreams of becoming effective mathematics teachers. Thus, it could be concluded that student teachers who had struggled to pass mathematics at O level conceived motivation and scaffolding during mathematics pedagogical practices as critical for them to reach their ZPD, as advocated by the socio-constructivists (Vygotsky 1978; Vintere 2018). However, negative motivation was conceived in College B where the lecturer during lecture observation did not expect a correct answer from a student who was not a mathematics major.

Another conception that also emerged around lecture-room practice related to how students' responses were handled during mathematics pedagogical practices.

9.4.2.11 Handling of students' responses

With regard to handling students' responses, participants' conceptions of pedagogical practices in mathematics education were that explanations for wrong answers were important for correcting misunderstandings, but these were not provided. Though the lectures stated that they attended to students' wrong answers during lecture observations, the lecturers across all colleges simply ignored wrong answers and proceeded to pick on another respondent to get the correct answers. Effective lecturers often make students understand the error in their response through questioning, explaining and scaffolding to bring them to the correct answer. Surveyed literature (Makonye and Fakude 2016) shows that misconceptions displayed by students in their wrong answers during pedagogical practices should be used by lecturers as natural and often necessary in learners' conceptual development.

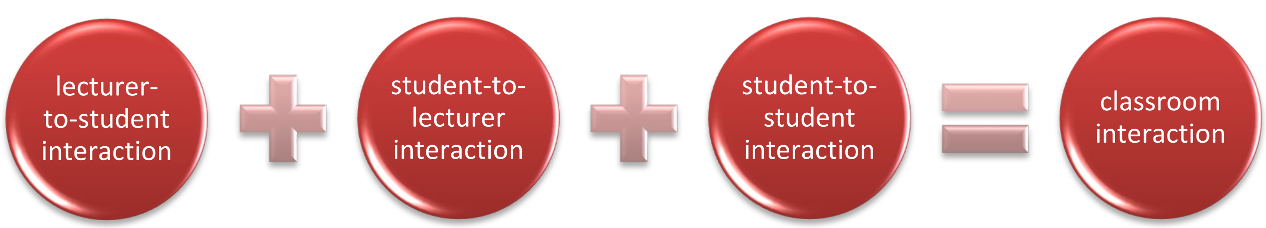
Non-attendance to wrong answers, which was also noted during lecture observation during mathematics pedagogical practices, often leaves the student with their incorrect understanding. A wrong answer from one student is often a reflection of misconceptions, held not only by that one student but also by some other students. Therefore, ignoring wrong answers and proceeding with the lecture negated the centrality of the student in their learning, as advocated for from the constructivists' perspective (Ochagavia 2017; Vintere 2018). Surveyed literature (Licorish, Owen, Daniel and George 2018) indicates that mistakes are the most important things that happen in any learning situation, because they inform the teacher on where to focus and deliberate practice. Thus, in any learning situation, but more so during mathematics pedagogical practices with students who have struggled to pass mathematics at O level, a wrong answer needs to be used as a building block for developing a deeper understanding, while dealing with the misconceptions in the process. Such discussions often generate lively, 'noisy' constructivist classrooms that displace traditionalist classrooms (Vintere 2018).

Further, during pedagogical practices effective lecturers would provide students with opportunities to learn from both their and their peers' errors. However, despite the students' conceptions revealed that correcting of wrong answers was vital, this was not practiced. One lecturer at one college contrarily revealed that they attended to students' wrong answers during pedagogical practices. Overall, from this study the conceptions of the student teachers' who had struggled to pass mathematics at O level were that students' wrong answers should be explained to make them see and learn from their errors during pedagogical practices in mathematics education.

9.5 Classroom interactions

With regard to classroom interactions, the students' conceptions that emerged were that interactions enabled effective mathematics learning during pedagogical practices. Student teachers revealed conceptions related to three forms of classroom interactions: student-to-student, student-to-lecturer and lecturer-to-student interactions. These are reflected in Figure 9.4 and discussed below.

Figure 9.4: Classroom interactions



Source: Researcher (2021)

9.5.1 Lecturer-to-student interaction

Findings showed that students conceived lecturer-to-student interaction as a very important aspect during mathematics pedagogical practices. However, students revealed that this kind of interaction was not evident during mathematics pedagogical practices except in dictating notes. The lecturer-to-student interaction if effectively used would help in imparting mathematical concepts and clarifying misconceptions during mathematics pedagogical practices. The absence of this interaction is contrary to the constructivist perspective which advocates for learner centrality and facilitative role by the lecturer in order to scaffold students to reach their ZPD (Vygotsky 1978; Vintere 2018).

9.5.2 Student-to-student interactions

The conceptions of pedagogical practices in mathematics education that emerged regarding classroom interactions were that active student-to-student interactions were very vital, albeit that only informal student-to-student interactions were allowed and only during short breaks, especially at College D. This kind of interaction was not effective as students rarely discussed anything mathematical during these kinds of breaks. Student-to-student interaction often promotes student's success. Students conceived that listening to other students' explanations in classroom interactions would give opportunities to develop their own understandings, particularly those who had struggled to pass the subject at O level. This was in line with the constructivist perspective (Vygotsky 1978; Kim 2001; Vintere 2018) which emphasises students' learning from knowledgeable peers. Surveyed literature (Sandstrom and Dunn 2014) indicated that supportive environments where opinions and positive interactions among students take place are pre-requisites for effective mathematics learning. While the lecturers studied also conceived student-to-student interaction as vital, students reported that they did not enable that kind of interaction during pedagogical practices in mathematics education, contrary to their conceptions and their claims that they promoted it. Thus, notwithstanding the value of such interactions, as conceived by both students and even the lecturers, such interaction did not exist during pedagogical practices. Reviewed literature (Afurobi 2015; Amineh 2015) indicates that student-to-student interaction supports and challenges strategic thinking, and this results in an interaction and language use which is a shared, rather than an individual, experience. The absence of student-to-student interaction was confirmed during observation of the mathematics pedagogical practices. Students' conception around student-to-lecturer interaction during pedagogical practices is discussed next.

9.5.3 Student-to-lecturer interaction

Findings from this study also indicated that students conceived student-to-lecturer interaction as important however this was not evident in any of the four colleges. Students revealed that they were not given opportunities to ask questions, but if they did pose questions and solutions were provided, this would help in filling their paucity of knowledge by providing solutions to their confusion and misconceptions. Literature surveyed (Drageset 2015) indicates that as students question, they get opportunities to articulate their understanding of and make connections between mathematical concepts. Thus, students' mathematical inquiries through questioning led to the creation of new knowledge, thus supporting the constructivist perspective (Kim 2001; Ochagavia 2017). Lecturers upheld that by addressing students' questions they promoted student-to-lecturer interaction during the mathematics pedagogical practices, however, no questions were allowed. Lack of student-to-lecturer interaction during mathematics pedagogical practices was also observed during the lecture observations in all of the colleges explored. The only interaction that was evident during my lecture observation was in the form of brief lecturer-to-students questions. One could then conclude that though students conceived student-to-student interaction and student-to-lecturer interaction as essential during mathematics pedagogical practices; these were not promoted during the pedagogical practices in mathematics education in these four colleges. Other students also revealed conceptions around the language of instruction during mathematics pedagogical practices, which is discussed in the next section.

9.5.4 Language of Instruction

Findings also suggested conceptions around classroom practice related to the use of indigenous language when explaining difficult concepts during mathematics pedagogical practices. The student teachers' conceptions were that during mathematics pedagogical practices lecturers should make use of the mother language to clarify difficult concepts. This was contrary to the national language policy where lectures in higher education had to be conducted in English. However, all participants at Colleges B and C and some from the other two colleges conceived that use of the mother language was paramount for enhancing conceptual mastery during mathematics pedagogical practices. During lecture observations, use of the mother language was witnessed in three Colleges A, B and C. The lecturers overlooked the issue that not all students were familiar with the language. Mathematics lecturers should use a language of instruction which all students are conversant with, so that no student is left behind, as argued by the constructivist perspective (Kim 2001; Vintere 2018). Literature (Riccomini, Smith, Hughes and Fries 2015) has it that mathematics instructors need to explore creative ways of using the language to enhance the teaching and learning process. Further literature reviewed (Khan 2014) indicates that in most universities, even though English is used as a medium of instruction, some lecturers use the local mother tongue in the classroom and consider this as their teaching strategy. The constructivist perspective emphasises a semantic system that is shared between the learner and the student teacher to enhance the teaching and learning of mathematics during mathematics pedagogical practices. Further to this, student teachers also revealed conceptions around teaching for understanding during mathematics pedagogical practices

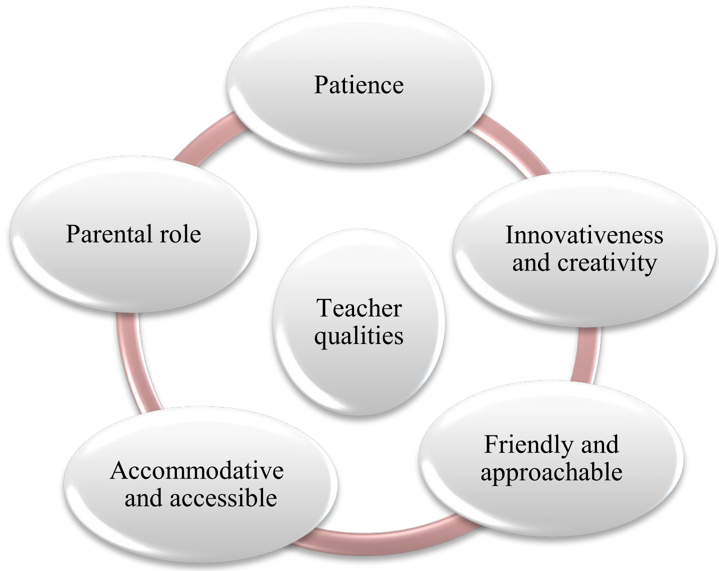
9.5.5 Teaching for understanding

Teaching for understanding mathematics is understood as teaching for conceptual comprehension of mathematical concepts so that they are retained for later use and this is critical, particularly for students who have struggled to pass mathematics. Student teachers' conceptions were that lecturers should teach slowly during mathematics pedagogical practices to ensure their understanding of mathematics concepts. Lecturing slowly for students who have struggled to pass mathematics is often a feature of well-scaffolded instruction that supports conceptual understanding. These students conceived that scaffolding, which is a step-by-step student-centred approach, made their individual learning a primary consideration during mathematics pedagogical practices. During lecture observations this stepwise approach to enhancing the understanding of mathematics during pedagogical practices was lacking, since lecturers concentrated on delivering their prepared notes. Seah (2016) explained conceptual understanding of mathematics as including the comprehension of mathematical concepts, operations and relations. Thus, teaching for understanding goes beyond examination preparation and helps those students who are likely to have been struggling to understand mathematics concepts, operations and relationships to understand, them thereby converting the factual information into usable knowledge for solving significant mathematics problems. Mathematical knowledge acquired should be transferable to other contexts and applicable to life situations, and is an indication that students have been taught for understanding. The constructivist conception about mathematics indicates that mathematics should be taught for understanding to be applicable to daily life (Ochagavia 2019). Students therefore conceived that when they were taught for understanding, they would retain the acquired knowledge and also be able to connect their new knowledge with prior knowledge. Other conceptions were related to the qualities of the teacher (teacher quality) and this will be discussed next.

