AN INVESTIGATION INTO UNDERSTANDING THE EXPERIENCES OF THE LEVEL 5-7 STUDENT TEACHERS WHEN TEACHING FRACTIONS IN PRIMARY SCHOOLS IN NAMIBIA: A CASE STUDY

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by

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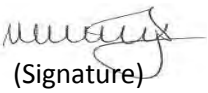
Declaration of originality

I, **Ndamononghenda Vatilifa, student no. 609V6600,** declare that this thesis is my own work written in my own words. Where I have drawn on the words or ideas of others, these have been acknowledged using complete references according to Departmental Guidelines.



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ABSTRACT

The Namibian government through the Ministry of Education seeks for teachers to meet the demands and rise to the challenges of the post-independence basic education system. Therefore the University of Namibia Education Faculty must ensure through the training of student teachers for both lower, upper primary and secondary school level that these demands are met. Research shows that one of the major challenges in teacher training programs, specifically in the mathematics education programmes, lies with the student teachers' difficulties in dealing with various topics in mathematics, particularly fractions. The teaching of fractions is a challenging area at primary level and lays the foundation for understanding different topics in upper grades such as algebra, ratio and proportion, statistics and probability, to mention just a few.

This study focused on an exploration of teaching fractions by five student teachers during their teaching practice .The main purpose was to gain an understanding of the experiences of the level 5-7 student teachers with regard to their practice of fraction teaching; their experience of the mathematics education course with respect to the teaching of fractions; and their prior experience related to fractions and fraction teaching at Grade 6 level.

The findings from this research showed that student teachers viewed mathematics, specifically fractions, as just about doing calculations, doing drill and practice as in this way learners' understanding of fractions is enhanced. The importance of using rules and procedures was emphasized as paving the way to mastering fractions. The data analysis also revealed that student teachers employed different teaching approaches when they considered learners' prior knowledge. However, they misinterpreted the learner-centred approach in terms of group work and class discussion in their teaching of fractions. The data also revealed that some student teachers had an understanding of fractions as they managed to redirect their learners from applying some fraction misconceptions. The findings further showed that due to lack of understanding most of the participants experienced fear and anxiety in their fraction teaching; attempted an approach then reverted to old practices used in schools; taught fractions as symbolic representations where no meaning was involved; used incorrect terminologies such as '1 over 4' or '1 out of 4' instead of a 'quarter' or 'one-fourth'. It is further revealed that the some student teachers viewed a fraction as a pair of two different whole numbers and can be broken apart.

The findings of this study yielded one main implication for the teaching of mathematics: that the teacher training programs, specifically for mathematics teachers, must take into consideration the weaknesses and strengths of the student teachers shown in this study to properly train and prepare them to become effective mathematics teachers.

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DEDICATION

This thesis is dedicated to my beloved late sister Martha Shangeelao Kashikatu-Moses. She passed away on the 19th August 2012. Martha was a caretaker for me throughout my early years of schooling.

ACRONYMS

BED = BACHELOR OF EDUCATION DEGREE

BETD = BASIC EDUCATION TEACHER DIPLOMA

MBESC = MINISTRY OF BASIC EDUCATION, SPORT AND CULTURE

MoE = MINISTRY OF EDUCATION

NCTM = NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

NIED = NATIONAL INSTITUTE FOR EDUCATIONAL DEVELOPMENT

SBS = SCHOOL BASED STUDIES

UNAM = UNIVERSITY OF NAMIBIA

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CHAPTER 1

INTRODUCTION OF THE STUDY

1.1 INTRODUCTION

In this chapter I provide an introduction to this research study. The chapter describes the background as well as the context of this study, which is followed by the goals of the research study. In addition I highlight the significance of the study and I close the chapter with a brief overview of the thesis.

1.2 BACKGROUND TO AND CONTEXT OF THE STUDY

In 1993 the Namibian government implemented a Basic Education Teacher Diploma (BETD) program at all four Colleges of Education in the country: Windhoek, Caprivi, Rundu, and Ongwediva Colleges of Education. These colleges have since been incorporated as satellite campuses into the University of Namibia (UNAM). The BETD program aimed to produce teachers who can meet the demands and rise to the challenges of the post-independence basic education system. Through this teacher training program, student teachers are exposed to a variety of teaching and learning styles and strategies, aiming to equip them to become competent and professional teachers (Namibia. Ministry of Basic Education, Sport and Culture [MBESC], 2004). It is further indicated that this program strikes a balance between subject knowledge on one hand, and professional skills on the other. It also emphasizes learner-centred pedagogy as well as reflective and analytical exposure to classroom situations so that the theory and practice can be integrated meaningfully for the benefit of the student teachers (Namibia. MBESC, 2004; Namibia. Ministry of Education [MoE], 2009).

After incorporating the four colleges into the University of Namibia at the beginning of 2011, a Bachelor of Education degree (BEd) was introduced at this university to cater for both lower and upper primary teachers. In addition to what was offered on the BETD program, the BEd (upper primary) is a four-year program, focusing on training teachers for level 5-7, that is grades 5-7, “who have sufficient knowledge and skills to be able to interpret syllabi on the basis of the aims and objectives of basic education, and to relate subject content to the needs of the learners” (University of Namibia [UNAM]. Faculty of Education, 2010, p. 5). It is further stated that on completion of this program student teachers will have the following skills to be able to:

- Integrate accepted educational theory and practice along with an understanding of young child's development in order to effectively teach the concepts, theories, principles and facts associated with their Major, Minor and elective school subject content areas for grades 5-7;
- Design and develop learning experiences and resources that are appropriate for the Namibian Upper Primary Curriculum;
- Use multiple assessment strategies to assess learners in grades 5-7 as well as demonstrate the knowledge and skills to analyse and communicate assessment results; and more...

  (UNAM., 2010, p. 6).

I am a teacher educator for the mathematics education course at one of the UNAM satellite campuses. I am currently involved with training student teachers (both BETD and BEd) to become mathematics teachers at Upper Primary level (Grades 5-7). I have noted with disappointment that many student teachers, especially those majoring in mathematics at the level 5-7, struggle with many mathematical topics, but most especially the topic of fractions. In my experience, the student teachers' performance in fraction tasks has been unsatisfactory compared to other topics in the mathematics education course. For some student teachers, their college/university understanding of fractions and learning of how to teach fractions does not appear to have had a positive impact on their understanding of the concept. I have observed this during micro-teaching and when doing routine school visits to college candidates who were deployed in the field.

The following examples are drawn from my experience in observing student teachers teaching fractional numbers and they demonstrate a problem that results from their prior knowledge of fractions. One particularly worrying example is when student teachers' prior knowledge of a fraction concept refers only to a part of a whole. I noticed that when teaching other meanings/interpretations of a fraction, such as a quotient, this lack of understanding causes problems. Another example is the student teachers' prior knowledge of memorizing rules without any understanding. I noticed that when student teacher are asked something like ¾ ÷ ½, they will automatically tell you to do a reciprocal of the second fraction or to invert the second fraction and multiply. If one asks why, they are unable to explain their reasoning. This causes a conflict as when I teach fractions I always incorporate reality and the use of teaching aids in order to facilitate their understanding of fractions. There are many other

occurrences, such as the student teachers' previous knowledge of the use of fraction notations and their corresponding names. With their lack of prior knowledge, they are not used to using proper fraction names such as 'a half', 'two-thirds', and so on, but are rather used to saying 'one over two', 'two over three', and so on. This really causes problems in the teaching and learning of fractions and I constantly have to remind them to use the correct mathematical terminology. All these examples create a conflict between what the mathematics education course intends to occur in the effective teaching fractions. It means that the student teachers tend not to appropriate the new practice taught on their mathematics education course as they continue using their old ideas of practice from their previous learning and teaching of fractions.

These observations prompted me to carry out an investigation using a sample of BETD students at my institution, to better understand the factors that shape their understanding and ability to teach fractions. I am seeking insight into the interaction/balance between level 5-7 student teachers' previous knowledge and practice, and how this may influence their appropriation of taught knowledge and practice in developing their own teaching practice. This investigation will help me to gain insight to inform my own practice and as a consequence, improve the fractional number teaching at my institution.

1.3 GOALS OF THE RESEARCH

The main purpose of this study is for me to gain insight into teacher training to better inform my practice in the learning and teaching of fractional numbers. Data stemming from this research will reveal the difficult task of instructing upper primary pre-service teachers in how to teach fractions, with the aim of increasing both the student teachers' knowledge of the fraction content of the syllabus and their knowledge of how to teach this particular content to the learners. I am focusing on and pursuing these research questions:

1. How do student teachers teach fractions?
2. How does the student teachers' experience of the BETD mathematics education course influence their teaching of fractions?
3. What is the student teachers' previous experience of fractions and learning and teaching of fractions?

The analysis of these research questions will enable me to deduce and look for possible influences on appropriation of taught knowledge and practice in student teachers' developing their own teaching practice.

1.4 SIGNIFICANCE OF THE STUDY

The significance of this study is that it will help to identify the factors which influence the student teachers' teaching of fractions in upper primary schools in Namibia. The study will help me on a personal level to gain insight to inform my practice and improve the fractional number teaching at my institution. It will also help the teacher educators in the teacher training institutions in Namibia to understand the problems associated with teaching fractions. Teacher educators could then identify their limitations and deficiencies in preparing their student teachers regarding the teaching and learning of fractions, and make the necessary adjustments to their practice. Finally, through this study, the student teachers will be alerted to what positive and negative effects their understanding and attitudes toward fraction learning and teaching will have on their career as teachers. This is supported by Tirosh (2000) and Borko**,** Eisenhart, Brown, Underhill, Jones, and Agard (1992) who state that it is the responsibility of the teacher educators to pay more attention to and understand the beliefs of pre-service teachers in preparing them for their future role in teaching mathematics topics such as fractions.

1.5 THE OVERVIEW OF THE THESIS

1.5.1 Chapter 2

In chapter 2 I review the relevant literature by painting the background of the education and initial teacher training in Namibia. The chapter then discusses the relevant literature that I reviewed on the factors influencing student teachers' teaching and learning of mathematics and their mathematical knowledge of fractions. This is then followed by a discussion of initial teacher education and practice, with emphasis on the traditional and reform practices, teacher knowledge of teaching mathematics, teacher educators and the teacher training, teachers' beliefs, Kilpatrick's strands of mathematical proficiency (Kilpatrick, Swafford and Findell (2001)), learning how to teach as well as on student teachers' reflective thinking as teachers of mathematics. A discussion of previous research studies considered as influential and contributing to this topic follows. Finally, a review of the coverage of the mathematics

education curriculum level 5-7 and the upper primary school mathematics syllabus for Grade 6 closes the chapter.

1.5.2 Chapter 3

This chapter is an outline of the research methodology employed in the study. This includes a description of the research orientation and methods I employ, namely a qualitative approach and a case study. Additionally, I describe the research site, my participants and the kind of sampling employed in selecting the participants. In this chapter I also discuss the techniques used to collect the data. I then consider the issues of validity regarding the adopted research instruments and lastly end off by considering the ethics of the research process.

1.5.3 Chapter 4

This chapter deals with the presentation and analysis of data. Data analysis was obtained from the lessons observed and the interviews (individual and focus group).

1.5.4 Chapter 5

This is the chapter where I present the discussion of the findings of the study. These findings result from the analysis of data from the observed lessons as well as the interviews, both individual and focus group interviews.

1.5.5 Chapter 6

This chapter concludes the thesis. Through this chapter I provide the following:

- the summary of the findings,
- significance of the study,
- limitations and challenges of the study,
- reflections,
- recommendations, and
- avenues for further research.

In the next chapter I present the review of the related literature as a way of informing the theory of this research.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Teachers are viewed as the major catalysts of learning and the education system depends on them. They are the main role players in changing the ways in which mathematics is taught and learned in schools (National Council of Teachers of Mathematics [NCTM], 1991).

In this chapter, I present a review and critical analysis of the literature pertaining to pre-service teachers' learning and teaching practice of fractions in primary schools (grades 5-7). This literature encompasses a wide range of topics regarding pre-service teachers of mathematics, focusing on their learning and teaching of mathematics in general, and of fractions in particular. Through the literature I identified some of the factors that could affect and influence student teachers' understanding/knowledge of fractions.

At the outset I present a brief overview of the kind of education and initial teacher training in Namibia. This section provides information on where the Namibian system of education currently stands and the expectations of the different teacher training programs being implemented. This study focuses mainly on the teaching practice experiences and knowledge of fractions of student teachers. The study also seeks to understand the aspects of teaching the student teachers employed during their practice. Therefore, in the following sections I present an analysis of research regarding student teachers' training, their teaching, and learning of mathematics in general and fractions in particular. I discuss this research under the following subheadings:

- ✓ Traditional practice versus reform practice,
- ✓ What teacher educators should know and do in the teacher training program,
- ✓ Teacher's mathematical knowledge,
- ✓ Teacher beliefs about mathematics and fraction teaching,
- ✓ Kilpatrick's strands of mathematical proficiency,
- ✓ Student teachers' reflective thinking as teachers of mathematics, and
- ✓ Learning to teach mathematics

I consider what earlier research identified as influential and contributing factors to both teachers' and student teachers' teaching and learning of mathematics and discuss the

coverage of fractions in the BETD mathematics education curriculum level 5-7 and upper primary school mathematics syllabus for Grade 6.

A study of the teaching and learning of mathematics provides the framework for how student teachers perceive their learning, training and teaching of mathematics, specifically the topic of fractions. A similar framework was used by researchers such as Kahan, Cooper and Bethea (2003); Grossman (1990); Anders (1995) and Artzt and Armour-Thomas (1999), guiding their research on the relationship between mathematics teachers' knowledge of content and teaching. The subheadings listed above guided me to examine carefully the student teachers' teaching of fractions their understanding of fractions; how they valued the teaching of fractions and also how they taught fractions during their practice. The framework also guided me in terms of what to observe during the lesson presentations, how to analyze relevant documents, design interview questions, and analyze the prepared lesson plans.

2.2 EDUCATION AND INITIAL TEACHER TRAINING IN NAMIBIA

Both the BETD and the BEd programs of the UNAM emphasize learner-centred pedagogy as well as reflective, analytical and productive methods and approaches as crucial ingredients for teaching mathematics in Namibian schools. Both programs attempt to integrate various types of exposure to classroom situations so that the theory and practice can be integrated meaningfully for the benefit of the student teachers (UNAM, 2010; Namibia. MBESC, 2004; Namibia. MoE, 2009).

The current theoretical guide for teaching mathematics (and other subjects) in the Namibian context is based on the theory of constructivism through using the learner-centred approach. Constructivists assume that "given an appropriate mathematical environment learners will be motivated and enabled to construct their own mathematical knowledge and such self – discovery promotes optimal understanding" (Geary, 1994, p. 262). Thekwane (2001) explains that teaching mathematics from a learner-centred approach will be well understood once teachers understand the pedagogical aims and assumptions of learner-centred education in the Namibian context. This also includes conceptualizing a learner as an active mathematical thinker who draws from personal experience to construct meaning and make sense for him/herself of what s/he is doing. This knowledge and experience is a potential that can be utilized and drawn upon in teaching and learning. According to the Broad curriculum for the BETD:

> Learner-centred presupposes that teachers have a holistic view of the learner valuing the learner's life experience as a starting point for their studies. Teachers should be able to select content and methods on the basis of the learners' needs. They should use local and natural resources as an alternative or supplement to ready-made study materials, and thus develop their own and the learner's creativity. A learner-centred approach demands a high degree of learner participation, contribution and production (Namibia. MoE, 2009, p. 3).

The driving force for the development of a knowledge-based society Vision 2030 National Document was drawn up in Namibia. The main purpose is to ensure that Namibia's education system is able to respond to the challenges of the 21st century, and emphasizes for example structural change, the learner-centred education system as well as universality in providing a strong foundation for a democratic educational system (Namibia. MBESC, 2004). According to Vision 2030, Namibia requires a total transformation into "an innovative, knowledge based society, supported by a dynamic, responsive and highly effective education and training system" (Namibia. MBESC, 2004, p. 3). Additionally, a framework for the Professional Standards for Teachers in Namibia was established by the Ministry of Education (Namibia. MoE, 2006b). This establishment of clearly articulated professional teaching standards is an essential element of any strategy for enhancing the teaching quality in the country. This framework content comprises four broad domains that describe the professional competencies or areas of skills and knowledge required by teachers, such as: 'professional knowledge', 'professional values', 'professional practice', and professional relationships' (p. 7). The framework further implies that the initial training programs of teachers including mathematics teachers in Namibia should incorporate the content of these domains to sensitize and inform the teacher trainees on the responsibilities of teachers in terms of the national standards (Namibia. MoE, 2006b).