9.5.6 Teacher quality

The student teachers who struggled to pass mathematics also conceived teachers' qualities (teacher quality) as essential during mathematics pedagogical practices. Students conceived the teachers' qualities as vital given the strong correlation between teacher quality and learner performance, as teacher quality supports the learning of a learner. Teacher quality is discussed under eight aspects: patience, innovativeness and creativity, friendliness and approachability, accommodativeness and accessibility, and playing a parental role (*en-loco-parentis*) during mathematics pedagogical practices. The conceptions on the qualities of a lecturer, as revealed by the students, are reflected in Figure 9.5.

Figure 9.5: Student teachers' conception of the qualities of a lecturer



Source: Researcher (2021)

9.5.6.1 Patience

To begin with, students in Colleges B and C conceived that a good lecturer should be patient during mathematics pedagogical practices. Students' conceptions were that a patient lecturer would take time to explain any misconceptions held by the students, particularly the strugglers from diverse backgrounds. Patience is a virtue, often vital for mathematics lecturers for effectiveness during lesson delivery as it is the nucleus of students' long-term retention of mathematical content and skills. Effective mathematics learning usually takes time and generally requires robust teacher expertise, hence the need for patience. Socio-constructivists foreground locating the learner at the centre of all learning (Kim 2001; Ochagavia 2017) and having patience to explain locates students centrally to their learning. Literature surveyed (Allan 2017) indicates that patience in teaching mathematics implies that mathematics instructors dedicate considerable class time to building prior knowledge in students, since new knowledge is built on and can be connected to already acquired concepts. However, despite the importance of this quality, it was reported missing in all lecturers in all four sites and lecturers gave the reasons for this as limited time to finish course content and large class sizes. Lack of patience was also confirmed during the mathematics lectures that I observed. Thus, based on this study, student teachers who struggled to pass mathematics at O level conceived patience as critical. They further conceived that mathematics lecturers who were patient were those who took time to explain concepts during mathematics pedagogical practices and this would help clear their misconceptions. Further to this, other student teachers' conceptions related to lecturer innovativeness and creativity.

9.5.6.2 Innovativeness and creativity

Secondly, findings showed that the student teachers explored conceived teacher quality as encompassing innovativeness and creativity during mathematics pedagogical practices. Innovativeness includes coming up and implementing changes in learning and teaching of mathematics. If innovativeness and creativity were to be incorporated in mathematics classrooms, the students would be given a variety of methods of working out mathematical problems and the lecturers would not always use the lecture method of teaching mathematics. Creativity enables the lecturer to develop opportunities for original thought by asking open questions that require critical thinking and by allowing more possible answers, thereby promoting students' conceptual understanding. Both innovativeness and creativity have roots in constructivist ideology which requires a variety of solutions to mathematical problems to do away with the traditional rigid methods of teaching mathematics (Kim 2001; Ochagavia 2018; Vintere 2018). Literature reviewed (Wang 2020) advocates for reform in mathematics instruction to adopt innovative and creative pedagogical approaches, which promote students' conceptual understanding. If mathematics lecturers lack innovativeness and creativity, this in turn may stifle innovativeness and creativity among their students and inhibit the creation of a positive mathematics learning environment during mathematics pedagogical practices.

Thus, based on the study, students who struggled to pass mathematics conceived that innovativeness and creativity were important as they were sources of motivation during mathematics pedagogical practices. However, these qualities, though vital, were not experienced by student teachers in all but one college where one lecturer used the interactive board to provide more mathematical information. In addition, the student teachers also revealed conceptions around lecturer friendliness and approachability as another of the essential qualities during mathematics pedagogical practices.

9.5.6.3 Friendliness and approachability

Thirdly, all students conceived that friendliness and approachability were vital during mathematics pedagogical practices, as they would have the confidence to ask questions and this would help address information gaps and clear any misconceptions. Often mathematics classrooms are safe havens where students trust their mathematics lecturers hence, the need for friendliness and approachability during pedagogical practices. All mathematics lecturers are expected to be friendly and approachable to all students, even when they struggle with some difficult concepts. Being a friendly and approachable lecturer can be disarming, and students will look forward to attending mathematics lectures if they know that their lecturers are not uptight and rigid. A lecturer who is friendly and approachable is also accessible for consultations by students and in so doing students will be scaffolded to reach their ZPD (Vygotsky 1978; Kim 2001). These qualities were essential in the learning of mathematics, as conceived by all of the students studied. However, they were reported as not evident to students in all of the colleges explored, notwithstanding claims to the contrary by two of the lecturers. Conceptions around teacher quality were also that a lecturer should be accommodative and accessible, and these are discussed in the next section.

9.5.6.4 Accommodativeness and accessibility

Fourth, from the findings all student teachers also conceived an accommodative and accessible lecturer as vital during mathematics pedagogical practices. As students did not master mathematical concepts at the same pace, the participants in this study conceived that an accommodative and accessible lecturer would always be willing to explain mathematics concepts further. According to Brown and Palincsar (2018), learning is thought of as acquisition of new knowledge, and teachers should be conceived as agents of change or transformation of the pre-existing knowledge of their learners by accommodating all of their students. A lecturer in the lecture room generally holds a position of authority and because mathematics has made most students struggle, the lecturer needs to be accommodative and accessible for all to ask any questions during mathematics pedagogical practices. In attending to students' mathematical problems, the lecturer scaffolds their learning and moves them to their ZPD, in line with socio-constructivist perspectives (Kim 2001; Ochagavia 2019). One of the students who also conceived accessibility and accommodativeness as vital during mathematics pedagogical practices clearly said, "… *The students are afraid to ask anything….*" Such a quality is not desirable for mathematics learning. The mathematics lecturer is expected to be aware that all students have the right to access education and the specific premise is that all students have the right to access mathematical knowledge (Schmidt 2016) and be accommodated during these lectures. Thus, students who struggled to pass mathematics conceived an accommodative and accessible lecturer as an asset during mathematics pedagogical practices, who could offer additional explanations.

However, these qualities, though important, were not available to the students in any of the colleges studied during mathematics pedagogical practices, as exemplified by one student's comment above. Other conceptions regarding teacher quality were that the lecturers should assume a parental role during mathematics pedagogical practices, and this is discussed next.

9.5.6.5 Parental role

Finally, student teachers conceived their lecturers assuming a parental role as another very vital quality during pedagogical practices. According to these students, the lecturer should cater for their personal and emotional needs in the absence of family, providing a supportive and empowering environment to promote their mathematics learning. According to Rumel (2013), student–teacher and parent–teacher relationship quality has a great influence on students' academic motivation, engagement and performance. When students experience a close and supportive relationship with their lecturer they often become so engaged and motivated that they work harder in the classroom, persevere in the face of difficulties to avoid disappointing the lecturer, and accept his/her instruction. This support is consistent with the socio-constructivist theory and constructivist conceptions about mathematics which advocate for strong relationships to enhance scaffolding and facilitation during pedagogical practices (Vygotsky 1978; Vintere 2018).

These students, who struggled to pass mathematics, conceived that their mathematics lecturer should play a parental role by offering academic and social support which was parental in nature for effective mathematics learning during their mathematics pedagogical practices. However, despite this conception, their lecturers did not assume parental roles. Instead the lecturers explored acted as knowledge dispensers, even in cases where students could not keep pace with the dictation of notes.

Therefore, one could conclude that students who had struggled to pass O level mathematics conceived that teacher qualities like patience, innovativeness, creativity, friendliness, approachability, accommodativeness, accessibility and assuming a parental role were some of the most important school-related factors which influenced their achievement during mathematics pedagogical practices. However, notwithstanding these conceptions, none of these students studied experienced them. Other conceptions also emerged around research.

9.5.7 Research

Results revealed that all of the student teachers conceived research as an important approach during mathematics pedagogical practices. The student teachers conceived that through research they could analyse, communicate, interpret, comprehend and become more knowledgeable of mathematics (Vogt, Hauser, Stebler, Rechsteiner and Urech 2018). Findings also suggested that both student teachers and lecturers conceived that research afforded students an opportunity to gain more knowledge individually. In addition, the student teachers conceived that a research strategy augmented their understanding of mathematical concepts, making them more knowledgeable. Drawing on these findings, student teachers who had struggled to pass O level mathematics conceived research as an important aspect which catalysed their grasping of mathematics concepts during mathematics pedagogical practices. All of the students explored experienced research during mathematics pedagogical practices through assignment writing.

Thus, from this study one could say that all of the student teachers who struggled to pass mathematics held traditionalistic conceptions about mathematics. Strategies related to demonstrations, explanations and cooperative learning were also conceived as vital during mathematics pedagogical practices. However, these strategies were not experienced, as observed during the lecture observations. With regards to teaching techniques, the students conceived interactive teaching, learner centrality, scaffolding and remediation as vital interventions during mathematics pedagogical practices. Other conceptions were related to the possession of content, motivation, handling students' responses, classroom communication and interaction, language of instruction, teaching for understanding, teacher quality and research as very vital during mathematics pedagogical practices. In all four colleges the students conceived that knowledge should be acquired actively and they only experienced active learning through research.

The next section discusses the findings related to question two.

What are the Student Teachers' Experiences of Pedagogical Practices in Mathematics Education?

Findings showed that the experiences during pedagogical practices in mathematics education of the student teachers investigated in this stud who had struggled to pass O level mathematics revolved around the classroom in relation to content knowledge, technology, lecture preparation, lecture delivery, lecture time, assessment and student engagement.

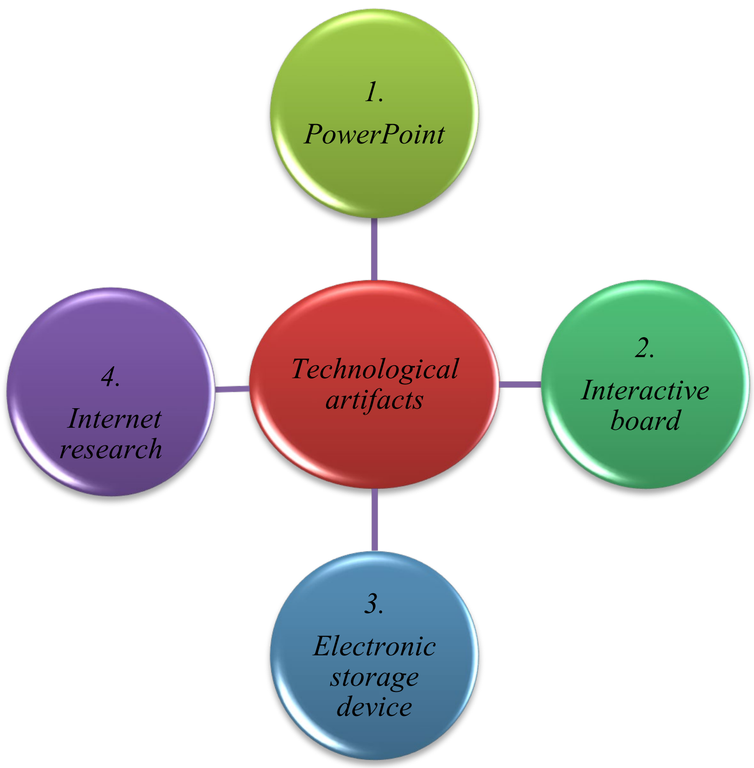
9.6 Experiences Related to Learning Mathematics Content

With regard to content knowledge, findings showed that all of the student teachers in all four colleges were exposed to and experienced limited mathematics content knowledge compared to pedagogical knowledge during mathematics pedagogical practices, contrary to their expectations and needs. This was notwithstanding that teacher content knowledge was crucial for effective teaching and learning, given its influence on planning, task setting, questioning, assessment, explaining, and feedback development. Content knowledge when well acquired generally boosts teacher confidence during lesson execution. Mathematical content knowledge that these student teachers expected to acquire during pedagogical practices was the knowledge that the teachers needed to teach, which they as learners had to learn. Literature reviewed (Grieser and Hendricks 2018) emphasises the critical role of the basic understanding of mathematics content in planning and carrying out instructions. Hoover, Mosvold, Ball and Lai (2016) in surveyed literature suggests that knowledge of content is vital, not only for teaching but also for appropriate decision making and evaluation of text books, computer software, teaching media, and other resources. It is also generally believed that teachers with a strong content knowledge grounding present lessons in a more interesting and dynamic fashion (Vintere 2001; Ochagavia 2018) while those with limited content knowledge often shy away from difficult concepts, or adopt didactic strategies. Findings showed that student teachers needed to acquire this type of subject-matter–specific professional knowledge during mathematics pedagogical practices; however, they reported having acquired only limited content knowledge. Literature surveyed (Sinelnikov, Kim, Ward, Curtner-Smith and Li 2016) further indicates that many teachers, due to their lack of mathematical content knowledge, are unable to provide conceptual explanations for the procedural tasks that they perform during lesson execution. From the findings, these student teachers who had struggled with mathematics at O level expected to gain more in-depth mathematics understanding in college, which would enhance their and learning and subsequent teaching. Contrary to this they reported more exposure to pedagogical knowledge than to mathematics content knowledge. From this study, student teachers who had struggled to pass O level mathematics before entering teacher training needed more exposure to content knowledge than to pedagogy during training. The next section discusses the experiences related to technology.