This study investigated upper primary (level 5-7) student teachers as they engaged with the teaching of fractions at different primary schools in Namibia during their teaching practice, known as School Based Studies (SBS). The study focused on how the student teachers developed, selected and used different representations in their teaching of fractions at classroom level, and on how they understood and implemented the strategies they employed to teach fractions. Additionally, this study sought to understand what factors influenced and shaped the student teachers' understanding as they engaged in the teaching of fractions, specifically situated in Grade 6 classes only. This includes student teachers' orientation to the understanding, learning, and teaching of fractions.

2.3 THE TEACHING OF FRACTIONS

2.3.1 Research on the teaching of fractions

Fractions form a crucial part of the middle school mathematics curriculum. Furthermore, fractions underpin the development of proportional reasoning; and are important for later topics such as algebra and probability (Lamon, 1999; Litwiller & Bright, 2002).

The literature emphasizes that the topic of fractions is deemed to be difficult to understand as well as to teach by many teachers (Ma, 1999; Post, Cramer, Behr, Lesh & Harel, 1993); and many learners find it very difficult to learn (Streefland, 1991; Gould, 2005). The teaching of fractions is not only seen as difficult, but "in a broader scheme of things, a dismal failure" (Tzur, 1999, p. 123). That is why Tzur's study suggested that it is important to integrate research on fraction teaching and on fraction learning if one is to suggest sensible ways to improve the current disturbing state of the teaching and learning of fractions. According to Siebert and Gaskin (2006) "children are bound to find fraction computations arbitrary, confusing, and easy to mix up unless they receive help in understanding what fractions and fraction operation mean" (p. 394).This is why I decided to engage in a study focusing on the teaching and learning of fractions in order to understand what student teachers' experiences were and what aspects of teaching they employed during this practice.

Several researchers have noted how children's whole number schemes can interfere with their effort to learn fractions (Ni & Zhou, 2005; Bezuk, 1988). Stafylidou and Vosniadou (2004) state that one of the reasons why the mathematical notion of fraction is systematically misrepresented is because it is not consistent with natural number counting principles. The concept of natural numbers can be seen as derived from counting, while the concept of fractional numbers is derived from measuring. Misconceptions about fractions may thus be generated as children attempt to relate the information they receive about fractions to their prior natural number knowledge.

Other researchers suggested many possible factors that may be contributing to the poor understanding of rational numbers in general and fractions in particular. For instance, children mistakenly apply a magnitude-comparison in comparing fractions when they choose a fraction with the larger denominator as the larger fraction, e.g. $^1/_6$is seen as bigger than a ¼ (Post, Wachsmuth, Lesh, & Behr, 1985). The reason behind is that children do not understand

that a fraction is a relationship representation and not a particular amount (Baroody & Hume, 1991). Streefland (1991) identifies two main sources of such problems:

- underestimation of fractions complexity as a conceptual field, and
- the teaching of fractions in a mechanistic way that it does not make any sense of the mathematics involved, but emphasizes only rules and complete detachment from reality.

The possible factors that may contribute to the poor understanding of fractions are summed up by Newstead and Murray (1998) in the following points:

- both the way and the sequence in which the initial fraction content is presented to the children, e.g. using pre-partitioned manipulatives and restricting to halves and quarters only
- children have a lack of opportunity in the classroom to resolve and monitor misconceptions (sometimes based on intuitions),
- children tend to apply their whole-number concepts to fractions, interpreting a fraction as two whole numbers.

It then follows that when "children encounter situations with fractions; they naturally use what they know about whole numbers to solve problems" (van de Walle, Karp & Bay-Williams, 2010). This simply means that children's prior knowledge of whole numbers both supports and inhibits their understanding and skills of working with fractions.

Research on teaching and learning fractions reveals that fractions have many possible meanings (interrelated sub-constructs or interpretations) and children need to develop these different meanings (NCTM, 2000; Hiebert, et al., 2003). These are identified as quotient (which includes both partitioning and sharing), part-whole, measure, operator and ratio (Lamon, 2007). These are all more complex than counting and Lamon stresses the necessity of using different kinds of representations to understand fractions (Lamon, 2007).Marshall (1993) supports the assumption that mastering the five interpretations of fractions contributes towards acquiring proficiency in the operations of fractions. It is suggested that when teaching fractions, teachers need to scaffold learners to develop a profound understanding of the different interpretations of fractions. So instead of rushing to provide them with different algorithms to execute operations on fractions, teachers should place more emphasis on the conceptual understanding of fractions (Lamon, 2007; Marshall, 1993).

It is further stated that as learners learn about fractions they sometimes lose sight of those meanings and instead see fractions merely as two different whole numbers with 'spatial relationship' (Hiebert, et al., 2003, p. 394). Hiebert and his colleagues suggest that for learners to develop meaningful concepts of fractions and fraction operations, they need to think of a fraction in new terms other than just whole-number combinations. They further suggest two powerful images for thinking about fractions, moving beyond whole-number meaning. These are iterating and partitioning images. Partitioning is the process of dividing an object or objects (wholes or units) into a number of equal-sized parts (Lamon, 1999; Mack, 2001). Iterating refers to an image for thinking about conceiving a fraction by first starting with a unit fraction, such as ¼ then combining copies of it with the original ¼ to make a whole (van de Walle, et al., 2010). The actions of partitioning and iterating are recognized as important to understanding and operating fractions (Hiebert, et al., 2003).

Other researchers suggested ways for enhancing and developing children's' understanding of fractions in the classroom. For instance, it is suggested that when fractions are introduced, the fraction symbols should be delayed until its concept is stable. It is advocated that initially children should rather be introduced to writing names in words, e.g. 'one-quarter' or 'one-fourth' instead of using numerals alone, e.g. ¼ (Newstead & Olivier, 1999; Mack, 1995). It is also suggested that the teacher should introduce fractions in the context of sharing situations as these bring forth the pre-knowledge that the children bring with them to the classrooms and can be used to introduce fractions (Murray, Olivier & Human, 1996; Mack, 1990; De Beer & Newstead, 1998). It is further recommended that teachers should introduce children to fractions other than just halves and quarters very early when working with fractions. The emphasis here is that if this is delayed, then children will start thinking that any piece smaller than a half is a quarter (Murray, Olivier & Human, 1996). Baroody and Hume (1991) propose that children should only be introduced to written symbols such as ½, ¼ and $^1/_3$ after being familiarized with concrete fair-sharing situations involving these representations. They further advocated that it is important that in teaching fractions comparison, teachers help children to understand that fractions represent a relationship; one cannot compare fractions such as ½ and ¼ unless the whole is identified. That is why different manipulatives can provide a concrete model for comparing fractions to help learners see that ½ is bigger than $^1/_3$. Kamii and Clark (1995) suggest that pre-partitioned manipulatives should not be used because these can lead to misconceptions. Van de Walle, et al. (2010) suggest that many visuals and contexts that show parts of the whole are essential in

helping the children understand the concept of fraction. An example of this is asking learners if they would rather go outside for half of an hour, or tenth of an hour. Other researchers suggest the use of different fraction models as they are seen as offering different opportunities to learn. An example here is the use of set models that help children's understanding of real world uses of fractions, which often involve using discrete objects rather than subdividing a singular whole into parts (van de Walle, et al., 2010). It is emphasized however that models can help learners to clarify ideas that are often confused in a purely symbolic mode, but only when properly taught (van de Walle, et al., 2010; Siebert & Gaskin, 2006). Van de Walle and his colleagues further state that the general approach to helping learners create an understanding of equivalent fractions is to have them use contexts and models to find different names for a fraction.

Siebert and Gaskin (2006) discuss some of common ways of talking about fractions when teaching using phrases such as 'out of' or 'over', such as '4 out of 7' or '4 over 7' for $\frac{4}{7}$. They pointed out that these phrases involve different language from that of partitioning and iterating as well as a different image. This is so because using 'out of' makes learners see 7 things presented, then they take 4 from these. They further explained that in both cases learners see the numerator and denominator of the fraction as merely whole numbers (Siebert & Gaskin, 2006). Siebert and Gaskin further stressed that this will lead children to experience difficulty in comparing fractions and they may never come to see fractions as being fundamentally different from whole numbers and struggle with operations. Further it is emphasized that the use of these phrases in the teaching of fractions is inherently problematic as the images associated with their language is not helpful in reasoning about different concepts (Siebert & Gaskin, 2006; van de Walle, et al., 2010). According to Siebert and Gaskin (2006) the implications for teaching fractions include providing learners with 'fraction-creation' and 'fraction-justification' tasks. They also explain how tasks of creating a unit from a whole and then recreating the whole from the unit fraction naturally elicit the powerful images of iterating and partitioning (p. 399).

Different research studies suggest that it is vitally important when teaching fractions for the teacher to give learners ample experience with a variety of materials (Baroody & Hume, 1991; Riddle &Rodzwell, 2000). Baroody and Hume (1991) further indicate that mathematics instruction should focus more on 'why' to help learners understand the underlying rationale for procedures. Riddle and Rodzwell (2000) emphasize that teachers should not tell learners

when asked 'why' questions responses such as "because it works", "just trust me on this", "you don't need to know that". These reinforce the belief that mathematics entails memorizing and using procedures and rules mechanically without thinking.

Fazio and Siegler (2010) explain that many learners view fractions as meaningless symbols or view numerator and denominator as separate entities rather than a unified whole as a result of a lack of conceptual understanding. They therefore suggest that teachers should focus on developing learners' conceptual understanding along with procedural fluency of fractions in their teaching. One way Fazio and Siegler suggest is through the use of manipulatives and visual representations as mentioned earlier by other researchers. This is supported by Ploger and Rooney (2005) when they specifically emphasize that children should be taught addition and subtraction of fractions using models. They further add that is only after children have mastered the use of models that teachers can then relate the symbols to the models, but the teacher should clearly demonstrate and show the connection with the symbols. Ploger and Rooney (2005) make the point that "nothing is wrong with having rules, the question is whether those are applied with understanding" (p. 15). Kilpatrick, et al. (2001) emphasize that in their teaching of fractions teachers should design mathematical work to challenge their learners' thinking and to elicit variations in their strategies and solutions. Kilpatrick and his colleagues further comment that teachers should aim at developing fluency with rules and procedures with a focus on their underlying meanings or justification.

2.3.2 Student teachers' mathematical knowledge of fractions

Research indicated that teachers' ability to teach is influenced by their lack of conceptual understanding of different mathematical concepts. One example is Fuller's (1996) study, where she examined the content knowledge of experienced and novice primary school teachers and found that both groups primarily possessed procedural knowledge of fractions. It means those teachers understood the steps and procedures required to solve a problem (Hecht, 1998). These mathematics teachers emphasize procedures in their teaching with little attention to explanations and justifications (Ball, 1991).Since most of the mathematics teachers are often products of procedural instruction from their early schooling years, teacher education challenges becomes, "helping teachers transcend their own school experiences with mathematics in order to create new practices of mathematical pedagogy" (Ball, 1993, p. 395). Ball (1988) charges teacher education with the job to become "a more effective intervention in preparing teachers to teach mathematics" through examining "the influence of different

kinds of teacher education experiences on teacher candidates' knowledge about and orientations toward mathematics and mathematics teaching and learning" (p.16).It is vitally important that the student teachers grasp the correct mathematics content, specifically of fractions, through their instruction on the mathematics education course.

It has been indicated by several researchers that pre-service teachers' understanding of fraction content knowledge is very weak (Simon, 1993; Cramer, Post &del Mas, 2002). It is shown that student teachers have an overall representational knowledge but that they depend heavily on algorithms and formal symbolism when representing mathematical concepts (Borko, et al., 1993; Goudling, Rowland & Barber, 2002). Evidence through Ball's (1990) research revealed that student teachers have difficulty with the concept of fractions and the meaning of division of fractions. It is further shown by Behr, Khoury, Harel, Post and Lesh's (1997) research that the student teachers cannot understand the operator construct of a rational number, while Chinnappan's (2000) research shows that the pre-service teachers have trouble explaining fractions and why algorithms work. Additionally, Becker and Lin's (2005) research presents evidence that student teachers are unable to carry out computation procedures correctly, even when their answers are correct.

Borko, et al. (1992) through a year-long case study looked at the role of teacher preparation programs in the knowledge development of a difficult topic of rational numbers, on division of fractions. As part of the study, one teacher trainee from a mathematics education course was followed by researchers to understand how her ability to teach the division of fractions developed. Through this research, classroom observation showed that the teacher trainee entered her student course with "only a rote understanding of the division of the fraction algorithm" (p. 207). This was demonstrated when this student teacher was asked a question by a learner about why one must invert and multiply to divide with a fraction, and she was astounded by the question and could not produce an answer. Though the topic was taught in the mathematics education course, researchers suspected that her previous algorithmic knowledge of 'invert-and-multiply' from her own primary and high school years might have interfered when constructing a more complete understanding of the concept (Borko, et al., 1992).

Different readings showed that student teachers' poor performance in understanding fractions can cause serious problems through their teaching of mathematics to the upper primary grades (grades 5-7). With regard to developing the concept of fractions, it is noted that

fractions are indeed difficult for primary school learners and that student teachers should be able to provide learners instruction with fractions beyond the common part-whole relationships, including looking at fractions as quotient, operator and as ratio (Conference Board of Mathematical Sciences (CBMS), 2000). Looking at various factors that might have caused the difficulty of fractional number development for many learners and teachers, Vergnaud (1983) argues that fractional number skill development relies on other essential elements. It is further indicated that under different contexts, fractional numbers have different personalities. As was stated earlier, fractional numbers have different constructs, namely, part-whole, quotients, measures, ratio, rate and operators (Lamon, 1999). Niemi's (1996) research revealed that one of the reasons for student teachers' problems with fractions might be their poor problem solving ability and skills, as a close association between students' level of problem solving ability and their knowledge of fractions was shown. Other researchers assert that the focus of teaching students different topics such as fractions should emphasize and focus on teaching them to understand what they are learning rather than on practicing computational skills (NCTM, 2000; Liu, 2000). They also indicated that this shift from computation to understanding is expected to balance the weights of procedure and content knowledge in middle school mathematics teaching. It is indicted by many researchers that procedural and conceptual knowledge are both important components of mathematical understanding (Hiebert & Wearne, 1986; Hiebert, et al., 2005; Lin & Tsai, 2006). This why it is important in the teaching of understanding mathematics in general and fractions in particular that both types of knowledge need to be balanced and emphasized.

Previous studies on student teachers showed formal fraction notation to be among the frequently used representations for fraction concepts (Borko, et al., 1992; Goudling, et al., 2002; Ward, Anhalt & Vinson, 2004). Kieren (1992) and van de Walle, et al. (2010) explain how formal fraction notation and symbolism are used to represent the language of rational numbers. However, they caution that this can be misleading for learners. Van de Walle, et al. (2010) adds that the importance in fraction terminology lies not in whether formal (numerator/denominator) or informal (top/bottom) terminology is used, but in whether teachers are providing conceptually correct explanations of the terms to the learners. Additionally, Schoenfeld and Kilpatrick (2008) assert that teachers must have a firm grasp of a variety of ways of representing fractions, to enable them to guide learners to navigate through the territory of problems involving fractions.

2.4 INITIAL TEACHER EDUCATION AND PRACTICE

2.4.1 Traditional practice versus reform practice

Traditionally, the teaching of mathematics relied heavily on doses of practices to help learners memorize facts, rules and procedures (Baroody & Hume, 1991). Baroody & Hume, (1991) further indicate that many learners through this traditional practice do not really understand mathematical procedures, and cannot relate them to word problems or real-life situations (p. 54). Ruppert (2010) also states that through this practice learners are taught mathematics using the lecture method followed by a textbook homework/exercise style. He further explains that this constrains learners' understanding of what mathematical concepts occur during real world situations and this does not lead to good problem solving skills in future grades. This actually means that with this traditional practice learners only attempt to arrive at the correct answer, often using the methods and procedures instructed by the teacher (Ruppert, 2010).

In conjunction with studies on teachers' subject matter knowledge, several researchers and professional education organizations have been calling for reforms in the mathematics education for teachers. This includes the National Council of Teachers of Mathematics (NCTM) which emphasizes the need for a deep, connected understanding of mathematics, its principles as well as concepts, but also the ability to instruct learners beyond a narrow set of algorithmic procedures (NCTM, 1991). Research indicated that through a reform practice, mathematics instruction should rather focus on promoting understanding and not fostering the memorization of facts, rules and procedures (Baroody & Hume, 1991; Riddle & Rodzwell, 2000). This entails helping learners to see how information connects with their existing knowledge (informal knowledge). Research further asserts that children need to see "how various concrete, pictorial, and symbolic representations can illustrate the same concept or procedure; and how different concepts (fractions, ratio, etc) are related to each other" (p. 55). It then follows that the instruction of mathematics should provide learners with real experiences (manipulatives) to assist them to construct a mathematical understanding. This means practice of skills should to be done in the context of purposeful activities, where learners are guided to see how procedures relate to concepts, why they work and when to apply them (Baroody, 1987).

Mack, (1990) shows that many older children can use their existing knowledge to determine answers to real-life mathematical problems, such as fractions. The implication of this is that

mathematics instruction needs to encourage and build on children's informal mathematical knowledge as it is their strength (Baroody & Hume, 1991).

It is also indicated in various research studies that it is essential for the teacher to help children to see the connections between symbolic mathematics and everyday mathematical knowledge. It means teachers should guide learners to see the connection between concrete models used when introducing a concept and its symbolic representation (Baroody & Hume, 1991; Wearne & Hiebert, 1988). Thus when a teacher introduces the concept of a fraction, she should draw examples from real-life situations. One example: instead of a teacher asking 'what is ¼ of a half', she could rephrase it like 'if half a cake is shared among four people, what fraction does each person receive' (van de Walle, et al., 2010).The implication for teacher preparation according to Kilpatrick et al. (2001) is that student teachers need to acquire the forms of knowledge that will enable them to make connections within and among their knowledge of mathematics, learners and pedagogy.

2.4.2 What teacher educators should know and do in teacher training

According to Lowery (2002) teacher educators need to know how teachers learn: "what types of knowledge and levels of knowledge acquisition are necessary to become effective teachers; and what contexts are most conducive to learning how to teach" (p. 18). She further stated that there is research evidence to suggest that pre-service teachers benefit from active, learner-centred constructivist environments and that teaching and learning occur in social contexts. Ball (1998) also argues that since teacher educators expect pre-service teachers to teach for a learner-centred approach, they must use it in teacher education so that the trainee teachers experience it and know what it looks like, how it feels and how successful it is. Wood, Cobb and Yackel (as quoted in Simon, 1995) assert that:

> teachers must … construct a form of practice that fits with their students' ways of learning Mathematics. This is the fundamental challenge that faces Mathematics teacher educators. We have to reconstruct what it means to know and do Mathematics in school and thus what it means to teach Mathematics (p. 117).

Simon (1995) adds that it is necessary for mathematics teacher educators to prepare their pre-service teachers by providing them with a structure and a set of plans that support the development of informed exploration and reflective inquiry without taking the initiative or control away from them. As teacher educators of mathematics, it is indicated that the teacher trainees will not become effective teachers by accident, but rather by design through the use

of the plans that teacher educators structure to guide exploration and inquiry (Simon, 1995). In support of this Ball (1988) suggests that teacher educators must find ways to address the issue of viewing teachers trainees as lacking knowledge or skills without considering their beliefs and existing knowledge. She maintains that this will help to change the practice of teaching and learning mathematics in schools.

Kilpatrick et al. (2001) assert that for teacher educators to develop student teachers' understanding of the mathematics they will teach, careful attention should be given to identifying the mathematics that teachers require in order "to teach effectively, articulating the ways in which they must use it in practice and what that implies for their opportunities to learn mathematics" (p. 373). It means that teacher educators of mathematics have a huge responsibility in training the student teachers and informing them of their future responsibilities as mathematics teachers. These responsibilities in the mathematics classroom are envisioned in the American Professional Standards for School Mathematics as:

- setting goals and selecting or creating mathematical tasks to help students achieve these goals;
- stimulating and managing classroom discourse so that both students and the teacher are clearer about what is learned;
- creating a classroom environment to support teaching and learning mathematics;
- analyzing student learning, the mathematical tasks, and the environment in order to make ongoing instructional decisions (NCTM, 1991, p. 5).

Additionally, teachers are called to teach fraction concepts in ways that are often fundamentally different from the way they learned them, in those ways that can only be successfully accomplished with deep understanding of the content knowledge and the ability to represent and encourage conceptually sound representation of fraction concepts (CBMS, 2000; NCTM, 1991; 2000)

It is pointed out that mathematics teacher educators should train and prepare their pre-service teachers to develop a 'bifocal perspective'. This is when they become capable of perceiving the mathematics they teach through the mind of the learner while perceiving the mind of the learner in mathematics (Ball, 1993). Simon (1995) notes that "a well-developed conception of mathematics teaching is as vital to mathematics teacher educators as well-developed

conceptions of mathematics are to pre-service teachers" (p. 142). Lowery (2002) argues that if pre-service teachers need to be taught in the same manner in which they will be teaching, then it is imperative that teacher education programs keep pace with new recommendations for their preparation. These include the produced national standards for mathematics education which promote learning and teaching environments that encourage the implementation of the constructivist learning perspective. In support of this, Tirosh (2000) indicates that the major goal in teacher education that the mathematics teacher educators should be aware of is to promote the development of pre-service teachers' knowledge of common ways children think about the mathematics topics the teacher will teach. For example, when dealing with fractions, they should keep in mind the common learner misconceptions as well as different representations of fractions (Schoenfeld & Kilpatrick, 2008).

2.4.3 Teachers' mathematical knowledge for teaching

Several researchers agree that understanding teacher knowledge and teacher thinking is critical to understanding teaching and learning how to teach (Clark & Dunn, 1991; Grossman, 1995; Shulman, 1986). Koehler and Grouws (as cited in National Research Council, 2001) note that the behavior of the teacher is influenced by the teacher's understanding of the particular content and knowledge of how learners might learn this content. This includes the knowledge of how learners think and learn (NCTM, 2000; Ball, 1993), as well as how this occurs within mathematics content, specifically fractions (Fennema & Franke, 1992; Stafylidou & Vosniadou; 2004).

A framework for discussion of this special kind of teacher knowledge was presented by Shulman (1986). This framework 'postulated' that teachers make decisions based on their knowledge (Van der Sandt, 2007). Ball and Bass (2000) emphasize that the mathematics knowledge needed by mathematics teachers should include knowledge of mathematics itself (subject content knowledge) and the knowledge beyond subject matter. In case of fractions, teachers should possess the content of multiple ways of fraction representations and meanings (Schoenfeld & Kilpatrick, 2008).According to Ball, Thames and Phelps (2008), content knowledge (CK) includes the knowledge of the subject and its organizing structures. Shulman (1986) added that content knowledge includes both concepts and facts in a domain, and at the same time why concepts and facts are true and how knowledge is generated and

structured in the discipline. He further argued that "mere content knowledge is likely as useless pedagogically as content-free skill" (Shulman, 1986, p. 8).

Chinnappan (2000) indicated that there are 3 major components which permit teachers to perform their duty effectively.

- *Teachers' mathematical content knowledge*, including information such as mathematical concepts, rules and procedures for problem solving;
- *Organization of content knowledge* linking teachers' construct between several content knowledge components; and
- *The blend of content and pedagogical knowledge* including understandings as to why some learners struggle with a particular concept, while others assimilate easily, knowing how to conceptualize and represent a selected concept, quality of teachers' explanations during and prior the instruction (p. 235)

Shulman and his colleagues identified this special kind of teacher knowledge that links content and pedagogy, namely the 'pedagogical content knowledge'. It is stated that in addition to general pedagogical knowledge, knowledge of mathematics curriculum materials and resources, and knowledge of content, teachers must know things such as topics pupils find interesting or difficult and the representations that are mostly useful for teaching a specific idea (Ball & Bass, 2003). Ball and Bass (2003) further clarified that pedagogical content knowledge is a "unique kind of knowledge that intertwines content with aspects of teaching and learning" (p. 4). It means this knowledge includes knowledge of approaches to school mathematics topics; teachers' knowledge of teaching procedures such as effective strategies for planning, classroom practice, management techniques, motivational techniques; and different ways of presenting mathematics (Rowan, Correnti& Miller, 2002; Shulman, 1986). Rowan, Correnti and Miller (2002) affirmed that the notion of pedagogical content knowledge allowed for the fact that knowing mathematics requires a unique understanding that intertwines aspects of teaching and learning with content. This implies that for the student teachers to be able to explain what equivalent fractions are, they need to have an understanding of the mathematical content. It means that they need to know the nature of fractions, what they are and their meaning; and how to manipulate and generate knowledge regarding fractions (van de Walle, et al., 2010).

Research by Ormrod and Cole (1996) reported that an increase in knowledge of content could lead to changes in classroom practice and this increases pedagogical content knowledge. Simultaneously, according to Ernest (1989), knowledge of mathematics (subject content knowledge) is transformed by means of practical knowledge of mathematics teaching, (i.e. both pedagogical and curricular knowledge) into mathematical representations for the classroom use of content knowledge.

In mathematics, Ball's (1988) interview questions for his research revealed how inadequate teachers' and pre-service teachers' knowledge of important mathematics needed for teaching was, on the one hand, and how much there was to understand on the other hand. What was seen as the most influential view was that teachers need to know whatever mathematics is in the curriculum plus an additional number of years of further study in college mathematics (Ball et al., 2008). After conducting research comparing US and Chinese elementary teachers' subject matter knowledge, Ma (1999) concluded that teacher preparation programs are the critical sites where the pre-service teachers' subject matter knowledge could be developed. According to her, "teacher preparation programs are the point in a pre-service teacher's education where mathematical competence starts to be connected to a primary concern about teaching and learning school mathematics" (p. 145).

2.4.4 Teacher beliefs about mathematics and fraction teaching

One of the factors that have a powerful impact on teaching is the teacher's beliefs through the teacher's behavior using different teaching styles and modes of learning (Ernest, 1989). According to Ernest (1989), a belief constitutes the teacher's system of conceptions, values and ideology; and Thompson (1992) added that it is not consensual and is therefore held in different degrees of conviction. Investigative research on teachers' beliefs in mathematics education revealed that the teachers' beliefs about the nature of mathematics are "conscious or subconscious beliefs, concepts, meanings, rules, mental images, and preferences concerning the nature of mathematics as a whole, that appear to affect teacher behavior" (Van der Sandt, 2007, p. 347). The other belief system that teachers hold according to Ernest (1989) is a mental model of mathematics teaching. This is viewed by Ernest as the key determinant of how mathematics is taught. Ernest (1989) added that important contributors to a teacher's style and approach are their attitudes to mathematics and its teaching. It is further explicated that teachers' attitude to the teaching of mathematics include "liking, enjoyment

and enthusiasm for the teaching of mathematics, and confidence in the teacher's own mathematics teaching abilities" (Van der Sandt, 2007, p. 346)

Borko, et al. (1992) suggested that teachers' beliefs about the subject matter plus an orientation toward the subject matter, contribute to ways in which they think about it and the choices they make in their teaching. It is indicated that the pre-service teachers' belief is an essential element in their development as teachers when they spend time in school classrooms. Through these expectations they will gain teaching skills in their teacher education programs (Ball, 1988; Lampert & Clark, 1990). So it is important that my study looks at the pre-service teachers' beliefs about fractions.

Prawat (1992) identifies some of the beliefs about teaching and learning, such as teachers view both content and learners as relatively fixed entities, so they devote so much time and attention to delivering the content. The other belief is viewing the content as a fixed agenda to be run with predetermined ends.

Ball (1988) argues that during their training, pre-service teachers need to 'unlearn' what they know about teaching and learning of mathematics. Ambrose (2004) also asserts that pre-service primary school teachers enter their teacher education programs with a variety of beliefs influenced by their experiences as learners in schools. She further states that some student teachers believe that teaching will be relatively straightforward, consisting primarily of offering clear explanations to children. Weinstein (1989) referred to this as 'optimistic bias', because these teacher trainees enter their teacher programs with an assumption that they already know what they need to know in order to teach. These beliefs often lead teacher trainees to underestimate how complex teaching is and the kind of knowledge that they will need to be successful (Ambrose, 2004). She also adds that student teachers underestimate the importance of subject matter knowledge in teaching. This will have implications for their teaching of mathematics as well as fractions.

Some mathematicians also suggested that promoting changes in teacher trainees' beliefs about mathematics and its teaching is critical in order to help them develop the content knowledge they need to become effective (CBMS, 2001; Mathematical Sciences Education Board, 2001). Ambrose (2004) further argues that student teachers' beliefs about teaching would together form an attitude about teaching. It is pointed out that the role of teacher education programs should be to support teachers to bring tacit beliefs into the open so that these beliefs can be transformed into objectively reasonable beliefs. This is seen as helping

the student teachers to make more principled/informed decisions on their practices of teaching mathematics. Borko, et al. (1992) analyzed a classroom lesson in which a student teacher was unsuccessful as she failed to justify the standard division of a fractions algorithm. It is reported that the teacher's beliefs about the role of practice in learning to teach may have inhibited an effort to improve her knowledge before she became a practicing teacher of mathematics. So my study looked for such cases in mathematics classes by focusing on how both their experience of the BETD mathematics education course as well as their previous knowledge of fractions influenced how they taught fractions.

2.4.5 Kilpatrick's strands of mathematical proficiency

Kilpatrick et al. (2001) identify five strands or components of mathematical proficiency. In the context of teaching, proficiency requires similar interrelated components, namely:
conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition.

(i) Conceptual understanding of the core knowledge that is needed in the teaching practice;

Kilpatrick, et al. (2001) explain that teachers need to possess knowledge that will enable them to make connections within and among their knowledge of mathematics, learners and pedagogy. This means student teachers when giving tasks to the learners in their classes; should not rely on memorization of rules or use of procedures without connections to concepts. Kilpatrick and his colleagues assert that research evidence showed that learners learn best when presented with academically challenging work, focusing on sense making, problem solving and skill building specifically, when they learn fractions (p. 335). This way, teachers will help their learners to represent mathematical situations in different ways and to know how different representations can be useful in different purposes (Kilpatrick, et al., 2001, p. 119).

Niemi (1996) states that once conceptual understanding is developed, procedures become easier to understand to the learners. This is supported by the NCTM (1989) when emphasizing that:

> A conceptual approach enables children to acquire clear and stable concepts by constructing meanings in the context of physical situations and allows mathematical abstractions to emerge from empirical experience. A strong conceptual framework also provides anchoring for skill acquisition. Skills can be acquired in ways that make sense to children and in ways that result in more effective learning. A strong emphasis on mathematical concepts and understandings also supports the development of problem solving (p. 17).

(ii) Fluency for a teacher to be able to carry out the basic instructional routines. In the teaching practice of mathematics it is required of teachers to know how to respond to a learner "who gives an answer that the teacher does not understand or who demonstrates a serious misconception" (p.382); e.g. if a learner is asked to compute for instance, ½ + ¼ and gives the answer as $^2/_6$ (van de Walle, et al., 2010).

(iii) Strategic competence in "planning effective instruction and solving problems that arise during instruction". In their teaching practice student teachers are expected to make decisions in "planning instruction, implementing those plans, and interacting" with learners (p. 382).This will help them in the teaching of fractions in their attempt to guide learners properly and turn them away from different misconceptions.

(iv) Adaptive reasoning for a teacher to be able to justify and explain her instructional practices and reflect on those practices in order to improve them. Both teachers and student teachers can learn from their teaching by reflecting on the difficulties their learners face in learning a particular topic such as fractions; what the learners have learned as well as how learners responded to " particular representations, questions and activities in the lessons" (p. 383).

(v) It is stated that teachers' beliefs about the subject matter contribute to the ways in which they think about it and the choices they make in their teaching (Borko, et al., 1992). This is in line with Kilpatrick's last strand of mathematical proficiency, namely, 'productive disposition'. This strand refers to

> the tendency to see sense in Mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning Mathematics pays off, and to see oneself as an effective learner and doer of Mathematics (Kilpatrick, et al.,2001, p. 131).

Student teachers' practice success is shaped and strongly influenced by their disposition towards mathematics. Kilpatrick, et al. (2001) explains that the mathematics teacher plays a critical role in encouraging learners to maintain positive attitudes toward mathematics. It means that the teacher's teaching practice is affected by how she views mathematics and its learning, and this in return affects not only what is learned, but also how learners view themselves as mathematics learners. Kilpatrick, et al. (2001) suggest that teachers should develop a similar productive disposition to that of the learners. He further explained that the teacher should do this by thinking that mathematics, their understanding of children's thinking, and their teaching practice fit together "to make sense and that they are capable of learning about mathematics, student mathematical thinking, and their own practice

themselves by analyzing what goes on in their classes" (p. 384). They suggest programs of teacher education that portray to the student teachers that they are in control of their own learning and that assist them to develop a productive disposition toward mathematics, learner mathematical thinking, and teaching practice (Kilpatrick, et al., 2001). Moreover, attitudes of student teachers could limit their learning and teaching practice. It then follows that if a student teacher dislikes mathematics, s/he may feel anxious about teaching the subject. As a consequence, that teacher will be unlikely to want to learn and obtain the skills required to use and teach mathematical knowledge (Gutiérrez & Boero, 2006).

2.4.6 Student teachers' reflective thinking as 'teachers' of mathematics

In his discussion of research on teacher education, Cooney (1994) acknowledges the challenge involved in preparing future mathematics teachers. He raises the question regarding the types of encounters student teachers would need in order to become effective mathematics teachers. Jaworski (1994) and Artzt (1999) suggest that teacher reflection is central to the improvement of mathematics teaching. These researchers further suggest that teacher education programs should take into account the strategies and activities that engage teachers in reflection on their own thinking as well as instructional practice.