9.7 Experiences related to technology

The student teachers in two of the colleges had classroom experiences related to the use of technology during mathematics pedagogical practices. Technology is rapidly changing the way people live and work, and the field of education. Mathematics education is no exception. Findings reveal that technological artifacts experienced were related to PowerPoint software, interactive boards, electronic data storage devices and Internet research. Figure 9.6 below shows the different technological artifacts that students experienced during mathematics pedagogical practices.

Figure 9.6: Technological artifacts experienced during mathematics pedagogical practices



Source: Researcher (2021)

Students in the two government colleges revealed that they experienced PowerPoint presentations, use of interactive boards, Internet research and the use of electronic storage devices such as flash drives during mathematics pedagogical practices. On the other hand students in the private colleges did not have these technological experiences during mathematics pedagogical practices. Lively presentations using PowerPoint were vital, in particular for students who struggled or would be struggling with mathematics as interest and engagement were likely to be stimulated and captivated while providing notes that could be jotted down, and in the process, they would learn. Use of such technological devices as interactive boards and electronic storage devices (flash drives) often impacted positively on students' success and attitudes towards mathematics learning. The strategy of infusing technology during mathematics pedagogical practices aligned with the constructivist perspective where learning is interactive and the learner is placed at the centre of learning (Vygotsky 1978; Spitzer and Aronson 2015; Vintere 2018; Yang et al, 2019). This was supported by reviewed literature (Higgins, Huscroft-D'Angelo and Crawford 2019) which indicates that these affordances, in particular made by projecting information, made PowerPoint and interactive boards innovative tools with high potential for mathematics instructional environments during mathematics pedagogical practices.

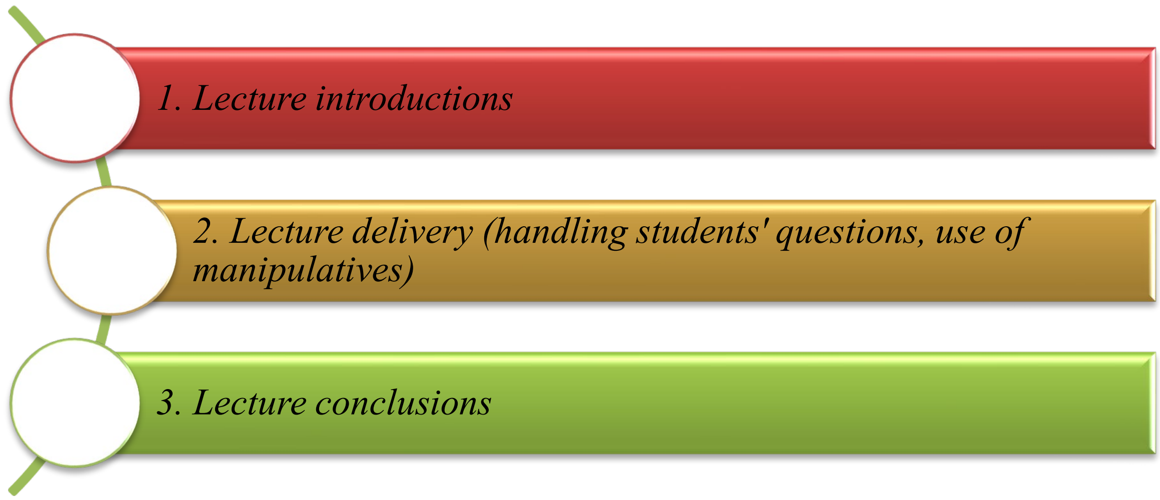
What the discussion above suggested was that constructivist learning in mathematics education could be promoted during pedagogical practices by using technological artifacts. Access to the technological artifacts discussed above apparently gave students opportunities to widen their horizons to conduct research during mathematics pedagogical practices, which in turn increased their engagement. However, notwithstanding the need for this educational shift to the use of technology during mathematics pedagogical practices, non-government colleges in this study were inadequately resourced in this respect, hence student teachers in those did not experience the use of technology during lectures. Surveyed literature (McKenney and Visscher 2019) indicates that technology is often still not being used to support learning and instruction paradigms that are believed to be the most beneficial for the student in mathematics education. Other experiences that emerged were related to lesson preparation.

9.8 Experiences related to lecture preparation

This study discovered that all of the student teachers experienced thoroughly prepared lectures during mathematics pedagogical practices. Findings further revealed that lecturers devoted a lot of time to advance preparation for lectures, given the detail that was presented. Literature surveyed (Palis and Quiros 2014) indicates that mathematics lectures should not only transmit mathematical knowledge, but also stimulate higher-order thinking. This can only be achieved through thoroughly prepared, planned, structured, and carefully thought through lectures. A well-planned lecture often increases lecturer self-esteem, enthusiasm and confidence, which can filter through to students and stimulate their interest while enriching their experiences in mathematics learning during pedagogical practices. Devoting time to preparation and planning, lecturers locate the student teacher central to their learning, as emphasised by socio-constructivist theory and constructivist conceptions about mathematics (Torner and Grigutsch 1994; Kim 2001; Yang et al. 2019). Literature surveyed (Blum 2015) indicates that thorough lesson planning is crucial for making the lecturer reflect on the 'what' 'how' and 'when' of the lesson, including how to evaluate it. Given the complexity of teaching and learning, appropriate preparation is required in both content and pedagogy, as it often involves examining each learner as an individual with a unique personality, who acquires knowledge, skills and attitudes at a different cognitive level, time, rate and way from his/her peers.

While the research findings revealed that the students experienced adequate and detailed preparation for each lecture, this may have prompted wide reading on the part of the lecturers, and incorporation of current information. Findings also revealed that in one college the lecturers relied on reused notes from previous years. This negated the dynamic and fluid nature of mathematics knowledge and implied that current information was not incorporated. The findings further revealed student teachers' experiences related to: lecture introduction, handling of students' questions, use of manipulatives and lecture conclusions, as summarised in Figure 9.7 below.

Figure 9.7: Experiences on classroom lecture structure



Source: Researcher (2021)

9.9 Experiences related to lecture introduction

Findings indicated that student teachers in all except one of the colleges did not experience a formal greeting from their lecturers during pedagogical practices. Lecturers in Colleges A, C and D, also confirmed by lecture observations, proceeded with lecturing without a formal greeting. From the surveyed literature (Edwards and Clinton 2019), a greeting in a lecture has the basic function of communication which connects the lecturer with his/her students, thereby opening the door for mathematical communication. The greeting gesture, in particular for those students who had struggled and were struggling with mathematics, often created high levels of bonding, thus it became the most important primary source of enjoyment and motivation for teaching and learning during mathematics pedagogical practices. Reviewed literature (Wanders, van der Veen, Dijkstra and Maslowski 2019) reveals that the relationship between student and teacher plays a large role in the path of a student's experiences of social development and academic success. Findings also suggested that student teachers generally experienced lecture introductions where an outline of the day’s objectives was provided. However, this was not observed during the lecture observations as the lecturers went on to lecture without outlining the lecture’s objectives. A lecturer at College A indicated that he introduced his lecture with a recap; however, this was disputed by the students at his college. Therefore, student teachers did not experience a recap of the previous lecture during mathematics pedagogical practices. An opening summary remains a vital pre-requisite of an effective lecture as the lecturer reminds student teachers of what they already covered before the introduction of new mathematical knowledge. Such a way of getting a lecture off to a ‘flying start’ forms the base on which to build new knowledge, as advocated by the socio-constructivist perspective (Kim 2001; Vintere 2018).

Surveyed literature (Ganske 2019) indicates that recapping is an important way of understanding students’ prior knowledge in order to use it as a foundation on which to build new knowledge. The absence of testing of prior knowledge during lecture introductions experienced by student teachers in this study could imply that students were generally denied some vital experiences during mathematics pedagogical practices in some teacher education institutions in Zimbabwe. Student teachers therefore conceived that teacher education lectures were treated in isolation, as there was no link with previously covered lectures. The next section discusses the experiences related to lecture delivery.

9.10 Experiences related to lecture delivery

With regard to the mode of instruction during pedagogical practices in mathematics, student teachers’ revealed experiences of the lecture method as the prime strategy of instruction. In all four institutions studied, lecturing was the predominant pedagogical strategy, revealed by lecturers as being due to limited time, large class sizes and its ability to share information with large numbers of students. Literature reviewed (Meguid and Collins 2017) indicates that a lecture is a familiar component in the delivery of mathematical content in teachers’ colleges. As alluded to above, student teachers revealed that the old-fashioned lecture style of having students jot down notes hindered the mathematics learning process as the students simply concentrated on writing notes without processing the information for mastery. This ‘universal’ distribution of lecture notes is generally criticized for its alienation of the audience, given the lack of engagement. Knowledge transmission of this nature and the lack of student engagement transformed the lecture room into a traditionalist classroom where the student was a passive recipient during pedagogical practices, as suggested by traditionalist conceptions (Ochagavia 2017). Mathematics is often regarded as an important subject in the school curriculum, and traditional mathematics teaching such as the lecture strategy is regarded as unsatisfactory.

Consistent with this, related literature consulted (Palis and Quiros 2015) indicates that there is an increasing trend toward transcending traditional didactic, teacher-focused teaching and moving to more student-centered pedagogies emphasised by constructivist perspectives. From the findings, the predominant teaching strategy in mathematics pedagogical practices experienced by the student teachers in this study was the lecture strategy, which students conceived as inappropriate for teaching and learning mathematics. Other experiences that emerged were related to the handling of students' questions.