Dewey (1965) contends that the primary purpose of teacher education programs should be to aid the teacher trainees to reflect on problems of practice. He further argues that pre-service teachers should be helped and guided to develop habits of reflection. This will enable them to break away from lacking an inquiring mind and intellectual dependency on those who provide them a clear-cut and definite instruction on how and what to teach. Mewborn (1999) stated that student teachers need opportunities to reflect on their personal experiences and on the "beliefs that have resulted from these experiences in order to become aware of how these beliefs and experiences may influence their views of teaching" (p. 317).

Goodman (as cited in Mewborn, 1999) advocates for a teacher education program that is both supportive and challenging and that encourages student teachers to analyze their practice rather than defend a particular position because defending a position necessarily leads to evaluative instead of reflective judgment.

Lowery (2002) raises the point that reflective thinking before, during and after teaching is imperative for a thorough teaching experience. That is why it is of vital importance that student teachers are continually encouraged and motivated to develop reflective thought as a

tool for developing confidence and competence in teaching mathematics. Kilpatrick, et al. (2001) emphasized that teachers and student teachers can become reflective practitioners, and that reflection is an essential component in improving their teaching practice.

2.4.7 Learning to teach mathematics

A vexing problem in the field of mathematics education is how to design programs that influence the quality and nature of teachers' practice (Borko, et al., 1992; Ebby, 2000). Hiebert, Gallimore and Stigler (2002) comment that there is an absence of strong effects in teacher preparation programs due to a lack of a widely shared knowledge base for both teaching and teacher education. They further suggest that for preparation programs to be more effective, they should focus on helping student teachers acquire the tools they will need to learn to teach mathematics rather than the finished competencies of effective teaching (Hiebert, Morris, & Glass (2003). Gallimore (1996) also states that teaching is a cultural practice, and is notoriously difficult for someone to change a cultural practice. Hiebert, et al. (2003) further stress that after people learn how to teach by growing up in a certain culture, when faced with the real challenges of the classroom; they often abandon new practices and revert to the teaching methods their teachers used.

Jeongsuk (2003) stresses that learning to teach mathematics for understanding is a very difficult task especially for the student teachers whose schooling taught them that mathematics consists of a set of rules. This is supported by Ball (1993a) when stating that despite student teachers' eagerness and willingness to teach differently, their actual teaching methods often remain unchanged. It takes a variety of interventions when learning to teach mathematics. These include studying mathematics content, pedagogical preparation, and experience as both a student and learner of mathematics (Mapolelo, 1999). Borko, et al. (1992) in support of this observe:

> Learning to teach entails the acquisition of knowledge systems or schemata, cognitive skills such as pedagogical problem solving and decision-making, and a set of observable teaching behavior. To understand learning to teach, one must study how these systems – and the relationship among them – develop and change with experience, as well as identify the factors that influence this change process (p. 211).

Mapolelo (1999) further emphasizes that transition to pedagogical reasoning is a major component of learning to teach, although student teachers often experience difficulties in

making that transition. That is why it is important when learning to teach mathematics that student teachers integrate content and pedagogy.

When preparing to become teachers, student teachers enroll in both the content and mathematics education courses. Jeongsuk (2003) explains that the mathematics method courses refer to the general courses in which student teachers learn structures of mathematical disciplines as well as strategies, techniques, basic rationales, and materials for teaching in upper primary school. Jeongsuk further emphasizes that these mathematics education courses play a crucial role in allowing student teachers to develop their instructional practices. Despite these encouraging indicators, the influence of teacher education programs on student teachers' learning remains relatively weak (Jeongsuk, 2003). Borko, et al. (1992) add that these mathematics education courses tend to fail leading teacher trainees to review their mathematical knowledge base or their beliefs about mathematics. They found through their research that lack of consistency between mathematics education courses and cooperative schools tend to lead teacher trainees to adopting the procedural approaches of those cooperative schools.

Hiebert, Morris and Glass (2003) believe that there are two goals that should be achieved by the teacher preparation programs as this will provide trainee teachers with the tools they need to become increasingly effective mathematics teachers when entering the classroom. These goals are:

- To become mathematically proficient (borrowed from Kilpatrick, et al., 2001)
- To develop knowledge, competencies, and dispositions to learn to teach, with increasing effectiveness over time, in ways that help one's own students become mathematically proficient (Hiebert, et al., 2003, p.202).

Hiebert et al. (2003, p.204) argue that it is unrealistic to expect student teachers to learn to teach for mathematical proficiency without becoming proficient themselves. It is therefore suggested that the teacher education courses should encourage studying mathematical topics of school curricula along with related mathematical ideas; in ways that encourage attention to all of Kilpatrick strands of mathematical proficiency (see section 2.4.5).

Artzt (1999) elucidates that preparing to teach means knowing how to learn from classroom teaching experiences. This means planning these experiences in a way that affords learning and then reflecting on the outcomes in order to maximize the benefits that one can gain from

these encounters. According to Darling-Hammond and Sykes (1999) learning to become a teacher means more than this. They state that it means becoming part of a profession, becoming a professional teacher whereby a teacher draws from, and contributes to a shared knowledge base for teaching.

Lastly, Brown and Borko (1992) and Pajares (1992) assume that when learning to teach, student teachers interpret experiences through their existing conceptual structures and according to their ways of participation. Borko and Putnam (1996) explain that although student teachers make sense of their learning experiences through using the lens of what they already know and believe their knowledge and beliefs must simultaneously become a target of their learning to teach mathematics. Through my study I explored how and what the participants used in their teaching of fraction lessons drawing from their prior knowledge, and what they learnt on the mathematics education course.

2.5 FACTORS INFLUENCING THE TEACHING AND LEARNING OF MATHEMATICS

Different factors influence both teachers' and student teachers' learning and effective teaching of mathematics. As stated earlier, Booth, et al. (1998) point out that the attitude of student teachers places a limit on their learning of mathematics. They stated that they begin their education with a wide range of different experiences, opinions, beliefs and conceptions of teaching and learning. Kagan's (1992) study confirms that pre-service teachers enter teacher education programs with personal beliefs about images of what good teachers are like, images of themselves as teachers, and memories of themselves as learners. These experiences and beliefs are the instrumental factors that influence how the student teachers learn and teach mathematics. That is why some student teachers believe that teaching is easy and it merely involves transmitting of information (Feiman-Nemser, McDiarmid, Melnick & Parker, 1989). Pajares (1992) asserts that beliefs about teaching include perceptions and expectations about what it really takes to become an effective teacher. He further pointed out that these are formed before student teachers enter the teacher training programs. Joram and Gabrielle (1998) also clarify that most teacher trainees tend to believe that most of their knowledge about teaching will come from practicing in the field or through trial and error when they are deployed to different schools after graduation. This habit results in many of them becoming less interested in what they perceive to be theory (course content) and more interested in practice approaches (Joram & Gabrielle, 1998). This shows that beliefs and

knowledge that student teachers bring to the teacher education program are references in their learning to teach, since these affect what and how they learn (Llinares, 2002)

Artzt (1999) explains that different factors affect the nature and quality of both teachers' and student teachers' thoughts and actions before, during and after their lessons. That means these factors have an affect both ways, such as teachers' design of lessons, their monitoring and regulating of their instruction during the teaching process, and the way they evaluate the lesson after it has been concluded. Peterson and Williams (2008) aver that teachers who possess better conceptual knowledge of mathematics "tend to teach more conceptually and are more successful in adopting curriculum materials and engaging learner questions" (p. 461). Kahan, Cooper and Bethea (2003) reach a similar conclusion. Wood (1988) reports that student teachers experience anxiety and tension as they are constantly evaluated in this process. He points out that the anxiety that student teachers experience could be linked toa particular teacher in their own schooling years. He stated that primary mathematics teachers have an important role to play in making this subject exciting, but this cannot be achieved if they have an inner dislike for mathematics (math phobia). This cycle should be broken in the teacher education institutions for primary teachers to be able to teach mathematics comfortably.

2.6 FRACTION COVERAGE OF BETD MATHEMATICS EDUCATION CURRICULUM LEVEL 5-7 AND UPPER PRIMARY SCHOOL MATHEMATICS SYLLABUS FOR GRADE 6

As part of the BETD curriculum (Mathematics education level 5-7), the student teachers are required to develop competencies with regard to the teaching of fractions. Specifically, they should be able to:

- Use different teaching aids to teach common fractions
- Design a learning experience to link fractions to daily life
- Use circle diagrams to show the relation between mixed numbers and improper fractions
- Design a fraction chart to identify equivalent fractions and simplify fractions
- Establish rules that can be used for determining equivalent fractions

- Identify, analyze and rectify misconceptions in the use of fractions
- Explain the four operations on fractions using diagrams connecting it to the basic understanding of the four operations (Namibia. MoE, 2006a, p. 9).

My study concentrates specifically on student teachers teaching fractions in Grade 6. The following is the discussion of the fraction content that should be covered with regard to the Grade 6 Namibian school syllabus accompanied by the specific learning objectives per subtopic.

COMMON FRACTIONS

(a) Equivalent fractions

- convert fractions to equivalents
- write fractions in their simplest form

(b) Comparing and ordering

- compare and arrange fractions with the same and different denominators up to1000 in a stated order by converting to a common denominator

(c) Addition and subtraction of fractions

- add and subtract fractions with the same and different denominators restricted to three terms /fractions
- add and subtract mixed numbers

(d) Word problems

- solve two-step word problems involving
- addition (restricted to three terms) and subtraction with common fractions

(Namibia. MoE, 2007, p. 13).

2.7 CONCLUSION

Through the review of literature presented, it is revealed that fraction teaching and learning is a serious issue in both the middle school mathematics and in mathematics teacher education programs for student teachers. It also emerged from the literature that mathematics teacher educators should prepare their student teachers by providing them with a structure, and a set of plans that support the development of informed exploration and reflective inquiry without taking the initiative or control away from them. I am aware that knowing mathematics requires a unique understanding that intertwines aspects of teaching and learning with content. This implies that for the student teachers to be able to explain for instance what equivalent fractions are they need to have an understanding of the mathematical content (i.e. they need to know mathematics), as well as different meanings and interpretations of fractions. Kilpatrick, et al. (2001) supported this by stating that

> to develop prospective teachers' understanding of the mathematics they will teach, careful attention must be given to identifying the mathematics that teachers need in order to teach effectively, articulating the ways in which they must use it in practice and what that implies for their opportunities to learn mathematics (p. 372).

To sum up, Baroody and Hume (1991) stated that "learning mathematics can and should be meaningful, purposeful, and interesting" (p. 65).

CHAPTER 3

METHODOLOGY

> *Methodology* refers to a theory of producing knowledge through research and provides a rationale for the way a researcher proceeds. Methodology refers to more than particular techniques, such as 'doing a survey' or 'interviewing students'. Rather, it provides reasons for using such techniques in relation to the kind of knowledge or understanding the researcher is seeking.
>
> Research in Education and Training, 2001, p. 4).

3.1 INTRODUCTION

In this chapter I outline the methodology employed in this research project. This includes the research techniques and the data collection methods employed in the study. At the outset the research goals and the research orientation are discussed. Secondly, I discuss the interpretive paradigm, the use of a qualitative case study, followed by the selection of the research site and participants. This is then followed by the discussion of the research techniques in which the variety of research tools and methods of collecting data are discussed. In addition I discuss the methods adopted in my data analysis. And in concluding the chapter, I discuss the ethical issues with regard to my research participants.

3.2 RESEARCH GOALS

The main purpose of this study is to gain insight into teacher training to inform my practice in the learning and teaching of fractional numbers. It is hoped that data stemming from this research will provide an understanding of the difficult task of teaching upper primary pre-service teachers about teaching fractions; with the aim of increasing both the student teachers' knowledge of the fraction content that they will teach and their knowledge of how to teach it (See goals in section 1.3).

3.3 ORIENTATION

This research study was conducted within the interpretive paradigm. Bassey (1995) states that the interpretive paradigm forms an integral part of the qualitative method, and is characterized by the description and interpretation of the phenomenon in the participant's world to attempt to get a shared meaning with others (p. 14).I have chosen this paradigm because it provides me with the opportunity to understand a particular situation or context.

Through this interpretive paradigm the researcher makes an effort to understand the subjective world of the people's experience (Cohen, Manion, & Morrison, 2007). As earlier mentioned and explained, this research study sought to understand the student teachers' experiences and perceptions on the learning and teaching of fractions at Grade 6 level.

3.4 METHOD

This research was conducted using a qualitative case study method. According to Miles and Huberman (1994) through using the qualitative approach, "the researcher attempts to capture data on the perceptions of local actors 'from the inside', through a process of deep attentiveness, of empathetic understanding, and suspending preconceptions about the topic under discussion" (p. 6).Cohen, et al. (2007) state that a case study "provides a unique example of real people in real situations", in that it enables readers to understand ideas more clearly rather than simply being presented with 'abstract theories' or 'principles' (p. 253). Ary, Jacobs, Razavieh and Sorensen (2006), add that case studies provide an "intensive description and analysis of a phenomenon or social unit such as an individual, group, institution, or community" (p. 456). Gay, Mills and Airasian (2012) clarify further that by saying a case study is descriptive, it means that its end results, "the narrative, includes 'thick description' of the phenomenon that was the focus of the case study research—inclusion of many variables and analyses of their interactions" (p. 446). Merriam (2009) indicates that the content of the case study involves situating the case within its setting, which may be physical, social, historical and/or economic, depending on the case. In addition, one of the hallmarks of the case study as considered by Hitchcock and Hughes (1995) is that "it focuses on individual actors or groups of actors, and seeks to understand their perception of events" (p. 317). In my study I was engaged with selected student teachers from the year 3 BETD Mathematics majors for level 5-7, doing their teaching practice at different primary schools in Namibia. I explored the student teachers' experiences and perceptions when teaching fractions. My unit of analysis was the five student teachers teaching fractions to grades 5-7.I worked with these teacher trainees by observing them; I then interviewed each one individually and finally conducted a focus group interview with the group. This enabled me to examine the student teachers' experiences in terms of their prior knowledge, their taught knowledge on the mathematics course, as well as their developed practice in terms of fraction teaching.

3.5 SAMPLE

Gay, et al. (2012) state that qualitative sampling is "the process of selecting a small number of individuals for a study in such a way that the individuals chosen will be good key informants (i.e. collaborators, co-researchers) who will contribute to the researcher's understanding of a given phenomenon" (p. 142).

3.5.1 Research Site

Since the case is situated at one of the university campuses, I believe this was a suitable and convenient site for the research as I had access to the research participants and to different resources that would contribute to the case study.

3.5.2 Participants

I had planned to work with student teachers majoring in Mathematics Education, Level 5-7, in a third year BETD class. These students had attended the mathematics education course, in which fractions are included in the syllabus. I purposefully selected 5 student teachers from the class group to participate in the research. Purposeful sampling is directed by certain criteria, rather than randomly, aiming to achieve the objectives of the study (Babbie & Mouton, 2001; Kumar, 2011). Silverman (2005) adds that "purposive sampling allows us to choose a case because it illustrates some feature or process in which we are interested" (p. 129). Therefore I used this method of sampling with a specific purpose in mind (Creswell et al., 2010). I looked at the mathematical performance (marks) with respect to the topic of fractions, of different groups of students, and then selected a sample that was composed of students with mixed abilities (below average, average and above average). The rationale for selecting a sample that includes students who excelled in the topic of fractions as well as those who might have misunderstood aspects of this topic despite having done the mathematics education course, was to get a broader view of the perceptions of teachers with diverse abilities. The sample was convenient in that it involved students with whom I interacted on a daily basis at my institution.

3.6 RESEARCH TECHNIQUES

According to Cohen, et al. (2007), validity threats could arise if data is selected in an unrepresentative way, inaccurate data presented or one does not answer the research question. For the purpose of triangulation, I used a variety of data collection methods, such as

document analysis, observations, and interviews, to validate my research findings. Triangulation is defined as a way of using two or more data collection methods in the study of some aspect of human behaviour (Cohen, et al., 2007). Denzin (1989) characterizes triangulation as a plan of action that will lift researchers above the personal biases stemming from single methodologies. It is further explained that through combining "methods and investigators in the same study, observers can partially overcome the deficiencies that flow from one investigator or method" (p. 236). Through these techniques I collected enough data to provide me with information on the participants' experiences of the learning and teaching of fractions.

3.6.1 Document Analysis

For this study I analyzed the school mathematics syllabus, specifically for Grade 6, to determine the basic curriculum requirements for proficiency in fractional numbers and in fractional number teaching. I also carefully examined the BETD Broad curriculum for a similar purpose. By examining the content taught on the mathematics education course, I would get an idea of what to look for in terms of the student teachers' expectations on the teaching of fractions.

3.6.2 Observation

I selected observation as it is seen as a "purposeful, systematic and selective way of watching and listening to an interaction or phenomenon as it takes place" (Kumar, 2011, p. 140). Patton (as cited in Best & Kahn, 2006, p. 247) asserts that the data from observations consists of "detailed descriptions of people's activities, actions, and the full range of interpersonal interaction and organizational processes that are of observable human experience". In their third year the BETD student teachers were deployed to nearby schools to do their School Based Studies (SBS), involving teaching practice in their major subject. These are primary schools from both rural and urban parts in Namibia. The schools were not well equipped with different resources, so the student teachers were supposed to prepare their own teaching and learning aids, and could also borrow mathematical instruments from their campus if there was a need. In this case the students taught mathematics to Grades 5-7. During this time, they were teaching the topic of fractions to real classes in Grade 6. I observed the 5 participants during this period. My aim was to observe them and see how they practiced teaching their prepared lessons on fractions in order to understand their experiences of the whole teaching process. During this time I examined how the student teachers' subject matter knowledge and

pedagogical content knowledge was utilized in practice in terms of their previous knowledge and what they had gained from the BETD mathematics education course with regard to teaching fractions. I also looked at how they designed the learners' activities, their lesson plans and other related teaching documents. The student teachers' lessons were audio recorded and then transcribed. Full transcriptions of those lessons are presented in the appendices (Appendix A1-A10). In addition to these, field notes were also taken and used as part of the analysis. Since this observation was part of the student teachers' SBS normal observation schedule (4 observations), those lessons were not consecutive, but randomly taken from the researcher's class visits.

3.6.3 Interviews

Babbie and Mouton (2001) see a qualitative interview as an interaction between an interviewer and a respondent in which "an interviewer has a general plan of inquiry but not a specific set of questions" to be asked in particular words and order (p. 289). A semi-structured interview (both individual & focus group) was carried out with the participants to obtain a more detailed account of their perceptions as teachers of mathematics, teaching fractions. I came up with both of these interview questions as a result of what was observed during the student teachers' presentations. I chose the questions in an attempt to gain an understanding of the student teachers' experiences, knowledge and understanding of teaching and learning fractions (see Appendices B1 & B2). This way the student teachers were encouraged to reflect on their actual teaching and relate it to their experience of how they prepared and taught fractions to the Grade 6 classes. They then responded to the interview questions relating to how and why events unfolded in their mathematics classrooms. I followed up on most of their particular responses during the interview. Dewey (1965) advocates that reflective thinking should be part of the development of pre-service teachers in the education programs. He further comments that teachers' lack of reflective thinking leads to intellectual dependency on being given clear-cut and definite instructions on how to teach their subjects. All interviews were audio-recorded and transcribed.

I opted to do a semi-structured interview because I am interested in understanding the experience of these student teachers and the meaning they made of that experience with regard to their teaching of fractions. Seidman (1998), states that the purpose of using an interview is that, "it is a powerful way to gain insight into educational issues through understanding the experience of the individuals whose lives constitute education". "As a

method of inquiry, interviewing is most consistent with people's making meaning through language" (p. 7). The main advantage of focus groups is the opportunity they provide "to observe a large amount of interaction on a topic in a limited period of time based on the researcher's ability to assemble and direct focus groups" (Babbie & Mouton, 2001, p. 292). In terms of my study, this was applicable and useful in exploring student teachers' experiences of teaching fractions as they reflected on the reality of their classroom teaching and what influenced their understanding of fractions. During the focus group interview each participant was given a chance to give their opinions on most of the questions. Participants made comments on their peers' opinions. This way even the shy participants could air their views aptly and not only those who usually dominate the discussions. Participants in the focus group were labeled Respondent1 (R1), R2 and so on. This numbering was not the same as the ones used during their lesson presentations.

4. DATA ANALYSIS

Student teachers' interview responses and lesson observation narratives were analysed and the results were grouped into categories according to the themes that emerged. To carefully examine the student teachers teaching of fractions and the possible factors that shaped their understanding and teaching of fractions, I made reference to Kahan, Cooper and Bethea's (2003) study, which designed a framework for research applied to the study of student teachers in terms of their knowledge and teaching. This is a two-dimensional framework focusing on the elements of teaching and the processes of teaching in which knowledge of content is of consequence (Kahan, et al., 2003). I implemented a similar framework then adjusted it to suit my research, with the focus on what influences the student teachers' understanding and teaching of fractions in terms of their knowledge of fractions, knowledge of learning fractions and knowledge of teaching fractions, in relation to their experiences in schools and on the mathematics education course. This framework guided me in terms of what to observe during the lesson presentations, how to design interview questions as well as analyzing the prepared lesson plans.

I scrutinized the data as a way of exploring student teachers' experience and practice teaching of fractions in terms of how they understood the fractions; the learning of fractions and the teaching of fractions. With these in mind I then focused on what factors influence and shape the student teachers' understanding as they engaged in the teaching of fractions. The analysis focused on student teachers' understanding of fractions and their experience with the

mathematics education course in terms of their subject matter knowledge and pedagogical content knowledge of fractions. This included the student teachers' beliefs of learners understanding of fractions. This framework also served as a tool for me to analyze how teacher education experiences had an impact on the process of learning to teach (Ball, et al., 2008).

5. ETHICAL ISSUES

Prior to conducting my research, I considered a number of ethical issues namely those of confidentiality, informed consent, and participant anonymity with regard to all my research participants. First of all, I followed the correct procedures by gaining, in writing, official permission to undertake research at my institution. Secondly, as explained by Hitchcock and Hughes (1995), I tried to explain as clearly as possible the aims, objectives and methods of the research to all the parties involved, and the period within which it would be carried out. I ensured that, when using documents, anonymity was maintained by eliminating any kinds of information that could lead others to identify the subject or subjects involved. Cohen, et al. (2007) state that all participants must be given a chance to remain anonymous and all data must be kept strictly confidential. Silverman (2005) also states that voluntary informed consent should ensure participants a right to choose to take part (or not) in the research as well as to withdraw at any time during the research without penalty. As suggested by Silverman, to preserve anonymity and safeguard confidentiality, I used pseudonyms for my participants throughout this research study.

Collection of data was carried out during the normal SBS schedule without interfering with the schools' timetables, therefore schools were not expected to give written consents. Before the beginning of each SBS session, a meeting between the tutors and the student teachers' mentors is held. I thus used the meeting to inform the mentors that the participating student teachers' lessons were going to be audio-recorded. The focus of the study was on the student teachers and no video-recording took place during the lessons. As a result consent from the parents was not necessary.

6. CONCLUSION

The coverage of this chapter began with the description of the research goals of the study. This was then followed by a description of aspects of the case study such as the orientation and the particular approach for this case study. The research site and the sample selection in

terms of the research participants were described. The tools employed for data collection were then identified and discussed. The approach to data analysis was then reviewed and the framework adopted in this study was explained and justified (Kahan, et al., 2003). Lastly, the consideration of ethical issues surrounding this particular study concluded this chapter.

The next chapter presents the data collected and its analysis.

CHAPTER 4:

PRESENTATION AND ANALYSIS OF THE FINDINGS

4.1 INTRODUCTION

In this chapter I present an analysis of the findings of my qualitative case study. The main purpose of this particular study was to gain an understanding of the value of teacher training in fractions during teaching practice.

The chapter includes the presentation of the findings from the interviews (individual interviews, focus group) in conjunction with the student teaching practice in terms of the observed lessons on fractions taught by the five student teachers. A vignette for each student teacher from one or both lessons is presented, and transcripts of the actual lessons are included in the appendices. Responses to both the interviews as well as the descriptions of the taught lessons were carefully analyzed and categorized. Through this data analysis (individual interviews, focus group interviews and lesson descriptions) several themes emerged that I identified and present below.

4.2 PRESENTATION OF RESEARCH FINDINGS

4.2.1 Student Teaching Practice

The main purpose of describing these student teachers' lesson vignettes is to draw attention to how they presented the fraction lessons; what attempts they made to adopt the taught knowledge practice of teaching. These are snapshots to find out how far into the lesson the teacher engaged with the knowledge; what happened when the attempt did not succeed during the lesson process, what directed their thinking and actions they took during these lessons such as reverting to prior knowledge. These vignettes provide a nearsighted view of the interactions in the student teacher mathematics instruction. Each of the five student teachers was observed twice and their lessons are included in the appendices.

In her teaching ST1 generally followed the following approach: She explained the content of her lesson by reading the notes she prepared on a flipchart. She involved her learners through posing questions to them and she did all the work on the chalkboard. ST1 told the class what to do, the procedure to use and they followed it by giving correct/incorrect answers to the teacher. The student teacher also emphasized the importance of the sign being used when

reducing a fraction into its simplest form. This can be seen in the following example lesson on simplifying fractions.

4.2.1.1 Vignette 1: ST1 teaching how to simplify fractions

After ST1 finishes the introduction of the lesson through storytelling, she pastes the flipchart with a heading "Simplifying fractions", and she tells the class that it is the topic for that day and they are going to learn about how to put fractions into simplest form. "When we are simplifying a fraction, we need to find an equivalent fraction using the smallest number for the numerator and the denominator", she explains. She gives an example (a) $\frac{4}{10}$ ('4 over 10'). She explains that they have to find the smallest number to represent the numerator and denominator by dividing. She shows $\frac{4}{10}$ by asking them the smallest number dividing both 4 and 10, therefore the answer: $\frac{4}{10} = \frac{2}{5}$. She further asks the learners whether they need a number that divides 2 and 5 to give the final answer. "$\frac{2}{5}$ is the last answer as there is no other number dividing both numerator and denominator, except 1", she clarifies.

She then writes the second example (b) $\frac{18}{24}$('eighteen out of 24'), asking "which number can divide into 18 and 24?" One learner says "two" and gives the answer as$\frac{18}{24} = \frac{9}{12}$. The student teacher asks the class whether this is the last answer and they respond "no". She then comments that it was not the last answer so the learners should give the other number to divide. After the class gives 3 the teacher works out$\frac{9}{12}$.. = $\frac{3}{4}$ and tells them that this ¾ ('3 over4') is the final form of the given fraction $\frac{18}{24}$ as there is no other number that would "divide into 3 and 4 except 1 and itself." Lastly, they work out the other example $\frac{10}{20}$ where the teacher again asks the class which number they have to use in this case and one learner says 3. The teacher disagrees and continues asking others. The other learner says 2, then the teacher asks her to complete …..$\frac{5}{10}$. ST2 then tells them that to write this into simplest form they should take 5 and divide to get $\frac{5}{10} = \frac{1}{2}$ the final answer. She then hands out papers with an individual class activity. She reminds the learners to remember that the sign they are using is not multiplication, but division, and that they have to make sure they put everything in simplest form, "you do it by dividing".

In his teaching ST2 emphasized the use of rules and procedures in order to understand what was being taught. This is seen in how he used examples in his teaching and the steps/ procedures he took. The student teacher tried to give learners a rule in order to help them understand how addition and subtraction of fractions is done. This way, the learners could develop and grasp the rule and use it reliably without referring to the reality of the situation. ST2 aimed at the learners memorizing the rule and arriving at the correct answer without exploring the real meaning behind it. This can be seen in the following example lesson on addition and subtraction of fractions.

4.2.1.2 Vignette 2: ST2 teaching addition and subtraction of fractions

After ST2's introduction to the lesson where he uses two flash cards with a + and a – signs on them, and testing them on their pre-knowledge on the addition of fractions, he puts these examples on the chalkboard: 1(a) $\frac{3}{6} - \frac{2}{12}$. "What are we going to do first?" he asks. Then one learner says "we have to multiply first." The teacher further asks "what are we going to multiply first?" The learner responds 6, then another one says 3 sixth. The teacher then asks what number they are going to multiply with and the learner says it is 2. So they work out together $\frac{3}{6} \times \frac{2}{2} = \frac{6}{12}$ and he writes $\frac{6}{12} - \frac{2}{12}$ asking what the final answer

is, one learner says it is $\frac{4}{12}$. The teacher explains to the class that "when you have one denominator as a multiple of another, you have to convert one fraction to an equivalent fraction, and make sure you have to have the same denominator". He then refers to the example $\frac{3}{6}-\frac{2}{12}$ explaining how they make it $\frac{6}{12}$. He writes the second example (b) $\frac{13}{16}-\frac{3}{8}$ asking the class, "what are we going to do?" He points to one learner who struggles to answer, saying "we are going to multiply $\frac{13}{16}$." The teacher asks whether he is correct, then another learner says no, but they will multiply $\frac{3}{8}$. The teacher then asks which number they are going to multiply with in order to have the same denominator. A learner says "2." He then writes $\frac{3}{8}\times\frac{2}{2}=\frac{6}{16}$ with learners giving the answers. He then explains how they can work out $\frac{13}{16}-\frac{6}{16}$, asking what the answer is.

One of the learners responds "7 sixteenth". "Any question," the teacher asks, and the class says no questions. The teacher then tells the learners that they will look at addition, so he writes 2(a) 2/5 + 3/10 repeating the same questions as in example 1.teacher then asks one of the learners to do the second example on the chalkboard: (b) $\frac{5}{10}+\frac{4}{20}$. After they work out example 2(a) together, he calls a learner on the chalkboard to come and she works out $\frac{5}{10}+\frac{4}{20}=\frac{9}{20}$. The teacher then requests another learner to come and work out the answer correctly. After the class struggles to work out this example the teacher informs them of the important rule used when doing addition and subtraction of fractions. After this explanation, this second learner writes $\frac{5\times2}{2\times10}=\frac{10}{20}+\frac{4}{20}=\frac{14}{20}$ and the teacher and learners agree that it is correct. The teacher writes the last example (c) $\frac{5}{7}+\frac{4}{28}$ asking what they are going to do, the class says they are going to multiply by 4 and they work it out with the teacher.

"Any questions," the teacher asks. The class says no. "How to subtract a fraction with a denominator a multiple of another", he asks. No one responds, and then after the teacher points one learner she responds that one multiplies. He reminds them that it is important to remember this rule of adding and subtracting a fraction with one denominator a multiple of another as this will help them to work with easy. The teacher then gives a class work walks around the class looking at how learners are writing. The time is up and the teacher tells the class to give the books to the class captain.

With regard to ST3, in most of her lessons she used the approach of asking learners to define terms before she explained them. In the lesson described below, it can be seen that time was spent on getting the idea of what an equivalent fraction is by using the definition. ST3 provided the procedure to follow when learners look for an equivalent fraction. Her goal here was to involve her learners in providing answers to her questions using the procedures she provided. Learners were not engaged with discussing why this fraction is equivalent to the other as long as they knew that equivalence meant they are equal or they have same value. This can be seen in the following example of ST3 lesson on equivalent fractions.

4.2.1.3 Vignette 3: ST3 teaching equivalent fractions

The teacher tells the class that "fraction is a way when you divide a whole number into parts". She further continues explaining that fraction "is a way of representing division, we divide that whole into parts." ST3 informs the class that the topic for the day is fractions, but the main focus was going to be about equivalent fractions. "These are the equivalent that look different but they have the same value", she says. She refers to numerical values representing a fraction and asks the learners to name them top/bottom numerator/denominator, writing the learners' answers on the chalkboard. She clarifies that "in the equivalent fraction the numerator and denominator may look different but they have the same value". She then tells the learners that this was the definition of equivalent fractions. She refers to an example of an apple (supposing that she has one apple) and divides it into 4 parts. She then asks the

learners how she will put this into a fraction. One learner responds that it is one over four – the teacher writes ¼ and explains that ¼ is numerator/denominator.

The teacher talks about equivalent fractions again, and then writes the definition on the chalkboard: "These are the fractions that may look different but have same value." The teacher presents an example of an equivalent fraction. She gives a ½ ("a half" – she says not 1 over 2). "Which fraction is equal to ½" or "which fraction is equivalent to ½?" She asks. She explains that she can use any number to multiply both numerator and denominator. She shows this $\frac{1\times2}{2\times2}=\frac{2}{4}$ and then explains that "2 quarters equal to 1 half". She also explains that they can use 3: $\frac{1\times3}{2\times3}=\frac{3}{6}$ and tells the class that $\frac{3}{6}$ is the equivalent to ½ because they have the same value. She further explains that when they look at equivalent fractions, they look different but they are equal, they have the same value. She repeats again that ½ can be multiplied by the same number both numerator and denominator such as 3 or 2 then it gives a different number with the same value as ½.The teacher then asks whether the learners understand or she can put one more example. The learners say yes.

The teacher gives this example to find equivalent fraction (she writes on the board) of the following $\frac{2}{6}$. She then explains the procedure asking the learners to choose any number. The learners choose 4. $\frac{2\times4}{6\times4}=\frac{8}{24}$. She writes the learners' answers on the chalkboard. The teacher then emphasizes how she knows that $\frac{8}{24} and \frac{2}{6}$ are equivalent by repeating the same explanation as above. She then decides to give the class an activity to be done in pairs.