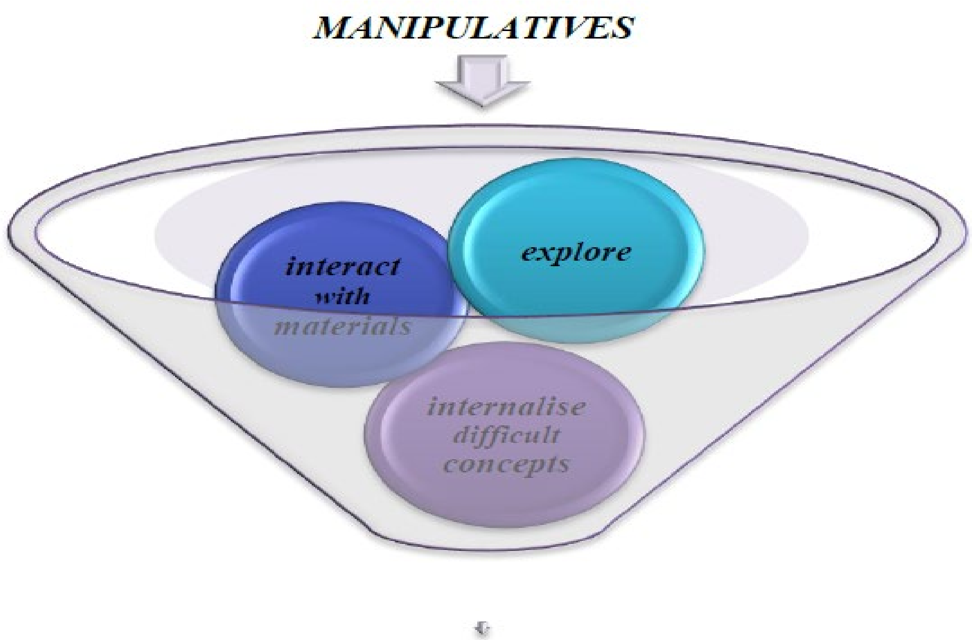
9.11 Experiences related to handling of students' questions

Research results also indicated that while the lecturers across all four colleges studied indicated that their students' classroom experiences included asking questions and receiving clear explanations, students disputed this as they revealed that they were not given time to ask questions. Instead, the lecturers themselves asked short recall questions. Furthermore, findings and the lecture observations conducted also revealed that no critical thinking questions were posed during mathematics pedagogical practices, and the four lecturers laid the blame for this on limited lecture time. Critical questions play a critical role during mathematics pedagogical practices in that they can be used to teach and also to assess whether students have understood.

One college indicated that they reserved such questions for students' research and take-home assignment writing. Failure to involve students in critical thinking questions could negate the creation of new knowledge foregrounded by constructivist perspectives. Reviewed literature (Santoso, Yuanita and Erman 2018) indicates that fostering student experiences of critical thinking during mathematics pedagogical practices gives rise to individual thinking and prompts reflection on and evaluation of what has been conceived during the lecture. Thus, from the findings, these student teachers neither experienced critical thinking questions nor were afforded space to ask questions during pedagogical practices in mathematics education in the selected teachers' colleges studied. This was confirmed during observation of the mathematics lectures where students were not afforded the chance to ask questions, nor did they experience critical thinking questions during mathematics pedagogical practices. Observations further revealed that it was the lecturers who asked simple recall questions. Experiences related to the use of manipulatives during mathematics education also emerged and these are discussed in the next section.

9.12 Experiences related to the use of manipulatives in the lecture

Figure 9.8: Effects of manipulatives



Source: Researcher (2021)

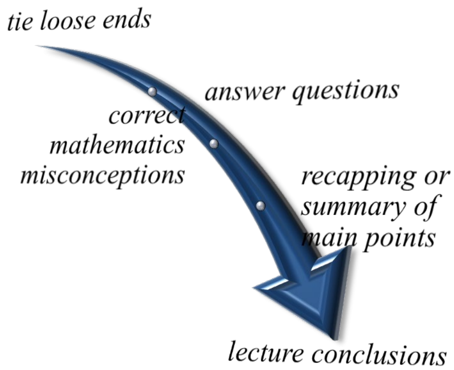
Drawing on the findings related to classroom experiences, the student teachers in one college indicated that they experienced the use of manipulatives during mathematics pedagogical practices. However, during lecture observation I did not witness any use of manipulatives in this college. Student teachers in the other three colleges reported a lack of such experiences in their mathematics lectures. Contrary to what students in College B said, lecturers in all of the colleges clearly pointed out that they did not use any media. The students in this one college revealed that during a lecture on fractions the lecturer had brought segmented indigenous fruits (*matohwe*) in order to illustrate the concept of fractions and how operations of fractions could be done using these fruits. Bringing these fruits also incorporated the aspect of culture, which helped demystify the subject of mathematics. Preparation of such manipulatives clearly reflected learner centrality, as advocated for by the socio-constructivists (Kim 2001; Vintere 2018).

Given that manipulatives generally enhance achievement when students use concrete objects to model, explore through interaction with materials and internalise difficult concepts, the lack of such experiences denied student teachers such benefits during mathematics pedagogical practices (Cockett and Kilgour 2015). Findings further suggested that due to the lack of manipulatives, student teachers were not located at the centre of their teaching and learning processes to enable them to explore and interact with materials to promote in-depth acquisition of mathematics knowledge. Literature (Lafay, Osana and Valat 2019) indicates that the use of manipulatives arouses students' interest in learning mathematics and promotes active engagement and critical thinking during mathematics lectures, in particular when dealing with students who may have or be struggling with the subject, as was the case with the participants in this study. Therefore, one could conclude that non-use of manipulatives by student teachers in the four sites explored implied that students did not have such classroom experiences during mathematics pedagogical practices; not only in the colleges explored but also in some other colleges in Zimbabwe. The next section discusses the experiences related to lecture conclusions.

9.13 Experiences related to lecture conclusion

Findings further indicated that none of the students experienced classroom experiences related to effective lecture conclusions, as reflected in Figure 9.9. Student teachers experienced an abrupt end to lectures during mathematics pedagogical practices. The diagram below illustrates the important functions of a lecture conclusion.

Figure 9.9: Importance of lecture conclusions



Source: Researcher (2021)

A lecture conclusion is the essence of a lecture, which provides a lasting impression of the concepts covered and 'take-aways' from the lecture during mathematics pedagogical practices. Results indicated that the student teachers in the four colleges were denied such experiences during mathematics pedagogical practices, contrary to the fact that this was the time to tie up loose ends, answer questions and correct any mathematics misconceptions. Surveyed literature (Ricks 2011) indicates that the conclusion to a lecture can be done by recapping the main points or asking the students to summarise the mathematics lecture during pedagogical practices. By letting students summarise, they are presented with space to engage in their learning, which is a socio-constructivism perspective (Kim 2001). Notwithstanding that a lecturer in one college had indicated otherwise, I noted the lack of lecture conclusions across all colleges studied during my lecture observations of mathematics pedagogical practices. This was contrary to what L2 had intimated during an interview: that he concluded his lectures with a question and answer session. The abrupt end to lectures experienced by student teachers could signal a lack of this vital component during mathematics pedagogical practices in many teacher training colleges in Zimbabwe. Students also revealed experiences related to lecture time and these are discussed in the next section.

9.14 Experiences related to lecture time

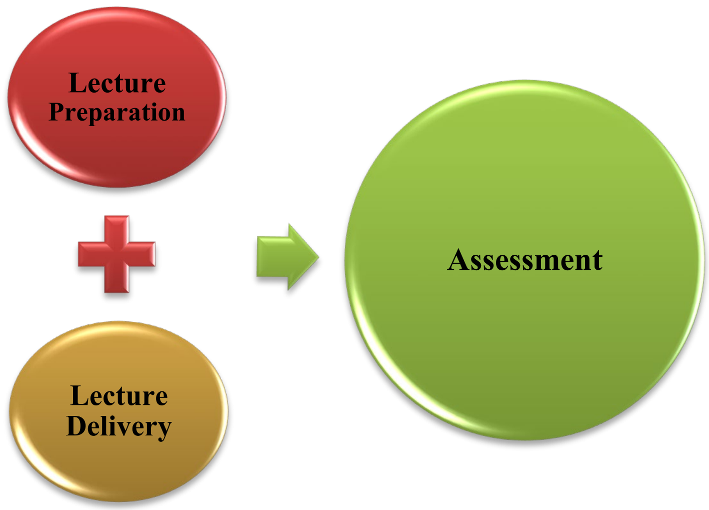
The student teachers in all four sites studied revealed that they experienced limited lecture time during mathematics pedagogical practices. This was evident during the lecture observation at College D where time was up before the planned lecture content was covered. This seemed to explain why the student teachers lamented experiencing limited content knowledge contrary to their expectations given their previous struggles with mathematics. Reviewed literature (Anderson 2016) indicates that in the mathematics curriculum, providing valuable resources and more time are important steps to enhance the achievement of conceptual understanding of concepts, particularly because some students may take long to master them, as was the case with the participants in this study. Student teachers indicated that they needed more time for interactive engagement with peers in mathematics inquiry, as advocated by constructivist perspectives that foreground active knowledge acquisition for retention (Kim 2001; Vintere 2018).

From the findings discussed above, student teachers experienced well-planned lectures. With regards to a greeting at the beginning of each lecture, only students at College B experienced a formal greeting before pedagogical practices. In all four colleges studied the students experienced the lecture method as the primary mode of instruction. However, none of the students experienced recapping of prior knowledge, use of manipulatives, critical thinking questions and even asking of questions during their mathematics pedagogical practices. Students also experienced an abrupt end to their lecture time. The lack of all the experiences mentioned above was also confirmed during lecture observations. The next section discusses the experiences related to assessment.

9.15 Experiences related to assessment

Other classroom experiences that emerged related to assessment. Assessment which is subsequent to lecture preparation and delivery generally plays an integral role in mathematics instruction as it establishes whether learning has taken place or not.

Figure 9.10: Experiences related to assessment



Source: Researcher (2021)

Findings around student teachers' classroom experiences during mathematics pedagogical practices revealed that they experienced assessment by means of tests and assignments. Use of tests and assignments for assessment purposes was also confirmed by the lecturers. Assessment generally plays a pivotal role in the learning process as it provides evidence to the lecturer about their student teachers' learning, which informs their instructional decisions and practices. Effective assessment in mathematics pedagogical practices also often provides feedback to both lecturer and students about their performance during mathematics pedagogical practices. Literature surveyed (Vonderwell and Boboc 2013) indicates that assessment plays an integral part in the teaching and learning process by facilitating student learning and improving instruction, and this comes in three forms: assessment *for* learning, assessment *of* learning and assessment *as* learning. These forms of assessment, if coherently linked through a well-articulated model of learning, can be effective during mathematics pedagogical practices. Assessment *for* learning (formative assessment) is continuous and allows the lecturer to monitor students in each lecture in order to adjust their teaching strategies to promote students' conceptual understanding of mathematics concepts. This type of feedback allows students to adjust their learning style. However, this vital aspect of assessment was not experienced as some misconceptions were not addressed during mathematics pedagogical practices. Assessment *of* learning provides information about student achievement but generally has little effect on student learning. Assessment *of* learning is cumulative, and usually occurs at the end of a unit or topic covered. This assessment captures what a student has learned, or the quality of their learning, and thus, measures a student's achievement at the end of instruction. This kind of assessment was experienced through assignments and tests. Assessment *as* learning is when students engage in peer and self-assessment as they make sense of information, relate it to prior knowledge and use it for new learning.

Literature surveyed (Torrance 2012) indicates that students develop a sense of ownership and efficacy when they use teacher, peer and self-assessment feedback to adjust, improve and change to what they understand. Student involvement in assessment foregrounds social constructivism. While the use of worksheets emerged at one college, one could conclude that student teachers explored in this study experienced two forms of assessment: tests and assignments in mathematics pedagogical practices within the selected colleges in Zimbabwe. Other experiences were related to student engagement.

9.16 Experiences related to student engagement

Findings also revealed that some students in two privately owned colleges (10) did not experience any engagement during mathematics pedagogical practices, as revealed on the video recording. Lack of engagement related to sleeping was also confirmed by one lecturer. Student engagement is vital during mathematics pedagogical practices as it often helps in student achievement. Student engagement allows participation as this is about behavioural involvement encompassing cooperative participation, conformity to classroom rules and routines and effort (Watt, Carmichael and Callingham 2017). Drawing on the findings, a number of issues seemingly contributed to the lack of engagement by some student teachers: dozing off to sleep; obstruction created by pillars inside the lecture hall; distance between the lecturer and students; the absence of PA systems; and unsuitable seating positions. Constructivist theory advocates for the elimination of power dynamics where the lecturer stands in front of students, as was noted in the lectures that I observed, and replacing that seating arrangement by having the students sitting in semi-circles or half-moons. Semi-circular seating arrangements could dispel the power dynamics and portray equality within the learning environment. However, given the large numbers of students (400) in the mass lectures that I observed, semi-circular seating was not possible.

Reviewed literature (Diaz 2017) indicates that low engagement during mathematics pedagogical practices affects students' capacity and mathematics performance. Therefore, due to the limited sitting space and lack of engagement experienced by the student teachers in the private colleges, one could conclude that the prevalence of limited infrastructure and consequently limited experiences in private teacher training colleges in Zimbabwe.

Having discussed the student teachers' experiences during mathematics education, in the next section I discuss the findings that addressed question three about the effects of conceptions and experiences on the student teachers' learning during mathematics pedagogical practices.

9.17 In what ways do conceptions and experiences influence student teachers' learning?

With regard to the influences of conceptions and experiences, the findings revealed three distinct aspects of how conceptions and experiences influenced the student teachers' learning in mathematics pedagogical practices: struggle to learn mathematics, fear of learning mathematics and learning mathematics for its utilitarian value.

9.17.1 Struggle to Learn

The study discovered that students' conceptions and their prior experiences with mathematics gave rise to struggling to learn mathematics during pedagogical practices. All but one participant at College B in the study struggled to learn mathematics during mathematics pedagogical practices due to their conceptions and prior experiences. Reviewed literature (Geary 2011) indicates that many students who struggled to acquire basic mathematics facts and conceptual knowledge in earlier studies are vulnerable to persistent struggle and underachievement throughout their mathematics education. As mathematics concepts become more advanced and challenging, such students who once struggled with the subject may experience problems since they need to work harder and practice more in order to understand the more advanced mathematics concepts. Thus, from this study, students who had struggled to pass mathematics at lower levels found the subject difficult and struggled to learn during mathematics pedagogical practices in college. What emerged was that student teachers who had struggled with O level mathematics conceived that their previous experiences and conceptions gave rise to their struggles with mathematics during mathematics pedagogical practices. While some struggled to learn mathematics during mathematics pedagogical practices in college, for others their conceptions and experiences generated fear of learning mathematics in them. Conceptions and experiences thus, influenced students to fear mathematics and this is discussed in the next section.

9.17.2 Fear of Mathematics

Findings also revealed that all of the student teachers explored across all of the colleges studied developed a fear of mathematics during mathematics pedagogical practices. McGregor and Elliot (2005: 219) state that fear of failure may be interpreted as "a self-evaluative framework that influences how the individual defines, orientates to, and experiences failure in achievement situations". Findings revealed that during mathematics pedagogical practices this fear led to poor performance during tests and in learning challenging topics. In addition, like those students whose conceptions and experiences gave rise to them struggling to learn mathematics due to this fear, four of the students had also not anticipated learning mathematics in college, and they viewed it as subject for the gifted few who were good at mathematics. This was a traditionalist conception about mathematics; that it was a subject for a selected few, the gifted ones (Dionne 1984; Vintere 2018).

Reviewed literature (Nolting 2011) indicates that feelings of fear towards mathematics greatly affect the student's confidence and ability to perform, even their desire to continue learning the subject, and leads to them viewing those comfortable with the subject as gifted with special talents. One lecturer explored also confirmed that students' conceptions and experiences influenced them to fear mathematics during pedagogical practices.

From the above discussion one could conclude that a student's conceptions and past experiences with mathematics brought about fear to learn the subject during mathematics pedagogical practices in later years. Other effects of conceptions and experiences were related to learning mathematics for its utilitarian value.

9.17.3 Learning Mathematics for its Utilitarian value

Due to their conceptions and experiences, all of the participants in two teachers' Colleges B and D, and a few in the other two colleges studied revealed that they only studied mathematics for its utilitarian value. Students who study mathematics for its utilitarian value usually just study mathematics because they want to use it to achieve their goals. Such students' conceptions are aligned to traditionalist conceptions which value mathematics for its utilitarian purposes (Lerman 1983; Dionne 1984; Vintere 2018).

In Zimbabwean primary school teacher education, student teachers were required to learn all primary school curriculum subjects, including mathematics. Hence notwithstanding their conceptions and experiences, they had to learn mathematics to be able to teach it. This was given that in Zimbabwe, primary school teachers were required to teach all curriculum subjects in their classes. Thus, the findings revealed that it was the conceptions and experiences that influenced these student teachers to study mathematics during pedagogical practices, just because it was a requirement. This was contrary to reviewed literature (Davies, Hersh and Marchisotto 2011) which indicates that mathematics as a subject should not only be done to get an academic qualification at school or college, or be studied as a requirement, but also for understanding and application to everyday life.

Thus, from this study, student teachers who struggled with mathematics before and during teacher education conceived that their conceptions and prior experiences with mathematics gave rise to struggles with mathematics, fear of mathematics and studying the subject as a requirement during mathematics pedagogical practices. Having discussed the findings from the study, the next section discusses some aspects relating to the original contribution of the study.

9.18 Lessons, Contributions and Implications of the study

As I approach the end of my arduous research journey, in my attempt to theorise regarding student teachers' conceptions and experiences in pedagogical practices in mathematics education, in teachers' colleges in Zimbabwe generally, and the student teachers studied in particular, I draw lessons, contributions and implications from three main contextual points: methodological, institutional, and national.

9.18.1 Methodological Context

To begin with, Mathematics plays a pivotal role in people's private, social and civil lives notwithstanding that many students struggle with the subject. It was therefore imperative to understand the conceptions and experiences of future mathematics teachers while they were in college to inform policy and practice. The student teachers explored had struggled to pass O level mathematics; they all sat for the subject more than once. Conceptions and experiences of mathematics have been studied significantly mainly focusing on school children, contrary to my study which examined student teachers in teachers' colleges who struggled to pass mathematics at O level in order to enter teacher education to train as primary school teachers. Given that all formal learning starts in the primary, findings from this investigation on conceptions and experiences of pedagogical practices in mathematics education in teacher training would contribute knowledge in this area. As these student teachers were expected to be change agents who would contribute towards enhancing education quality, as a teacher educator, it was imperative for me as a teacher to understand how such students conceived and experienced pedagogical practices in mathematics education during their teacher preparation. Conceptions and experiences of student teachers are central to their acquisition of mathematical knowledge and future teaching behaviour, hence the need to understand such aspects given the paucity of academic work on the particular category of student teachers. Literature reviewed (Lerman 1983; Toner and Grigutsch 1994; Gezer 2018) point out that the teachers' philosophy or conceptions and experiences of mathematics have strong influence on, and shapes their teaching practice. Thus, findings of this study will contribute to wider debates on mathematics teacher education and development.

Secondly, to enable me to interpret and explain the phenomenon of student teachers’ conceptions and experiences of mathematics pedagogical practices, I needed a theoretical way of understanding these conceptions and experiences. Thus, Dionne (1984) and Vygotsky (1978) provided the theoretical lenses. Firstly, conceptions about mathematics (Dionne 1984) were used to unpack the different conceptions students held about mathematics. Employing this theory in combination with socio-constructivism to explore conceptions and experiences of student teachers in teacher’s colleges, who struggled to pass O level mathematics, is the major contribution of this study. Dionne’s conceptions about mathematics are in three categories, however only two categories emerged: the traditionalist and constructivist conceptions about mathematics. Generally, the student teachers who struggled to pass O level mathematics displayed traditionalist conceptions about mathematics. The struggle to pass mathematics through repetitive, drilling strategies seemingly gave rise to adoption of traditionalistic conceptions. This is in tandem with surveyed literature (Martin 2013; Abramovich; Burns; Campbell and Grinshpan 2016) which indicates that traditional conceptions about mathematics can be acquired through learning and instructional practices students experience and or are exposed to. The socio-constructivist theory employed in this study supports interactive learning and further suggests that in mathematics pedagogical practices students should be central to their knowledge construction and the knowledge should be constructed collaboratively from the knowledgeable ‘other’ (in this case the lecturer or their peers). Generally, students’ experiences and conceptions portrayed teacher-centred pedagogies which negated students’ centrality to their learning. Hence, this study discovered that, in teacher education in Zimbabwe generally, students studied in particular, conceptions and prior experiences impact negatively on the student teachers’ learning.

Thirdly, in trying to understand the conceptions of the student teachers who had struggled to pass O level mathematics theoretically, conceptions theory offered a suitable theoretical lens. This was premised on the notions that a teacher's conceptions, views, beliefs and preferences about mathematics played a significant role in shaping their instructional behaviour (Thompson 1984; Schoenfeld 2016). However, conceptions theory on its own was insufficient; I therefore needed a theoretical way of understanding how such students experienced learning during mathematics pedagogical practices. I thus, needed an instructional theory which would provide me with guidelines for understanding the execution of mathematics lectures during mathematics pedagogical practices. Consequently, the socio-constructivism theory was relevant for establishing how students experienced mathematics education and how lecturers enacted and promoted such experiences during mathematics pedagogical practices. The theory spells out that instructors need to recognise how learners use their own experiences and prior knowledge, and this is appropriate to mathematics learning since mathematics concepts are not taught in isolation due to the hierarchical nature of the subject. Hence, the conceptions theory needed to be complemented by the socio-constructivist theory.
The combined theoretical lens was explored regarding its effectiveness as a methodological tool for understanding, describing, analysing and explaining student teachers' conceptions and experiences of mathematics pedagogical practices. With the use of this combined framework, I argue that this dual lens enhances examining and thinking through other aspects of student teachers' conceptions and experiences of pedagogical practices in mathematics education as it provides a more nuanced understanding of these conceptions and experiences.

Fourthly, my study found that students who held traditionalist conceptions about mathematics expected to experience in-depth conceptual understanding of mathematics during mathematics pedagogical practices. Such mastery requires lecturers adopting more constructivist teaching strategies and less knowledge or lecturer-centred approaches during pedagogical practices. At one level this may imply lecturers' paradigm shift to understand their responsibility in training a mixed bag of student teachers; those who struggled with mathematics and those who did not during pedagogical practices in mathematics education. They would then cease to expect all students to be at the same cognitive level when they entered the mathematics lecture room because they had all attained a Grade C pass or better.