ST4 in his teaching mostly applied his previous knowledge on fractions which in most cases was not quite in line with what was taught on the mathematics education course. This lesson showed how ST4 practiced teaching writing fractions in their simplest form. It can also be seen how he applied his previous knowledge in terms of fraction names (e.g. '2 over 4'), identified a bigger fraction, and also how to find equivalent fractions with a misconception that one adds (½ to $^2/_4$: 1 + 1 = 2 and 2 + 2 = 4). ST4 saw a group of equivalent fractions as a sequence and proceeded to teach the properties of a sequence to the learners even though it was incorrect. This can be seen in the following example lesson on writing a fraction in its simplest form.

4.2.1.4 Vignette 4: ST4 teaching how to write fractions in their simplest forms

After ST4 writes a definition of a factor on the chalkboard, "a factor is a number that divides another number without a remainder", he turns their attention to changing of equivalent fractions."Suppose we have a fraction ½ ("one over two"), so this is equivalent to?" he asks. One learner says "2 over 4". The teacher agrees with the class, and then asks another equivalent fraction. "4 over 8", one learner responds. The teacher continues asking learners "4 out of 8 is equivalent to?" Learners give answers until they have this list: ½, 2/4, 4/8, 8/16, 16/32, 32.64, 64/128…

The teacher then asks what the big fraction is, and one learner says "32/64" ('32 over 64'), another one says "64 over 128".The teacher then asks the learners to look at these fractions moving from ½ to 2/4, 2/4 to 4/8 and so on whether they "divide, multiply or add?" "2, 4, 8, 16, 32, 64, we multiply or we add?"He shows on the chalkboard 2+2=4, 4+4=8, 8+8=16, 16+16=32, 32+32=64, and concludes that it is obvious that the rule here was that they add when moving from fraction ½ to 2/4.The teacher further asks the learners how they know that they have to add e.g. 2/4 to 4/8, which number can be added, the class gives 2, because 2+2=4.The teacher then explains that one has to add the number itself. He further continues saying they are going to look at how to turn an equivalent fraction (a) 2/4 into the simplest form, stating that the learners should remember

about the 'factor', he tells them about earlier. He then asks learners to find a number that divides both 2 and 4 without a remainder, which could be a 1, 2, and 3,4,5,6. He asks them to take one number, then one learner says "one." "What happens, 2 divided by 1 = 2", "4 divided by 1 = 4" with learners giving answers. The teacher then explains that since those numbers did not change they should pick another number. "Which one?" he asks. "Let us take 2", one learner suggests. ST4 checks whether it works writing this $\frac{2}{4} \div \frac{2}{2} = \frac{1}{2}$ and points out that this is what is called the simplest form starting from big into small.

After solving different examples with the learners, ST4 then asks the learners to look at the example of the equivalent fractions and he explains what equivalent fractions are about: $\frac{3}{5} = \frac{6}{10} = \frac{9}{15} = \frac{12}{20}$. "If we look at this sequence do we add or do we multiply?" he asks. He directs the learners' attention to the numbers 3, 6, 9, 12 asking whether they add or multiply. The learners respond that they add. The teacher also agrees saying that they add 3 because 3+3 = 6, 6+3 = 9, 9+3 = 12.So "here the denominator 5,10,15,20 now we multiply but how many numbers do we add?" he asks. The learners responds "5," then the teacher continues asking 5+5 = "10" the learners respond, "10+5 =?", "15"and so on. The teacher then refers them back to the current topic, and they continue doing simplification of other fractions.

In his teaching ST5 generally followed an approach where he asked for definitions and the use of learning through procedures. It is seen that even though the student teacher asked the learners to define a fraction, he never got round to giving it to them. Instead he proceeded to the topic on how to find an equivalent fraction. Again as with ST1 and ST4, his previous knowledge caught up with him on fraction names. As with the other student teachers' presentations, ST5 provided learners with a procedure for finding an equivalent fraction. This teaching emphasized the learning of following a procedure that the teacher provided without incorporating reality or teaching aids to supplement the learners' understanding. The following ST5's lesson on equivalent fractions demonstrates this.

4.2.1.5 Vignette 5: ST5 teaching equivalent fractions

After ST5 introduces the lesson he asks learners to give a definition of a fraction. A learner says "it is 1 over a number". The teacher then asks the learner to use the square provided earlier on the chalkboard to define a fraction. "What fraction can you see there?" The learner answers that "is 1 over 4"and he agrees. "Within 1 over 4, we have 2 names, this number has a name and also this number has a name", "what are those names?" he asks pointing at 1 and 4. One learner states that 4 is a divisor then asks about the other number. A second learner says "a numerator". The teacher then asked this learner to identify which of the 2 numbers ($\frac{1}{4}$) is a numerator. The learner says 4. The teacher disagrees with that learner and gives a chance to another learner who says "4 is a denominator". After writing this information on the chalkboard, he tells them "now we are going to turn an equivalent fraction, 1 over 4 into equivalent fraction". "Here we have 1 over 4, now to turn it into equivalent fraction," he writes on the chalkboard. He then states the definition of an equivalent fraction that "equivalent fractions are equal but not exactly the same. Now we are going to turn 1 over 4 into equivalent fraction, to show how they are equal but not the same", he continues. He repeats that to turn equivalent fraction, learners should remember that they are equal values, but not exactly the same. He asks whether learners understand what 'equal value' means.

"To turn $\frac{1}{4}$ (1 over 4) you've to multiply both the numerator and denominator by the same number, any number of your choice. He tells the class that they are going to use 2 and writes on the board: $\frac{1\times2}{4\times2} = \frac{2}{8}$ asking the learners the answer for top and bottom. ST5 then tells the class that it was the way to turn $\frac{1}{4}$ into equivalent fraction. He explains that "we can multiply with 3 to turn it into another fraction". He writes $\frac{1\times3}{4\times3}$, asking learners to give the answer($\frac{3}{12}$). He further repeats the procedure asking whether they understand equivalent fractions and points to the definition written on the board: "they are equal, but not exactly the same". After a while ST5 asks the learners if they have any question then one learner stands up asking "where do you get the number that you multiply with?" The teacher comments "you mean the number such

as 3 (pointing at $\frac{3}{12}$), you pick any number you want". He further explains that "it is not that they are somewhere you pick any number 2, 3, 4, 5… as long as you multiply both numerator and denominator by the same number". He explains again that one could not do $\frac{1\times2}{4\times3}$ as this will not give the same value. He asks whether they still have questions, but they say no.

4.2.1.6 General discussion on the student teachers' teaching styles

Looking at the five student teachers' classroom vignettes, they provide glimpses of the styles of teaching fractions and the kind of interaction that occurs in these five classrooms. There are more similarities than differences in their lesson presentations. Focusing on ST1's lesson, she provided the learners with a definition and explained it. Her way of involving the learners was through using a question-and-answer method. The focus of this lesson did not involve exploring different ways of solving problems, but she did provide a procedure to be followed.

ST2's teaching style is in a way similar to ST1's where he emphasized rules and procedures. His lesson did not involve any reality of fractions as long as learners grasped the rules that he provided. ST3's teaching style is that she asked for definitions first and then explained them. As with ST1 and ST2, she provided learners with procedures to follow. Her involvement of the learners in the lesson was through the question-and-answer method as with ST1.

ST4's style of teaching involved applying his previous knowledge of fractions though they were not quite in line with the content taught on BETD. He directed learners to find a rule or procedure of the 'sequence' and also involved them through a question-and-answer style. Lastly, ST5's style of teaching fractions was similar to ST1 and ST3 when he asked for definitions. The difference was that he did not actually give them to the learners. His approach was heavily influenced by his previous knowledge as with ST4. As with all the other student teachers, he emphasized learning through following procedures. The other common characteristic with all the other student teachers' lessons is that he did not incorporate reality in his teaching of fractions.

4.2.2 Student teachers' experience from the BEDT mathematic education course

Through examining the data carefully, I noticed how the student teachers were influenced through their teaching of fractions by their BETD mathematics education course experience. For instance, in his interview ST2 testified that the course helped him as he acquired more knowledge on the topic of fractions than he used to know. This can be seen in his testimony:

> *Now in my lesson I use to give a lot of examples, a lot of exercises. I have the notion on my lecturer. That is why when it comes to teaching of fractions is not tough anymore because I am equipped. At least I have the knowledge and the foundation (Appendix C2, line 123)*

Similarly, ST3 also testified to gaining knowledge from the mathematics education course. She commended on how the course experience influenced her teaching of fractions by saying:

> *Let me say I now know many important things about fractions. Even now when I have to think that this is what needs to be taught or this is how I have to teach fractions according to what I have learned here and this is how I should deliver my lesson about fractions, and that experience or that knowledge I got from what I learned well. So it from what I learned here that I can teach well (Appendix C3, line 144).*

ST4 and ST1 both testified to being influenced by their mathematics education course:

> *Added to my knowledge from the mathematics course are many new things about fractions that are in my mind now. The way I delivered the lessons of fractions, and the way I question my learners like I was taught here on the course (Appendix C4, line 129)*

> *I am saying it because when I went for my SBS (School Based Studies), I did not find it very difficult on how to plan lesson on fractions. I have not really struggled to plan only sometimes I went to ask a few questions from my support teacher, but most of it was ok. The course has helped me quite a lot, because for example, modeling fractions helped me to make sense of parts of a whole being shared (Appendix C1, line 112)*

In addition to the student teachers' interview testimonies of the course influence on their teaching; it was also evident in their lessons in different ways. The student teachers taught their lessons using different approaches and most of these were experiences from their mathematics education course, e.g. ST3's lesson introduction (see Appendix A6, paragraph1 and 4; also see Appendix C5, line 45). They also considered their learners' prior knowledge on different taught lessons as they were trained to do on the mathematics education course (see appendix A10, paragraph 2).

4.2.3 Student Teachers' Prior Knowledge Experience

The data showed how the student teachers' teaching of fractions was influenced by their previous knowledge experiences in several instances.

In her lesson on comparing fractions, ST3 struggled to put into practice the approach taught on the mathematics education course, so she reverted to using the traditional way of teaching fractions (see Appendix A3, paragraphs 2-5). The student teachers used fraction terminologies that were taught in their early schooling years. Examples of these are such as referring to 3/6 as '3 over 6', 5/6 as '5 over 6' and so on (See Appendix A4, paragraph 4).

The data revealed that the student teachers' previous knowledge of learning and teaching fractions influenced their teaching heavily, especially in their use of symbolic representations of fractions. It meant they adopted a method of teaching fractions without incorporating reality, only using fractional numbers as they were previously taught in schools (See Appendix D, line 114). This previous knowledge experience in some student teachers, led them to apply incorrect ideas in their teaching of fractions. This was observed in ST4's lesson on comparing fractions when he used additive inverse reasoning for partitioning (Appendix A9, paragraph 4). ST4 also applied his previous experience in the way that he saw a fraction as a pair of two different whole numbers.

The commonality that was seen through the analysis of data as a result of the student teachers' previous knowledge experience on their teaching of fractions, was their emphasis on following rules and procedures. They believed that knowing the rules and procedures that a teacher provided to the learners, improved their learning of fractions as well as their skills with fractions. ST1 testified to this:

> *I am saying that these rules and procedures are important to them as they help them to do calculations correctly. Especially with fractions, the learners have to stick to the use of rules and apply them many times (Appendix C1, line 94).*

Similarly, ST4 had this to say:

> *I am saying that it is the right way when learners are doing fractions that they should do it in steps that the teacher provides them. They should follow the exact rules to get their answers. This way they learn best. It is how I learned fractions in primary and secondary school that rules are important (Appendix C4, line 114).*

It is also seen in the vignettes presented earlier that their prior knowledge heavily influenced most of the student teachers' teaching of fractions.

4.2.4 Emerging Themes

During the process of analyzing and organizing the data, several themes gradually emerged. There was commonality among the views or perceptions from student teachers' interviews and their lesson observation narratives. These were colour coded, grouped and categorized into themes/topics that were seen as the best fit. These themes included disposition and mathematics rules, symbolic representations of fractions, disconnected (arbitrary), fraction terminology, fractions as a pair of whole numbers, fraction understanding and anxiety, lesson presentation (and implications), teaching for passive learning, and intentions and reverting (practice issues).

4.2.4.1 Disposition and Mathematics Rules

It was observed that through their teaching of fractions student teachers provided learners with different examples as well as plenty of exercises. Learners spent most of their lesson time doing calculations on fractions. The student teachers claimed that this practice would perfect their learners' skills as 'practice makes perfect and they learn how to think very fast through doing activities and not always to wait for the teacher to get answers from them'. In agreement both ST3 and ST4 indicated that they wanted learners to understand fractions, the best way to achieve this was through doing drill and practice. The major reason they believed this was helpful was that in schools and even on the mathematics education course they practiced a lot of exercises with fractions, and felt that this enhanced their understanding of fractions. This can be seen from their interview extracts:

Student teacher 5 testified that this was the way to learn fractions

> *Because they say that 'practice makes perfect'. That is why I gave my learners many tasks so that they can solve different fraction problems. Is just a way that when you do something over and over, you cannot forget, it becomes like a poem in your head, so you really master the skill. In schools we did it like this, we solve many exercises in fractions to learn (Appendix C5, line 71).*

ST4 similarly in his testimony on calculations stated

> *For me to give more activities and exercises for the learners, it says 'the more you give the better the learning becomes'. I mean is better for me to give a lot of exercises then I will know exactly where different learners have problems instead of just giving one or two exercises. This is the only way they learn. I remember doing many exercises with fractions in the math course, it taught me so much (Appendix C4, line 100).*

ST1 also testified to the use of many calculations in her teaching of fractions

> *Yes I think that they can learn fractions better this way when they do a lot of practice. Even when we learn fractions in our math course, we did lots of exercises and learned a lot. (Appendix C1, line 85)*

Additionally, the student teachers viewed the use of rules and procedures as important in doing fractions.ST1 explained that she always showed steps/rules of calculating fractional problems because she believed that these rules and procedures were important to the learners as they helped them to do calculations correctly. Similarly, ST2pointed out that he emphasized rules and procedures to lay the foundation, so they had to learn specific steps and procedures as they exist. They also made a point that learners should follow the steps shown to them by the teacher as in this way they would understand the concepts better. ST4 pointed out that he had to teach mostly procedures and rules of doing fractions using the steps otherwise he would mislead them. Similarly, student teacher 5 also emphasized the use of rules and procedures in

his teaching of fractions. He saw it as an important tool to follow rules and procedures correctly as this was the way one learned fractions. He testified to this in his interview

> *I think that following rules and procedures in mathematics is the only way. But is very important to show exactly steps the teacher gives in the class to show that you follow and remember what was taught. Addition and subtraction of fraction for example, one uses the rule of lowest common multiple, is important that you do it step by step to show the answer(Appendix C5, line 86)*

ST3 also testified to the use of rules

> *I am saying that procedures and rules are very important in the teaching and learning of fractions. The learners have to learn and use rules when calculations as they make them remember what to do, what step to take next. That is how we learn mathematics in our schooling years and I think it helps (Appendix C3, line 117).*

It is clear that the main reason these student teachers emphasized the use of rules in the learning and teaching of fractions was that they experienced the same method during their schooling years. They felt that it was important for learners to memorize the rules and procedures used with fractions because they saw this as the right way to learn.

4.2.4.2 Symbolic Representations of Fractions

The student teachers indicated that they taught fractions using the ways they were taught in schools. The main reason was that they were comfortable with these methods and they knew how to work easily with them. From the focus group interview one respondent testified that

> *Most of the time we teach just using the fractions as numbers. The reason is that most of us follow the way we were taught in schools. Teachers out there do not teach real life so we are used to for example, to add or subtract fractions, I just take* $\frac{1}{2} + \frac{1}{3}$ *without thinking real life*(*Appendix D, line 115*).

What happened was that the student teachers when teaching fractions did not incorporate real-life situations and manipulatives. They only used symbolic representations of fractions, like ½ or 1/3 as that was how they were taught in schools (primary and high school). In support of this, the student teachers in their interview indicated that they mostly used only drawings either on flipcharts or on the chalkboard as they had not had time to look for other manipulatives and concrete teaching aids. Different remarks from most of them showed that they did not have enough experience on what to look for and how to incorporate real life examples in their teaching of fractions which would have resulted in teaching symbolic representations. From their focus group interview respondents R1and R5 respectively, had this to say

Sometimes I think because we lack experience we just follow examples from the textbooks and give it to the learners. Hopefully these are simple, so if you bring in something extra, maybe learners will not understand (Appendix D, line 120).

By that I think that we do not really have experience or how to bring in real life examples. I mean maybe we do not really have an idea on how to incorporate real life examples to engage learners with those. Teachers in schools out there taught us fractions, you know mostly this way(Appendix D, line 133).

4.2.4.3 Disconnected (Arbitrary)

The analysis showed that through lesson observation student teachers opted to use a particular teaching aid, but its relevance was not demonstrated.