9.18.2 Institutional Context

With regard to institutional, the lecture method in mathematics pedagogical practices in the colleges studied is no longer appropriate. Modern teaching methods must cater for students who struggle with mathematics and be aligned with global trends where emphasis is now on interactive learner-centred pedagogies. The lecture method which dominated the mathematics lecture rooms during mathematics pedagogical practices in this study needs more complimentary interactive methods to turn the teacher exposition strategies into constructivist strategies. Concomitant to this was the issue of subject content knowledge, which these student teachers conceived as limited during mathematics pedagogical practices. This study discovered that student teachers who struggled to pass O level mathematics expected to learn more content to master mathematics concepts and not pedagogy. This aspect needs urgent attention to ensure adequate and in-depth conceptual understanding of mathematics before these student teachers get into the classroom. Ensuring acquisition of adequate mathematical knowledge by these student teachers who struggled with mathematics will not only boost their teaching confidence, but enhance their teaching effectiveness, as well as their self-esteem. They will in turn not teach in a traditionalist way, but instead adopt the constructivist way of teaching mathematics for primary school learner comprehension. The need for interactive learning and learner centrality is supported by the constructivist perspectives (Kim 2001; Ochagavia 2019). The study therefore, recommends bridging programmes for student teachers who struggled to pass O level mathematics to enter teacher education, in order to equip them with sound mathematical content.

Further, the issue of mathematics content coverage needs serious consideration if institutions are serious about equipping these student teachers with appropriate and adequate knowledge and skills for mathematics teaching to the primary school child. Timetabling may be re-visited to ensure that there is more time for in-depth exploration and coverage of mathematical content and where necessary, extra learning time and coaching allotted for students, not only those who struggled to pass mathematics at O level but also those who may be struggling with the subject so that they adequately engage with mathematical ideas, using multiple mathematical representations. In any learning situation it is imperative to understand the students' conceptions and experiences in the classroom before teaching them. Therefore, institutions are challenged to understand the conceptions about mathematics held by their students and their prior experiences during mathematics pedagogical practices to enhance effectiveness in mathematics teaching and acquisition of mathematics concepts by students.

The study also discovered that lecture venues in privately owned colleges were conceived as inadequate and unsuitable for mass lectures during pedagogical practices and this needed urgent attention. Efforts need to be made to provide adequate and comfortable learning venues, probably by dividing students into smaller groups in order to reduce the overcrowding which was observed in these institutions. This will ensure students' comfort in the lecture venues and promote their learning and engagement. The study recommends that in order to boost effectiveness and engagement in learning for these students, particularly those who struggled to pass, provision of adequate physical and material resources should be prioritised in the private colleges. The government and responsible authorities are therefore challenged to avail funds and other forms of supports to these teacher training colleges to improve their resources.

9.18.3 National Context

The need for adequate infrastructure in privately owned teachers' colleges should be treated as a matter of urgency. The government, responsible authority and communities could intervene and provide financial support to the privately-owned colleges in the form of infrastructure - lecture rooms with appropriate technological gadgets (PA systems, interactive boards and other technological gadgets). Government may also look into employing more mathematics lecturers to reduce the lecturers' workloads and enhance their effectiveness during pedagogical practices. Some good practices, for example the use of interactive boards for researching mathematical knowledge, need to be promoted through the creation of platforms where lecturers can meet and share their best practices in pedagogical practices in mathematics education using technological gadgets. If teacher development is to be supported, particularly in private colleges, in-college support should be built into structures and activities to continuously and purposefully bring lecturers together and increase the likelihood of learning with and from each other. Lecturers in these institutions need opportunities for dialoguing and multiloguing publicly about their work and challenges. Typically, Heads will need to re-structure and re-arrange college schedules to provide time for interaction and collaboration, and even times for sharing teaching loads and observing each other as professionals.

9.19 Implications for research

Of the 17 teachers' training colleges in Zimbabwe, this study explored only 4 primary teachers' training colleges. Again, given the qualitative nature of the study, coupled with the sampling design and size of the sample, findings from this study may not hold strongly. There is therefore a need for a more comprehensive study involving more research sites and more student teachers in order to come up with more concrete evidence. There may also be a need to carry out a longitudinal study on the conceptions and experiences of the student teachers to help assess changes of conceptions and experiences among the same individuals over time.

The study focused only on those students who had struggled to pass O level mathematics and only on one-year group. However, there may also be a need to include other year groups and even students who did not struggle in order to understand their conceptions and experiences in comparison with those who struggled to pass mathematics.

Further, having developed a dual lens going beyond (Dionne (1984) and Vygotsky (1978) individually, the model can only take hold after it has been used and further developed by other researchers. There is need for more studies, drawing on the framework and developing it to determine its applicability beyond this particular inquiry. My study was qualitative in nature, further studies could adopt mixed methods or quantitative approaches.

As I conclude, I must point out that student teachers' conceptions and experiences of mathematics pedagogical practices affect the way they conceive mathematics, as articulated by ST9 at College B, who stated during their FFI:

> *… Not all of us are capable of doing this thing (mathematics)… I think we should be treated differently because we have different abilities so they are really making it difficult for us to understand the subject. We are struggling…*

These words affirm the conception that implies the need for appropriate handling of diversity in teacher education. ST9 makes a call for all-embracing constructivist differentiated strategies during mathematics pedagogical practices, as opposed to the traditionalist lecture dominant mathematics pedagogical practices in the teachers' colleges explored.

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APPENDICES

Appendix A: Questionnaire for student teachers

Topic: Pre-service Teachers’ Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.

Questionnaire for pre-service teachers in the general mathematics education course

1. Gender

Male	
Female	

2. Age

Range	✓Please tick
18-25 years	
26-30 years	
31-35 years	
Over 35 years	

3. Highest Academic Qualification

Qualification	✓Please tick
O level	
A level	

4. Year of Study

Year	✓ Please tick
First	

Second	
Third	

5. Do you have any teaching experiences? Yes ☐ No ☐

If yes how many years? _____

6. In which year did you write O Level Mathematics for the first time______

7. Did you write O Level Mathematics more than once? Yes ☐ No ☐

   If yes how many times______

Appendix B: Focus group interview schedule for student teachers

Topic: Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.

Focus Group Interview Schedule for Pre-Service Teachers

- Tell me about your best mathematics teacher in all your mathematics learning.
- Tell me about the worst mathematics teacher you have had in your mathematics learning.
- Tell me about the best mathematics lecture you have attended in the college.
- Tell me about the worst mathematics lecture you have attended in the college.
- Tell me what you think about mathematics subject? Why?
- Tell me in what ways do you think your experiences of being taught mathematics affected your re-writing of O level mathematics?
- Tell me about your experiences of being taught Mathematics in the college.
- Tell me in which ways do you think the way your experiences of being taught mathematics in college have prepared you adequately to be an effective primary school mathematics teacher?
- Tell me did any person, event or experience influence your decision to study Mathematics?
- Tell me what experiences you expect to acquire during Mathematics method course?
- According to your past experiences in Mathematics can you encourage your learners to pursue further mathematics studies?
- Tell me in what ways the way you view mathematics affect your learning of mathematics in the college?
- Tell me in which ways does the way you experienced teaching and learning of mathematics in the college influence the way you learn mathematics?
- In which ways do you think the way you view mathematics will affect your teaching of mathematics when you qualify as a teacher?
- Tell me do you think you would teach mathematics the way you are taught?

- Tell me what will be your greatest challenges in learning Mathematics at College? Why
- In which ways do you think your conceptions and experiences will affect your learning of Mathematics?
- Tell me the sources of these conceptions and experiences?
- What do you think is the best way of learning Mathematics? Why?
- Tell me how did you manage to pass mathematics?
- Is there anything else you would like to add to this interview?

Appendix C: Face-to-face interview schedule for student teachers

Topic: Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.

Face-to-face Interview Guide for Pre-service teachers

Tell me about your best mathematics teacher in all your learning. Why you think he/she is your best teacher?

Tell me about the worst mathematics teacher you have had in your learning. Why you think he/she is worst mathematics teacher you have experienced.

Tell me about a good mathematics lecture you have attended in the college. Why do you this mathematics lecture was a good one? Tell me more about it, what did you like about it?

Tell me about the worst mathematics lecture you have attended in the college. Why do you think this was a bad mathematics lecture? Tell me more about it. What did you not like about this mathematics lecture?

Tell me in what ways do you think your experiences of being taught mathematics affected your re-writing of O level mathematics

Tell me about your experiences of being taught Mathematics in the college

Tell me about your experiences of learning mathematics in the college.

Tell me in which ways do you think the way your experiences of being taught mathematics in college have prepared you adequately to be an effective primary school mathematics teacher.

Tell me did any person, event or experience influence your decision to study Mathematics?

Tell me what experiences you expect to acquire during Mathematics method course.

According to your past experiences how do you define Mathematics?

Tell me in what ways does the way you view mathematics affect your learning of mathematics in the college?

Tell me in which ways does the way you experienced teaching and learning of mathematics in the college influence the way you learn mathematics?

In which ways do you think the way you were taught mathematics will affect your teaching of mathematics when you qualify as a teacher?

Tell me what you think will be your greatest challenges in learning Mathematics at College? Why?

In which ways do you think your conceptions and experiences will affect your learning of Mathematics?

What do you think is the best approach to learning Mathematics? Why?

In Mathematics learning what do you value more? The correct answer? Or the correct method? Please explain why?

What do you think constitutes Mathematics learning? Please explain to me? What do you value more good instructions? Or good teacher instruction? Or good textbooks? Please tell me more.

Do you agree with the assertion that Mathematics is about memorising facts and passing exams. Please explain more.

Is there anything else you would like to add to this interview?

Appendix D: Face to face interview guide for lecturers

Topic: Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.

Face to face interview guide for lecturers

Tell me how you greet your students? How you introduce your lectures?

Tell me about the about the teaching methods that you use?

Tell me how you use manipulatives during mathematics education lectures?

Tell me how you allow pre-service teachers to talk to each other?

Tell me how you use media and technology in your methodology lectures?

Tell me the type of assignments, tutorial and tasks you give to the pre-service teachers?

Tell me how you give clear explanations to the assignments or tasks you give?

Tell me how do you prepare your lectures in advance? If yes what is it that you prepare?

Tell me are your lectures inclusive? If so how?

Tell me do you provide clear explanations and answer questions asked by pre-service teachers? If so how?

Tell me how do you react to questions asked by students?

Tell me how do you react to a wrong answer?

Tell me how do you allow students to give their opinion?

Tell me how do you cater for individual learning differences?

Communication with students: tell me what language do you use in relation to student expectation?

Tell me what strategies do you use to ensure understanding?

Tell me how do students react to these strategies?

Tell me how do you conclude your lectures?

Tell me how do students react to these concluding strategies?

Tell me do your questioning techniques call for critical thinking (i.e. use of open ended questions that call for inferential/independent thinking?

Tell me how do you think students conceive your mathematics pedagogy?

Tell me about the conceptions about mathematics you think these students hold considering the several times they wrote mathematics? Why?

Tell me how do you think these conceptions may influence their learning in mathematics education?

Tell me what you think are pre-service experiences concerning mathematics? Why?

Tell me how do you think these experiences may influence their learning?

Tell me how do you conduct your lectures?

Tell me how do you think these pre-service teachers will conduct mathematics lessons? Why?

Appendix E: Lecture observation checklist

Topic: Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.

Observation checklist

Year Group:

Date:

Time:

Lecturer:

<u>Lecture Structure:</u>

Methods of Instruction

Do they greet each other?

Use of interactive methods

Instructional Aids and Technology:

Use of white board

Use of interactive board to access information

Instructional materials

Use of Audio-Visual materials - friendliness

Relevant tasks, assignments, tutorials etc

Content Knowledge and relevance

Appropriateness to student knowledge and background

Ability to provide clear explanations and answer questions asked

Lecturing Procedure

Lecture introduction was it motivating and relevant

Sensitivity to feedback

Student to student interaction

Sensitivity to learning differences

Communication with students (one way or reciprocal)

What language is used by staff in relation to expectations?

What language is used by students in relation to staff expectations?

What body language is exhibited at different stages of the lecture?

What body language is exhibited by students at different stages of the lecture?

When and how do students/staff show signs of confusion/distress?

How does the staff react to the confusion/distress?

What strategies does the lecturer adopt to ensure understanding?

How do students react to staff strategies?

How does the ages and gender of all participants influence their interactions with each other?

How does the lecture conclude each session?

How do students react to the lecturer concluding strategies?

Questioning techniques (did they call for critical thinking ie use of open ended questions that call for inferential thinking or independent thinking)

Pacing of lecture

Overall comments

Did the students benefit from the lecture (content wise or any acquisition of mathematical skills)

Appendix F: Letter of information and consent form for all participants

LETTER OF INFORMATION

Title of the Research Study: Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Teacher Education in Selected Teachers' Colleges in Zimbabwe

Principal Investigator: Manyadze Constance **Student Number:** 21751938

Email: sazisoman@gmail.com **Cell No.** +263 775 130 605/ +263 733 439 274

Supervisors: Prof Tabitha Grace Mukeredzi and Prof Julia Preece

Brief Introduction and Purpose of the Study:

I am a student at Durban University of Technology and I have to carry out a research study. The purpose of the study is to explore pre-service teachers' conceptions and experiences of pedagogical practices in mathematics education. In Zimbabwe, a pass with grade C or better in O Level Mathematics is a pre-requisite for entry into teacher education institutions and most professions however, many prospective pre-service teachers make several attempts to re-write and pass mathematics to enable them to gain entry into teacher training. The study therefore seeks to understand conceptions and experiences of these pre-service teachers who will have struggled to pass mathematics since they will be expected to teach all the subjects in the primary school including mathematics. I therefore invite you to take part in the study. The study hopes to come up with recommendations to make to the Ministry of Higher and Tertiary Science and Technology Development (MHTSTED) concerning Teacher Preparation.

Outline of the procedure:

If you accept this invitation to take part in the study you will engage in focus groups, face to face interviews and the researcher will also observe you in your mathematics education lectures. The discussions will be tape recorded with your permission. Data collection will be done between August 2017 to February 2018. Follow ups will be done in order to verify information.

Risks or Discomforts to the Participant:

You will not experience any risks or discomforts since interviews will be taped only when permission has been granted by you.

Benefits (to the participants and to the researcher):

The study will create a forum for you to express your conceptions and experiences in mathematics education in teachers' colleges for the benefit of teacher development programmes. The MHTSTED will be informed by the study in order to make meaningful and relevant education programmes which will benefit teacher preparation.

Persons to contact in the event of any problems or queries:

Prof Tabitha Grace Mukeredzi Email: TabithaM@dut.ac.za Cell: +27 82 605 6401

Prof Julia Preece Email: JuliaP@dut.ac.za Cell: +27 73 465 7609

Costs of the study:

Please note that:

- ✓ Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion
- ✓ Any information given by you cannot be used against you and the collected data will be used for purposes of the research only
- ✓ Data will be stored in secure storage and destroyed after 5 years

- ✓ You have a choice to participate, not participate or stop participating in the research. You will not be penalized for taking such action
- ✓ The research aims at exploring conceptions and experiences of pre-service teachers of pedagogical practices in mathematics education.
- ✓ Your involvement is solely for academic purposes only, and there are no financial benefits involved.
- ✓ You are not expected to cover any costs towards the study. All the costs will be borne by the researcher.

Thank you

Manyadze Constance

CONSENT FORM

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, about the nature, conduct, benefits and risks of this study – Research Ethics Clearance Number:

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

I have agreed to have the interview **voice recorded**.

I have also agreed to be video recorded during mathematics education lectures.

I have agreed to the use of pseudonym.

Full Name of Participant…………………………………. Signature………………..
Date……………..

I ……………………………… herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Full Name of Researcher…………………………. Signature…………………
Date……………

Appendix G: Letter to the ministry requesting permission to conduct a research

The Permanent Secretary
Ministry of Higher and Tertiary Science and Technology Development
P O Box CY
Causeway
Harare, Zimbabwe
14 June 2017

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH

I am a PhD candidate studying at the Durban University of Technology, Indumiso Campus, South Africa. I would like to request your permission to conduct research in your colleges in Zimbabwe. The title of my study is entitled: **Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.** The study will help inform teacher development about the conceptions and experiences of pedagogical practices in mathematics education.

Your positive response to this request will be highly appreciated.

Yours faithfully

Manyadze Constance
Email: sazisoman@gmail.com

Cell No. +263 775 130 605/ +263 733 439 274

Supervisors' Details: Prof Tabitha Grace Mukeredzi Email: TabithaM@dut.ac.za

Prof Julia Preece Email: JuliaP@dut.ac.za

Appendix H: Letter to Principals

The Principal
Masvingo Teachers' College
P O Box 760
Masvingo, Zimbabwe.
14 June 2017

Dear Sir/ Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH

My name is Constance Manyadze. I am a PhD candidate studying at the Durban University of Technology, Indumiso Campus, South Africa. I am conducting a study entitled: **Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.** I intend to first conduct focus group discussions for pre-service teachers and lecturers. Secondly I will pick students for the face to face interviews. I will also observe PSB (methodology) lectures.
Your positive response to this request will be highly appreciated.
Yours sincerely

Manyadze C

I can be contacted at:
Email: sazisoman@gmail.com

Cell No. +263 775 130 605/ +263 733 439 274

My supervisors are:

Prof Tabitha Grace Mukeredzi Email: TabithaM@dut.ac.za

Prof Julia Preece Email: JuliaP@dut.ac.za

The Principal
Marymount Teachers' College
P O Box 85
Mutare, Zimbabwe.
14 June 2017

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH

My name is Constance Manyadze. I am a PhD candidate studying at the Durban University of Technology, Indumiso Campus, South Africa. I am conducting a study entitled: **Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.** I intend to conduct focus group and face to face discussions for pre-service teachers and focus groups for lecturers. Secondly, from the focus group discussions I will pick students for the face to face interviews. I will also observe PSB (methodology) lectures.
Your positive response to this request will be highly appreciated.

Yours sincerely

Manyadze C

I can be contacted at:

Email: sazisoman@gmail.com

Cell No. +263 775 130 605/ +263 733 439 274

My supervisors are:

Prof Tabitha Grace Mukeredzi Email: TabithaM@dut.ac.za

Prof Julia Preece Email: JuliaP@dut.ac.za

DUT DURBAN UNIVERSITY OF TECHNOLOGY
INSTITUTIONAL RESEARCH ETHICS COMMITTEE

The Principal
Bondolfi Teachers' College
P O Box 300
Masvingo, Zimbabwe.
14 June 2017

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH

My name is Constance Manyadze. I am a PhD candidate studying at the Durban University of Technology, Indumiso Campus, South Africa. I am conducting a study entitled **Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.** I intend to first conduct focus group discussions for pre-service teachers and lecturers. Secondly, from the focus group discussions I will pick participants for the face to face interviews. I will also observe PSB (methodology) lectures.
Your positive response to this request will be highly appreciated.

Yours sincerely

Manyadze C

I can be contacted at:

Email: sazisoman@gmail.com

Cell No. +263 775 130 605/ +263 733 439 274

My supervisors are:

Prof Tabitha Grace Mukeredzi Email: TabithaM@dut.ac.za

Prof Julia Preece Email: JuliaP@dut.ac.za

The Principal
Morgenster Teachers' College
P O Morgenster
Masvingo, Zimbabwe.
14 June 2017

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH

My name is Constance Manyadze. I am a PhD candidate studying at the Durban University of Technology, Indumiso Campus, South Africa. I am conducting a study entitled **Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.**
I intend to first conduct focus group discussions for pre-service teachers and lecturers. Secondly, from the focus group discussions I will pick participants for the face to face interviews. I will also observe PSB (methodology) lectures.
Your positive response to this request will be highly appreciated.

Yours sincerely

Manyadze C

I can be contacted at:
Email: sazisoman@gmail.com

Cell No. +263 775 130 605/ +263 733 439 274

My supervisors are:

Prof Tabitha Grace Mukeredzi Email: TabithaM@dut.ac.za

Prof Julia Preece Email: JuliaP@dut.ac.za

Appendix I: Letters to the responsible authorities for church owned colleges

The Education Secretary
Catholic Diocese of Masvingo
Robertson Street, Masvingo
14 June 2017.

Dear Father

RE: Request for Permission to Conduct Research

I am a student pursuing a PhD study through Durban University of Technology. I am writing to seek permission to carry out research at Bondolfi Teachers College. The title of my study is, **Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe. "**
I intend to conduct focus group discussions with lecturers and students then hold face to face interviews with students. I will also observe PSB lectures with Mathematics lecturers.
For more information, you may contact my supervisor whose contact details are below:

Prof. Tabitha Grace Mukeredzi (PhD).
School of Education
Adult, Community and Post Graduate Education Unit
DUT Indumiso/ Midlands Campus
15 JF Sithole Road
Imbali 3201

Pietermaritzburg

Yours faithfully

Manyadze Constance.

The Education Secretary
Reformed Church in Zimbabwe
Masvingo
14 June 2017.

Dear Sir/Madam
RE: Request for Permission to Conduct Research

I am a student pursuing a PhD study through Durban University of Technology. I am writing to seek permission to carry out research at Morgenster Teachers College. The title of my study is: **Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Education in Selected Teacher Training Colleges in Zimbabwe.**

I intend to conduct focus group discussions with lecturers and students then hold face to face interviews with students. I will also observe PSB lectures with Mathematics lecturers.

For more information, you may contact my supervisor whose contact details are below:
Prof Tabitha Grace Mukeredzi, PhD
Adult, Community and Post Graduate Education Unit
DUT Indumiso/ Midlands Campus
15 JF Sithole Road
Imbali 3201Pietermaritzburg

Yours faithfully

Manyadze Constance.

All official communications should be addressed to:
"The Secretary for Higher & Tertiary Education
Telephones: 795891-5, 796441-9, 730055-9
Fax Numbers: 792109, 728730, 703957
E-mail: thesecretary@mhet.ac.zw
Telegraphic address: "EDUCATION"

ZIMBABWE

Reference:

MINISTRY OF HIGHER AND TERTIARY EDUCATION, SCIENCE AND TECHNOLOGY DEVELOPMENT
P. BAG CY 7732
CAUSEWAY

26 September 2017

Masvingo Teachers' College
P.O Box 760
MASVINGO

Dear Mrs C. Manyadze,

RE: REQUEST FOR AUTHORITY TO CARRY OUT A RESEARCH ON "PRE-SERVICE TEACHERS CONCEPTIONS AND EXPERIENCE OF PEDAGOGICAL PRACTICES IN MATHEMATICS TEACHER EDUCATION": MINISTRY OF HIGHER AND TERTIARY EDUCATION, SCIENCE AND TECHNOLOGY DEVELOPMENT

Reference is made to your letter in which you requested for permission to carry out a research on **"Pre-Service Teachers conceptions and experience of pedagogical practices in Mathematics teacher education": a case study of Bondolfi, Morgenster, Masvingo and Marymount Teachers Collegs".**

Accordingly, please be advised that the Head of Ministry has granted permission for you to carry out the research.

It is hoped that your research will benefit the Ministry and it would be appreciated if you could supply the office of the Permanent Secretary with a final copy of your study, as the findings would be relevant to the Ministry's strategic planning process.