During the lesson introduction on equivalent fractions, the teacher handed out four equal-sized flash cards, with different colours and names: red, blue, yellow and green. He asked: "who can tell me what is written on the red card?" "Red bull", responded one learner. "On the green one?" "Green glass"; and they gave the rest of the names written on the cards. The teacher then informed the class that they were going to learn about equivalent fractions. He then posed this question to the class "who can tell me what it means equivalent fractions?"(Appendix A7, paragraph1)

The possible reason that ST2 did what he did with a teaching aid was that on the mathematics education course they are trained to include and use teaching aids in their lessons (See Section 2.6). It meant he thought that by including the cards, this would satisfy the criterion of 'using teaching aids' in order to satisfy the assessment criteria of the course.

4.2.4.4 Fraction Terminology (presentation, communication)

It was noticed that through their teaching majority of the student teachers used fraction terminologies such as '1 over 2' when referred to a 'half' and their learners tended to follow suit. This can be seen in ST4's second lesson:

The teacher then wrote the example where learners were required to arrange on the chalkboard 1) 3/6, 6/6, 1/6, 5/6 and 2/6 ("3 over 6, 6 over 6, 1 over 6, 5 over 6 and 2 over 6") "which one is the first if you arrange from the biggest," he asked(*Appendix A4, paragraph 4)*

Similarly, in her lesson 2, ST3 used the same technique when referring to different fractions:

The teacher then showed the learners the different pieces she brought. She wrote on the board the two fractions ¼ (she read as 'one over four') and ¾ ('three over four') then asked 'which sign can I use here, between greater than (>) or less than (<)?" (*Appendix A3, paragraph 2)*

The student teachers kept on using incorrect fraction terminology because this was how they were taught in schools. It was observed even during the focus group interview how the participants repeatedly used the terms '1 over 3', '5 over 50'. R1 said:

…To me I experienced like numbers like 1 over 3 there, is easy for learners to relate, but if you give them like 5 over 50 then it is difficult for them (Appendix D, line 59).

It was observed that these student teachers adopted the use of fraction terminologies even though the BETD mathematics education course training discouraged their usage.

4.2.4.5 Fraction as a Pair of Whole Numbers

ST4 presented his lesson on comparing fractions through equivalent fractions and used the additive reasoning for partitioning instead of multiplicative reasoning; this resulted in his learners following the same method/procedure when looking for equivalent fractions.

> *ST4 in his lesson on simplifying fractions, he talked about equivalent fractions. He gave some equivalent fractions* $\frac{1}{2}$; $\frac{2}{4}$; $\frac{4}{8}$; $\frac{8}{16}$; *.....the teacher then asked the learners to look at these equivalent fractions moving from ½ to* $\frac{2}{4}$. *He however connected this to additive reasoning where fractions are found by doubling e.g. from a* $\frac{1}{2}$*to* $\frac{2}{4}$, $\frac{2}{4}$*to* $\frac{4}{8}$, *and so on whether they divide, multiply or add."Look, 2, 4, 8, 16, 32, 64, we multiply or we add?" the teacher asked. The then showed on the chalkboard 1+1 =2, 2+2 = 4, 4 + 4 = 8, 8+8 = 16, 16+16 = 32, 32+32 = 64 and concluded that it was obvious that the rule here was that they add when moving from fraction ½ to* $\frac{2}{4}$, $\frac{2}{4}$ *to* $\frac{4}{8}$, *as they added a fraction to itself.*(Appendix A9, paragraph4)

What happened was that the student teacher thought that to turn a fraction such as ½ into another equivalent fraction, 2/4, one should just add 1+1 = 2 and 2+2 = 4. He saw this as a form of sequence with whole numbers 2, 4, 8, 16 …One of the possible reasons why ST4 viewed a fraction as a pair of different whole numbers was because he did not conceptualize that equivalent fractions involve partitioning as they were taught on the BETD course (See 2.6). He resolved this by applying his previous knowledge on fractions where he could not view the fraction 2/4 as 'two=quarters' or 'two-fourths', but 'two over four'. This simply meant that ST4 viewed fractional numbers as two different entities and thought that these could be dealt with separately. This was seen when he encouraged learners to focus on breaking fractions into parts and treating them as whole numbers rather than fractions. The resultant problem was that when ST4 compared ½ and 2/4, because of his previous knowledge experience, there were four different whole numbers instead of two fractional numbers.

4.2.4.6 Fraction Understanding and Anxiety

Evidence through data revealed that not all of the student teachers lacked fraction understanding in their teaching. This was shown when they managed to turn their learners away from applying misconceptions in different cases, for instance, during the addition and subtraction of fraction lesson, a student teacher redirected the learners and showed them the proper way. See the extract below

> *The teacher pastes two flash cards with two equivalent fractions on the chalkboard and asks, pointing to 4/8: "what fraction is this?" "Four eighth" one learner answered. He then asked the second fraction (2/4) and another learner responded "two quarters". The teacher then asked "can you add these two fractions together?" One learner then said "4/8 + 2/4 = 6/12". He then informed the learners that this was incorrect as when fractions are added one did not add as in case of whole numbers. He further continued explaining the procedure of adding fractions such as these by using a common denominator (Appendix A2, paragraph 1)*

This student teacher demonstrated an understanding of addition of fractions. It was observed that even the terminology usage in that classroom was correct ('two-quarters', 'four-eighth'). He showed the learners how to add fractions using a common denominator rule. This reveals that as a result of the mathematics education course, most student teachers can teach and show learners what to do about fractions. R1 from focus group interview testified:

> *…. because I am still learning, it is still useful. Because what we have learned in the lessons here it has given us knowledge and experience of fractions, how to give it to someone else (Appendix D, line 14).*

The understanding obtained through the student teachers' individual interviews revealed that they greatly appreciated the fact that they furthered their own conceptualization and understanding of fractions through undertaking the mathematics course training. They also indicated that they experienced fear and anxiety throughout their teaching of fractions because they felt that their understanding and knowledge of fractions still needed to be strengthened, especially on developing and designing teaching materials for their lessons on fractions. This could be seen by their testimonies from the interview below.

ST1 testified that she was afraid of making mistakes in front of the learners. She indicated that this was especially so when they asked questions and she got confused. This added to her fear that she might give the wrong answers to the learners. ST2 explained that in his teaching of fractions, he was full of doubts, asking himself the questions 'am I really making my learners come to the point where I am trying to bring them?' Or 'are they really getting my way of teaching?' 'Am I really getting the message across?' Those questions plagued him. ST3 similarly testified that her fear lay with the teaching of equivalent fractions and comparing fractions, and the teaching aids she tried to bring into the lessons as evidence. The main reason here was that the teaching on the mathematics education course did not equip her and the others with sufficient skills to teach fractions effectively. As a result, these student teachers reverted to what they knew from their own school teaching experiences and this made the task more difficult. ST4 commented that his fear and anxiety in fraction teaching came as a result of thinking that maybe the learners would not understand and maybe he as a teacher would not be able to explain clearly what was taught, and might just end up confusing the learners. He also

stated that he did not use teaching aids except flipcharts as he did not know what to design for his lesson. In his remarksST5 stated that he experienced fear and anxiety especially when thinking about whether learners would understand what he taught on the different topics of fractions.

As a result of their lack of understanding of fractions, these student teachers were forced to apply their previous knowledge in their teaching. From the focus group interview, R3 stated:

> *….. I struggled with the teaching aids, that one I cannot do it. I mostly teach using numbers like 1 over 4, 5 over 12 and so on to make them understand (Appendix D, line 93).*

Also in support of this R5 from focus group interview had this to say:

> *For me I do not bring reality in the classroom because of lacking experience. We do not know enough. Many times I use what I know from primary school and secondary school, is not easy.(Appendix D, line 119).*

All these indicate that the student teachers experienced fear and tension throughout their teaching of fractions as a result of having poor mathematics content, specifically fractions. Look at the following inset from ST2 lesson 1:

> Another learner asked him "what if we have an odd number over an even number, e.g. $^{11}/_{28}$?" The teacher responded that it was a good question, but they should take it as part of the homework for everyone to bring an answer the following day (Appendix A7, paragraph 5).

4.2.4.7 Lesson Presentation (And Implications)

As a result of their training on the mathematics education course in their teaching of fractions, student teachers used different approaches which they felt fitted with what they were teaching at the time. It was observed that most of the student teachers employed similar teaching methods such as starting off by posing one or two questions for learners to define new terms, followed by the lecturing method, where the teacher would define terms and explain the content to the class. This was mostly followed by a class activity (group/individual work) just to see which learners understood and which did not, as ST3 put it in the interview. She further explained that she used the lecturing method/explanation method first because through the questions that she posed she realized that they did not have the correct information about fractions. That was why she first explained a little bit about a fraction then went ahead with group work, where learners shared information and also pair work to add to their sharing of information. This was observed from the lessons when student teachers distributed handouts with exercises to different groups or through the use of a flipchart with an activity pasted on the chalkboard. The learners would then discuss amongst

their groups and the teacher would request the group leaders to present their work. Similarly, with the class discussion, the teacher posed questions and learners gave correct/incorrect answers.

ST1, ST2 and ST4 similarly defended their use of the lecturing method in the beginning as it allowed them the opportunity to explain to the learners what they had prepared for them. They further indicated that they thought that through their methods the learners could learn more easily, especially when it came to class discussion, and in this way learners were given a platform to learn through interaction because by helping one another or discussing the problem, they could more easily arrive at a solution. That was why these teachers opted for these methods as they believed that this was the way the learners in their classes learned best.

> ST5's interview remark was that
> *Like when I used class discussion method when teaching fractions, we talked I moved around the class, ask questions and we discussed together. I think this makes it easier for the learners to understand what is taught(Appendix C5, line 45)*

Participant ST5 stressed that through using different methods such as discussion, he was able to interact with the learners and that it helped their understanding ashe corrected them as they went along. He also used the question and answer method to test whether learners had grasped the new content taught.

4.2.4.8 Teaching for passive learning

Through lesson observation some student teachers practiced their fraction teaching using passive teaching. The following extract shows this

> *In his introduction to equivalent fractions, the teacher drew a square on the chalkboard and cut it into 4 equal portions, e.g.*
>
> 
>
> *He then asked the class: "can somebody tell us what you see on the chalkboard?" George* (not real) replied "a square with 4 blocks". The teacher then asked the class whether they all saw a square with 4 blocks. Then one learner said "a square with 2 lines inside". The teacher stated that the square has a name "is a fraction". He further said that "those blocks that we divide in a square are fractions"*(Appendix A5, paragraph1).

From the excerpts above it became evident that the teacher gave a good representation of fractions, but did not help the children to identify what was useful. The data reveals that the student teacher's focus was on the word 'fraction' rather than on the process of making and using fractions. The main reason was that on the mathematics education course student teachers are encouraged to always introduce their topics. ST5 wanted to highlight his topic of

the day into the introduction without saying much about it, but in this way he forced the children to become passive and listen to what he was telling them about the representation given.

4.2.4.9 Intentions and reverting (practice issues)

Some student teachers' intentions when teaching fractions were aligned with the practice that they did on the mathematics education course. These teacher trainees attempted to put into practice the methods and techniques of teaching fractions, but due to a lack of preparation and testing in advance whether these would work, the method was not completely successful. This led the student teacher becoming uncomfortable and frustrated so that she reverted to the 'old way' of teaching, as she found it non-challenging and comfortable. This is seen in the extract below

> *The teacher prepared different coloured pieces of paper and put them on the table, but not in any order (pretending as 'cake pieces'). She asked one learner to come on the chalkboard and construct a shape with 2 pink pieces out of 6,and then another one to do 3 pink out of 6. The teacher instructed the learners to put their pieces in a shape of a whole. A third learner was called to do a similar task but constructing '4 over 5' and '3 over 5'. Both of them were to use the signs < or > to compare (2/6 & 3/6; 4/5 & 3/5). The learners struggled to put their shapes together to make a whole; it was not easy as pieces fell down on the floor. This forced the teacher to withdraw from using practical way of teaching to focus only on the four fractions involved: 2/6 & 3/6; 4/5 & 3/5. For the rest of the lesson the teaching proceeded using the 'old way' of teaching* (*Appendix A3, paragraphs 2 - 5)*

As it is clearly seen, the teacher's intention was to use the prepared teaching aids to arouse learners' interest on connecting reality with fractions. It was a good intention but the drawback was that the results did not work out as planned. Because of her previous school experience on how she had been taught fractions, she felt comfortable and at ease when practicing the traditional way of teaching fractions (See Appendix D, line 114).

4.3 CONCLUSION

This chapter presented the findings of the study. This was done by providing vignettes of some of the student teachers' observed lessons. The data generated via the observed lessons, the individual interviews and the focus group interviews were also analyzed. Using this information, I explored how the student teachers' practice, how the course and prior knowledge experiences influenced their knowledge and understanding of teaching and learning of fractions in their mathematics classrooms. The research data analysis created a pathway to emergent themes that were identified and presented. Through exploration of these themes I identified the various factors that influenced the student teachers' teaching

experiences of mathematics and fractions in particular. This included their prior knowledge and understanding of the topic of fractions during their early schooling years, as well as their beliefs of how they perceived mathematics should be taught and learned.

The following chapter provides the discussion of the research findings in terms of the emerged themes in relation to the reviewed literature.

CHAPTER 5

DISCUSSION OF RESEARCH FINDINGS

5.1 INTRODUCTION

In this chapter I present a discussion of my analysis and interpretation of the data with reference to the literature reviewed in chapter 2. Particular attention is given to the student teachers' experience of teaching fractions with regard to their orientations in terms of learning and knowledge of fractions gained during their BETD course.

5.2 DISCUSSION

Through this discussion I draw the threads of the ideas together. This research sought to understand the teaching experience of the level 5-7 student teachers as they taught fractions to Grade 6 classes during their teaching practice. Specifically, the research investigated a group of student teachers majoring in mathematics level 5-7 partaking in the preparation and teaching of fraction lessons to Grade 6 in different primary schools in Namibia. I wanted to find out what aspects of the mathematics education course these student teachers assimilated through their teacher training, in conjunction with their mathematics knowledge, specifically fraction knowledge during their early years of schooling. I also wanted to see how these experiences, affected their teaching and preparation of different lessons.

The discussion focuses mainly on the themes that emerged during the analysis of the data as identified in the chapter on data presentation.

5.2.1 Disposition and Mathematics Rules

The revelations from my data analysis lends support to the results shown in previous studies on pre-service teachers and the learning fractions where fractions are seen as a set of rules and the teachers show mainly procedural understanding without making connections (Jeongsuk, 2003; Baroody & Hume, 1991; Ma, 1999). Most participants thought that mathematics is merely about calculations and particularly that when learning about fractions; one should master the rules and procedures provided by the teacher. This indicates that for most of these teacher trainees, knowing fractions meant being able to produce the answer the teacher wanted with little attention as to why the algorithms worked. It is revealed through data analysis that the main reason student teachers emphasized rules and procedures

throughout their teaching was as a result of the kind of teaching they experienced during their school years (See section 4.2.4.1). Similar to what Baroody and Hume's (1991) research found, the student teachers thought that an important tool in learning mathematics was drill and practice using plenty of exercises. Some student teachers thought that in this way learners become fast thinkers; that this lays the learners' mathematics foundation when they follow the steps provided without questioning as to why those procedures work.

The BETD training that these student teachers went through emphasized the practice of mathematics teaching that focuses on promoting understanding and not fostering the memorization of facts, rules and procedures (Namibia. MoE, 2009).This is supported by Baroody (1987) and Baroody and Hume (1991) who maintain that student teachers should guide learners to see how procedures relate to concepts, why they work and when to apply them. The five strands of mathematical proficiency advocated by Kilpatrick also support the teaching of fractions by developing fluency with rules and procedures with a focus on their underlying meanings or justification (Kilpatrick, et al., 2001).

Previous research on teacher education with regard to student teachers' beliefs (Ernest, 1989) shows similar results in terms of the student teachers' beliefs of what mathematics is about. This contributes to a teacher's style and approach of teaching such as these. It means the student teachers in my study viewed their use of drill and practice as well as putting emphasis on repetition of rules and procedures they provided the learners as acceptable. But the student teachers need to unlearn some of these beliefs in order to adapt to the new practice of teaching mathematics, as Ball (1988) indicated. The student teacher need to think that mathematics is beyond the use of rules, procedures and drilling of calculations. This is supported by Kilpatrick, et al. (2001) through their strand of productive disposition that states that a mathematics teacher plays a critical role in encouraging learners to maintain a positive attitude toward mathematics, and this can only be achieved through making mathematics teaching enjoyable and interesting.

5.2.2 Symbolic Representation of Fractions

The analysis showed that the student teachers felt comfortable when practicing the traditional way of teaching mathematics. The reason for this was revealed through interviews where they showed that their perceptions of what they were oriented to and taught on the mathematics course was difficult for them to apply in their practice of teaching fractions (See Section 4.2.4.2). They felt comfortable when teaching through the use of fractional numbers as they

had used these throughout their schooling years. This is supported by the research done on student teachers' beliefs (Weinstein, 1989; Ambrose, 2004) that they enter their mathematics education courses with an assumption that they already know what they need to know in order to teach mathematics and this makes them underestimate the importance of the subject matter knowledge in teaching. In my study participants taught using only symbols without incorporating the reality of fractions as a result of their previous knowledge experience on fractions. These results lend support to Brown and Borko's (1992) research, who state that when learning to teach, student interpret experiences through their existing conceptual structures.