P.Mavhondo (Mr)
Acting Director - Human Resources
FOR: PERMANENT SECRETARY

REGISTRY
MINISTRY OF HIGHER EDUCATION
MASVINGO TEACHERS COLLEGE
03 OCT 2017
P.O. BOX 760
MASVINGO
TEL: 264444, 262074

HIGHER & TERTIARY EDUCATION
MASVINGO TEACHERS COLLEGE
PRINCIPAL
03 OCT 2017
P.O.BOX 760 MASVINGO
ZIMBABWE

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

6 August 2018

IREC Reference Number: **REC 164/17**

Mrs C Manyadze
3 Flame Tree Avenue
Northleigh
Masvingo
Zimbabwe

Dear Mrs Manyadze

Pre-service Teachers' Conceptions and Experiences of Pedagogical Practices in Mathematics Teacher Education: Implications for Teacher Preparation in Zimbabwe Teacher Training Colleges

The Institutional Research Ethics Committee acknowledges receipt of your final data collection tool for review.

We are pleased to inform you that the data collection tool has been approved. Kindly ensure that participants used for the pilot study are not part of the main study.

In addition, the IREC acknowledges receipt of your gatekeeper permission letter.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely,

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2018 -08- 06
INSTITUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix L: Bio-data for all questionnaire respondents

COLLEGE A

Number	Gender	Age	Highest academic qualification	Year of study	Teaching experience (in years)	Year of first sitting	Number of sittings
1	F	26-30	O level	3	1	2007	2
2	F	31-35	O level	3	1	2002	1
3	F	Over 35	O level	3	4	1997	3
4	F	18-25	A level	3	1	2013	1
5	F	18-25	O level	3	1	2013	1
6	F	31-35	O level	3	2	2003	3
7	F	18-25	O level	3	1	2011	2
8	F	26-30	O level	3	3	2008	3
9	F	31-35	O level	3	5	2003	2
10	F	18-25	O level	3	1	2012	4
11	F	31-35	O level	3	2	2001	4
12	F	26-30	O level	3	1	2007	3
13	F	31-35	O level	3	1	2000	2
14	F	18-25	A level	3	1	2013	2
15	F	Over 35	O level	3	6	1995	3
16	F	31-35	O level	3	4	2001	1
17	F	26-30	O level	3	2	2003	1
18	F	18-25	O level	3	1	2012	3
19	F	31-35	O level	3	1	2001	2
20	F	26-30	O level	3	1	2005	3
21	F	18-25	O level	3	1	2011	1
22	F	26-30	O level	3	2	2007	1
23	F	31-35	O level	3	4	2003	1
24	F	18-25	O level	3	1	2010	2
25	F	Over 35	O level	3	1	1999	3
26	M	31-35	O level	3	1	2000	3
27	M	Over 35	O level	3	1	2000	3
28	M	18-25	O level	3	1	2011	4
29	M	26-30	A level	3	2	2008	3
30	M	18-25	O level	3	1	2010	2
31	M	31-35	O level	3	3	2003	2
32	M	26-30	O level	3	1	2007	1
33	M	31-35	O level	3	1	2002	1
34	M	18-25	O level	3	1	2012	1
35	M	Over 35	O level	3	1	1999	3
36	M	Over 35	A level	3	1	1997	3

37	M	18-25	O level	3	1	2013	1
38	M	26-30	O level	3	1	2007	1
39	M	18-25	O level	3	1	2014	1
40	M	26-30	O level	3	1	2008	3
41	M	18-25	O level	3	1	2014	1
42	M	26-30	O level	3	1	2008	2
43	M	31-35	O level	3	3	2003	2
44	M	18-25	O level	3	1	2012	1
45	M	31-35	O level	3	2	2002	3
46	M	Over 35	O level	3	1	1996	3
47	M	26-30	O level	3	1	2007	2
48	M	31-35	O level	3	1	2003	2
49	M	31-35	O level	3	1	2002	3
50	M	26-30	A level	3	1	2005	1

COLLEGE B

Number	Gender	Age	Highest academic qualification	Year of study	Teaching experience (in years)	Year of first sitting	Number of sittings
1	F	Over 35	O level	3	3	1999	1
2	F	26-30	O level	3	1	2010	2
3	F	18-25	O level	3	1	2014	1
4	F	31-35	O level	3	2	2001	2
5	F	18-25	O level	3	1	2013	3
6	F	26-30	O level	3	1	2010	3
7	F	18-25	O level	3	1	2012	3
8	F	26-30	A level	3	1	2011	2
9	F	31-35	O level	3	1	1999	1
10	F	18-25	O level	3	1	2011	1
11	F	Over 35	O level	3	1	1996	2
12	F	26-30	O level	3	1	2012	1
13	F	18-25	O level	3	1	2011	2
14	F	31-35	O level	3	3	2001	1
15	F	26-30	O level	3	1	2009	3
16	F	18-25	O level	3	1	2011	1
17	F	31-35	O level	3	2	2003	1
18	F	18-25	A level	3	1	2012	1
19	F	26-30	O level	3	2	2005	1
20	F	31-35	O level	3	1	2003	1
21	F	26-30	O level	3	3	2008	3
22	F	26-30	O level	3	1	2007	2
23	F	18-25	O level	3	1	2014	1

24	F	31-35	O level	3	1	2003	3
25	F	Over 35	O level	3	2	1998	3
26	M	18-25	A level	3	1	2012	1
27	M	31-35	O level	3	1	2001	3
28	M	18-25	O level	3	1	2013	1
29	M	26-30	O level	3	2	2008	1
30	M	18-25	O level	3	1	2014	1
31	M	31-35	O level	3	2	2003	2
32	M	26-30	O level	3	1	2009	1
33	M	18-25	O level	3	1	2012	1
34	M	31-35	O level	3	1	2003	1
35	M	31-35	O level	3	3	2002	3
36	M	Over 35	O level	3	1	1995	2
37	M	Over 35	O level	3	1	1998	4
38	M	31-35	O level	3	1	1999	1
39	M	26-30	O level	3	1	2007	1
40	M	18-25	A level	3	1	2011	1
41	M	18-25	O level	3	2	2012	2
42	M	26-30	O level	3	1	2007	3
43	M	18-25	O level	3	1	2013	1
44	M	26-30	O level	3	2	2008	3
45	M	31-35	O level	3	1	2002	1
46	M	Over 35	A level	3	1	1995	3
47	M	26-30	O level	3	1	2007	1
48	M	31-35	O level	3	1	2003	1
49	M	26-30	O level	3	1	2008	3
50	M	18-25	O level	3	1	2013	2

COLLEGE C

Number	Gender	Age	Highest academic qualification	Year of study	Teaching experience	Year of first sitting	Number of sittings
1	F	26-30	O level	3	1	2007	2
2	F	18-25	O level	3	1	2014	2
3	F	31-35	O level	3	1	2000	3
4	F	Over 35	O level	3	1	1999	1
5	F	26-30	O level	3	3	2008	3
6	F	31-35	O level	3	1	2001	2
7	F	31-35	O level	3	1	2001	3
8	F	18-25	O level	3	1	2013	2
9	F	26-30	A level	3	2	2009	1
10	F	31-35	O level	3	1	2002	3

11	F	26-30	O level	3	1	2010	1
12	F	18-25	O level	3	1	2011	1
13	F	26-30	O level	3	1	2006	1
14	F	Over 35	O level	3	1	2000	1
15	F	26-30	O level	3	1	2007	4
16	F	31-35	O level	3	3	2003	1
17	F	18-25	O level	3	1	2012	1
18	F	18-25	O level	3	1	2012	1
19	F	31-35	O level	3	3	2004	2
20	F	Over 35	O level	3	1	1998	3
21	F	26-30	O level	3	1	2008	2
22	F	18-25	O level	3	1	2013	1
23	F	26-30	O level	3	1	2009	1
24	F	Over 35	O level	3	2	1996	2
25	F	26-30	O level	3	1	2009	3
26	M	31-35	O level	3	1	2005	2
27	M	26-30	O level	3	1	2008	1
28	M	18-25	O level	3	1	2014	1
29	M	26-30	O level	3	1	2007	1
30	M	31-35	O level	3	1	2004	3
31	M	26-30	O level	3	1	2006	1
32	M	18-25	O level	3	1	2011	1
33	M	18-25	O level	3	1	2012	1
34	M	Over 35	O level	3	2	2000	2
35	M	26-30	O level	3	1	2006	2
36	M	31-35	O level	3	1	2003	2
37	M	18-25	O level	3	1	2013	1
38	M	18-25	O level	3	1	2013	1
39	M	26-30	O level	3	1	2008	3
40	M	31-35	A level	3	2	2000	1
41	M	26-30	O level	3	1	2007	2
42	M	18-25	O level	3	1	2014	1
43	M	26-30	O level	3	1	2010	1
44	M	Over 35	O level	3	1	2000	1
45	M	31-35	O level	3	2	2001	2
46	M	26-30	O level	3	1	2007	3
47	M	31-35	O level	3	1	2002	3
48	M	18-25	O level	3	1	2011	1
49	M	26-30	O level	3	1	2008	1
50	M	18-25	O level	3	1	2013	1

COLLEGE D

Number	Gender	Age	Highest academic qualification	Year of study	Teaching experience	Year of first sitting	Number of sittings
1	F	18-25	A level	3	1	2011	2
2	F	31-35	O level	3	1	2002	1
3	F	31-35	O level	3	2	2003	3
4	F	26-30	O level	3	1	2005	4
5	F	Over 35	O level	3	2	1994	1
6	F	18-25	O level	3	1	2012	3
7	F	26-30	O level	3	1	2011	4
8	F	31-35	O level	3	1	2004	4
9	F	18-25	O level	3	1	2012	2
10	F	26-30	O level	3	1	2010	3
11	F	18-25	O level	3	1	2013	1
12	F	18-25	O level	3	3	2013	1
13	F	18-25	O level	3	1	2013	5
14	F	26-30	O level	3	1	2009	2
15	F	31-35	O level	3	1	2001	1
16	F	31-35	O level	3	1	2001	3
17	F	Over 35	O level	3	1	2002	4
18	F	18-25	O level	3	1	2014	2
19	F	26-30	A level	3	1	2006	3
20	F	18-25	O level	3	1	2012	4
21	F	Over 35	O level	3	1	1999	3
22	F	26-30	O level	3	1	2007	4
23	F	31-35	O level	3	1	2003	3
24	F	18-25	O level	3	1	2013	2
25	F	26-30	O level	3	1	2008	2
26	M	31-35	O level	3	1	2004	3
27	M	Over 35	O level	3	1	1999	1
28	M	18-25	O level	3	1	2014	4
29	M	26-30	O level	3	1	2009	1
30	M	18-25	O level	3	1	2013	4
31	M	26-30	O level	3	1	2009	1
32	M	Over 35	O level	3	1	2000	1
33	M	26-30	O level	3	1	2008	3
34	M	31-35	O level	3	1	2004	3
35	M	26-30	O level	3	1	2007	1
36	M	31-35	O level	3	1	2003	1
37	M	Over 35	O level	3	1	1996	1
38	M	26-30	O level	3	2	2010	3

39	M	18-25	O level	3	1	2013	1
40	M	18-25	O level	3	1	2012	2
41	M	18-25	O level	3	1	2012	3
42	M	26-30	O level	3	1	2008	4
43	M	31-35	O level	3	1	2002	1
44	M	18-25	O level	3	1	2013	1
45	M	26-30	O level	3	1	2012	4
46	M	26-30	O level	3	2	2009	2
47	M	31-35	A level	3	1	2001	1
48	M	31-35	O level	3	1	2000	3
49	M	Over 35	O level	3	1	2001	3
50	M	18-25	O level	3	1	2014	4