Data analysis revealed that the training and the teaching that most research participants were exposed to on the mathematics education course did not change many of their beliefs nor improve their knowledge of mathematics; specifically fractions. The student teachers still viewed fractions as use of symbols such as 1/2, 1/3, and so on, as they tended to interpret mathematics as a discipline distanced from reality. Teacher trainees were shown the practicality of teaching mathematics, and fractions in particular, but what they brought with them, their fraction knowledge from their schooling years, overpowered their new knowledge learned in the course.

It means as previous research indicates that student teachers could not understand the meaning of the concept of a fraction (Simon, 1993; Ball, 1990). The participants struggled because of their current level of conceptual understanding on fractions. This could be related to Niemi's (1996) research which reveals that one of the reasons for student teachers having difficulty with fractions might be due to their poor problem solving ability and skills.

From my teaching experience of mathematics, I find it essential that the student teachers incorporated reality in their teaching of fractions, in order to make sense of the fraction topics taught. This was taught on the mathematics education course. The participants should have gone beyond seeing a fraction as just a symbolic representation as they were exposed to different realities and interpretations of fractions through the use of manipulatives and fraction models. In the end, the analysis of the data gathered reveals that even though the student teachers underwent training and were oriented to the teaching of mathematics and its different themes, such as fractions, they were not willing to adapt to the changes in teaching practice offered on the course. The implication here is that it is still a challenge for the mathematics education course to help student teachers "transcend their own school

experiences with mathematics in order to create new practices of mathematics pedagogy" (Ball, 1993, p. 395).

5.2.3 Disconnected (Arbitrary)

ST2 was of the opinion that when teaching a lesson, a teacher should present learners with teaching aids. This is in agreement with previous research that student teachers begin their education with a wide range of different experiences, opinions, beliefs and conceptions of teaching and learning (Booth, Abdulla, Lingham, Singh, Wilson, & Armour, 1998).This is similar to Kagan's (1992) study on student teachers that they come with their personal beliefs of images of what good teachers are like, and of themselves as teachers. It is true that research emphasized the use of visuals and fraction models through the teaching of fractions (van de Walle, et al., 2010; Siebert & Gaskin, 2006). The BETD mathematics education course also puts an emphasis on the use of a learner-centred approach, where student teachers should incorporate the use of manipulatives and use of contexts to help learners to learn mathematics, particularly fractions with understanding (Namibia, MoE, 2009).

ST2 did not see the connections in teaching fractions; he failed to see mathematics, specifically fractions as real, but merely as symbolic (See Section 4.2.4.3). Again this revealed that the student teacher was aware of what the course assessment (assessor) was looking for. Moreover, in terms of the teaching aids, he knew that their use and function was to involve learners to enable them to touch, see and feel something. He did get the learners to touch, feel and see something, thinking that was sufficient for the 'teaching aid' to serve its purpose. The problem was that what was missing from this student teacher's teaching was any relevance of the 'teaching aids' he adopted. This finding therefore shows that the research indicating that it essential for teachers to use teaching aids is not valid if they do not use them to guide learners to see connections between concrete models when, introducing a concept and its symbolic representations (Baroody & Hume, 1991; Wearne & Hiebert, 1988). The problem here was that the student teacher did not connect the 'teaching aid' to direct the learners to the content presented in the lesson. As a result, ST2 did not focus on sense making, problem solving and skill building through his teaching as Kilpatrick, et al. (2001) suggested. Again this case shows the implication for the mathematics education course that student teachers such as ST2, need to acquire the forms of knowledge to enable them make connections within and among their knowledge of mathematics, learners and pedagogy (Kilpatrick, et al., 2001).

5.2.4 Fraction Terminology

Student teachers through their presentation of fraction lessons used phrases such as 'out of' and mostly 'over' (See Section 4.2.4.4).This means that most of these student teachers communicated with learners during their lessons using these phrases. It is suggested by Hiebert and his colleagues (2003) that for learners to develop meaningful concepts of fractions and fraction operations, the iterating (van de Walle, et al., 2010) and partitioning (Lamon, 1999; Mack, 2001) images are to be used in teaching. Siebert and Gaskin's (2006) research points out that these phrases 'out of' and 'over', involve different language and a different image from that of partitioning and iterating. It means when student teachers use this kind of language, learners see for example, in the case of '3 out of 8', 8 things presented then they take 3 from these. Similarly, with '3 over 8' the learners are made to see 8 as a divisor rather than a fraction relationship. In this way student teachers were encouraging the learners to see the numerator and denominator of a fraction as merely whole numbers written, one on top of the other (Siebert & Gaskin, 2006).

In my opinion unless student teachers use the correct mathematical terminology this will become problematic for them when teaching fractions in middle schools. Previous research shows that learners who use these phrases experience difficult with fraction comparison and they may never come to see fractions as being fundamentally different from whole numbers (van de Walle, et al., 2010; Siebert & Gaskin, 2006). The end result as studies by Behr, Khoury, Harel, Post and Lesh (1997) and Chinnappan (2000) reveal is that the student teachers themselves will not understand the operator construct of a rational number and they will have difficulty in explaining fractions and why algorithms work. The student teachers need to use and communicate mathematically using proper phrases and they need to have an understanding of the mathematical content, that is, they need to know fractions.

5.2.5 Fraction as a Pair of Whole Numbers

ST4 viewed a fraction as a pair of different whole numbers Mack's (2001) study shows that he did not see the 'process of dividing a whole unit into equal-sized parts' (p. 269). According to Lamon (1999) this implies that ST4 had not made the transition to seeing the composite symbol $\frac{1}{2}$ or $\frac{2}{4}$ as representing one thing. That was why the he thought that a pair of numbers could be converted into another pair using the four basic operations.

Previous research on fraction learning revealed that one of the factors contributing to poor understanding of fractions in middle schooling is that children tend to apply their whole-number concepts to solving fractions interpreting a fraction as two whole numbers (Newstead& Murray, 1998; van de Walle, et al., 2010). ST4 placed the learners in a confusing situation by using the whole number concept. One of the reasons was that from this student teacher's view anything to do with fractions does not involve reality. That is why he was unable to visualize equivalent fractions in terms of wholes being partitioned into equal divisions. This way he could not even relate partitioning to the multiplication nature of the problem, but rather its additive nature. This student teacher needs to have an understanding of the fraction content and knowledge of teaching fractions to be able to explain what equivalent fractions are (Shulman, 1986). This is the unique understanding that Shulman and his colleagues refer to. This student teacher lacked an understanding of the four basic operations (+, -, ×, ÷) that he added ½ + ½ = $\frac{2}{4}$, but he was performing operators acting on complete numbers, because ½ + ½ = 1. The student teachers need to think of fractions in terms of other than whole number combinations. And this can be expressed as Hiebert, et al. (2003) suggest using two powerful images for thinking about fractions, namely, partitioning and iterating.

Possibly what was missing here is that the student teacher lacked the knowledge of seeing fractions as real. Though taught, shown and oriented to this reform way of teaching using different teaching aids and situations incorporating fractions into real-life situations, the student teacher did not adopt and implement the idea that is aligned with this practice. Once again, this revealed that the student teacher's previous knowledge of fractions overpowered the idea of understanding and seeing a fraction as a relationship representation and not a particular amount (Baroody & Hume, 1991).

5.2.6 Fraction Understanding and Anxiety

It was revealed through data analysis that due to their lack of experience, student teachers experienced difficulties in teaching their learners to grasp the fraction content taught as they were not confident enough to deliver fraction lessons. This agrees with Ball's (1993) study which shows that student teachers possessed insufficient knowledge of teaching mathematics as well as how learners acquire the content of mathematics. Previous studies on fraction teaching, such as Schoenfeld and Kilpatrick (2008) assert that teachers need a firm grasp of all the multiple fraction representations to properly guide learners through problems of

fractions. This finding agrees with Ball (1988) that student teachers' knowledge of important mathematics that is needed for teaching is inadequate.

The analysis of data showed that student teachers experienced fear and anxiety throughout their teaching of fractions, as a result of poor understanding and knowledge of fractions. These findings lend support to previous studies on teachers and student teachers (Simon, 1993; Cramer, Post & del Mas, 2002), showing that when a student teacher lacks proper content knowledge and understanding such as that of fractions, s/he would not be confident and experience fear and tension in teaching fractions. Previous studies with student teachers (Borko, et al., 1992; Goudling, Rowlands & Barber, 2002) have shown that teacher trainees have an overall weak representational knowledge and rely heavily on algorithms and formal symbolism when representing concepts in mathematics such as fractions. The data analysis showed that some participants after being taught fractions on the BETD mathematics education course were not sufficiently well equipped and they were reduced to using prior knowledge from their school teaching and learning experiences of fractions (refer to chapter 4). This finding agrees with Ball (1993b) indicating in her research that it takes a variety of experiences when learning to teach mathematics such as the topic of fractions. This fear and tension forced the participants to relate their teaching to their early years of schooling. But as Mapolelo (1999) indicates, in order for student teachers to become confident and courageous teachers they are required to study more mathematics, have more pedagogical preparation and experience as both learners and teachers of mathematics.

The analysis of data in this study revealed that some student teachers' basic understanding of fractions was not so poor. As a result, they delivered some of their lessons with confidence and redirected the learners in their classes when they had misconceptions, such as applying the addition and subtraction of fractions incorrectly (see Appendix A2, paragraph 1). This supports Peterson and Williams' (2008) study concluding that teachers with better mathematical conceptual knowledge teach more conceptually and are more successful in adopting curriculum materials and engaging learner questions. It means that student teachers must portray confidence, not fear and tension in their teaching of fractions, this will reflect their productive disposition toward mathematics (in support of Kilpatrick's fifth strand of mathematical proficiency). These student teachers need to be helped to be in control of their own learning of mathematics as this assists them to develop the necessary productive disposition toward mathematics, learner mathematical thinking and teaching practice (Kilpatrick, et al., 2001).

5.2.7 Lesson Presentation (and Implications)

My analysis showed that student teachers employed different approaches in their presentations of fraction lessons (Appendix C5, line 45). The data analysis further revealed that student teachers made use of naive interpretation of learner-centred education through 'class discussion' and 'group work'. This interpretation that they put into practice has a negative effect on their teaching and learning of fractions. The teacher trainees labeled their learner-centred activities as class discussion when actually they used the question-and-answer method, where the teacher would pose a question and the learner(s) presented an answer without justifying as to why something was true or untrue (Appendix A1, paragraph 2). Similarly, it was revealed that teachers put learners in groups to work out the exercise provided on a flipchart pasted on the chalkboard, or handouts distributed to the groups by the teacher. The teacher interpreted a learner-centred approach this way, where learners were seated together completing the work or when questions were posed to them and they provided answers without any comments.

Previous research on this approach (Geary, 1994) indicates that learners need to be given an appropriate mathematical environment to motivate and enable them to construct mathematical knowledge that promotes optimal understanding. It means that the student teachers required a thorough understanding of how to appropriately apply and use the learner-centred approach. This agrees with Thekwane's (2001) explanation that teaching mathematics using a learner-centred approach will be better understood once teachers understand the pedagogical aims and assumptions of learner-centred education in the Namibian context. This means that these student teachers in their interpretation and application of learner-centred approach should accommodate learners in a way that facilitates their fraction work (group/individual); and also utilizes and draws upon their knowledge and experience in teaching and learning of fractions. This supports the Ministry when it states that a "learner-centred approach demands a high degree of learner participation, contribution and production" (Namibia. MoE, 2009, p.3).

The analysis of data revealed the use of the lecture method followed by a textbook or exercise style in the taught lessons. And the student teachers defended this method as a way of giving information to the learners (Appendices C1, line 50; C3, line 51).This finding disagrees with Ruppert (2010)who explained through his research how this approach contributes to learners' inability to understand what mathematical concepts really occur during real world situations.

The use of this particular approach could be a result of the student teachers' beliefs. This supports findings by Ambrose (2004) on primary student teachers' variety of beliefs influenced by their previous experiences as learners in schools. This also agrees with Ernest (1989) who showed that what contributes to a student teacher's style and approach are their attitude to mathematics and its teaching. Previous studies on student teachers (Borko & Putnam, 1992; Llinares, 2002) have shown that student teachers make sense of their learning experiences through using the lens of their previous knowledge so these beliefs and previous knowledge serve as references in the participants' fraction teaching.

The previous discussion and the analysis indicate that most student teachers employed the procedural methods and approaches to teaching fractions as experienced in their early schooling years. This revelation agrees with Hedegaard (2001) in terms of a mismatch between the methods of teaching employed by the student teachers in their practice in relation to what they were trained to use on the mathematics education course. Evidence was showed of the student teachers' misconception of the learner-centred approach in their teaching practice which was not completely aligned with the practice offered through their training on the mathematics education course.

5.2.8 Teaching for Passive Learning

The data analysis showed how some student teachers taught fraction lessons for passive learning. In one specific case ST5 wanted to bring in the word 'fraction' into his introduction in such a way that he 'forced' the children to become passive and to listen to what he was telling them about the representation given to them. This student teacher applied a traditional way of teaching in which learners were encouraged to follow what they were told to do or say as shown in previous studies on traditional teaching (Hedegaard, 2001; Baroody & Hume, 1991). This finding is contrary to studies such as those by Baroody and Hume (1991) who advise on how to help learners understand the underlying rationale for procedures in the instruction. Feiman-Nemser, McDiarmid, Melnick, & Parker (1989) have shown why some student teachers such as this one believe that teaching is easy and it merely involves transmitting of information. This finding showed that ST5 was somehow forcing his ideas on the learners, that is, putting words in the learners' mouths for them to produce the answers that he desired.

Data analysis also showed that a representation was selected; though it was not put to correct use to assist the children to see what was helpful for them to learn fractions (See Section

4.2.4.8). This indicates that the student teacher was unable to help learners to use the particular representation for them to see how information connects with their existing knowledge. Previous research such as Baroody and Hume (1991) assert that children need to see "how various concrete, pictorial, and symbolic representations can illustrate the same concept or procedure; and how different concepts are related to each other" (p. 55). This implies that the implication for teacher preparation according to Kilpatrick, et al. (2001) is that student teachers need to acquire the forms of knowledge that will enable them to make connections within and among their teaching and learning of fractions.

5.2.9 Intentions and Reverting

It was revealed through the analysis of data how some participants attempted to put into practice the reform way of teaching mathematics taught on their mathematics education course. Unfortunately, as shown in the case of ST3 (Appendix A3), due to a lack of preparation and feeling of discomfort with this particular practice, the student teacher reverted to the traditional way of teaching. Previous studies indicate that the traditional way of teaching includes the use of symbolic representations and heavily relies on memorization of facts, rules and procedures, while through reform practice, the teaching of mathematics focuses on promoting understanding (Baroody & Hume, 1991).

The data analysis showed that the student teachers felt comfortable with practicing the traditional way of teaching mathematics, as they were taught through this particular teaching practice during their early schooling years (Appendix D, line 114). This disagrees with previous research advice on how to design programs that influence the quality and nature of teacher practice (Borko, et al., 1992; Ebby, 2000); and focus on how to help student teachers to acquire the tools of becoming effective teachers (Hiebert, Morris, & Glass, 2003). It was noted through observation that ST3 felt at ease, unchallenged and comfortable with the method of teaching that she was taught through during her schooling years. Similar results found in previous studies with student teachers and teaching practice (Gallimore, 1996) indicates that teaching is a cultural practice, and is difficult for someone to change. This agrees with Hiebert, et al. (2003) and Ball (1993b) who stress that after growing up in a certain culture, such as the case of ST3, when faced with real challenges of the classroom they often abandon new practices and revert to the teaching methods their teachers used.

5.3 CONCLUSION

This chapter discussed the analysis of the data from observed lessons and interviews incorporated with the literature review from chapter 2. The discussion of the findings of the study was based on the student teachers' experiences and perceptions from the interviews and observed lessons on the topic of fractions. This discussion was presented in terms of the emerged themes identified from chapter 4. Revealed through this discussion are different factors that influence the student teachers' learning and teaching of fractions, both from schools and the mathematics education course.

The following chapter concludes the research project.

CHAPTER 6

CONCLUSION

6.1 INTRODUCTION

The focus of this study was to investigate BETD year 3 level 5-7 student teachers' practice of fraction teaching in conjunction with their experiences both on the mathematics education course, and their previous knowledge of fractions on the way they taught fractions.

The information emerging from this research study provided insight into the difficult task of teaching upper primary pre-service teachers about the topic of fractions on the mathematics education course.

This chapter synthesizes and concludes the study by interweaving the themes and significant insights that emerged through the data analysis of this research project. The structure of this chapter is comprised of:

- A summary of the findings through briefly describing the emergent themes in terms of research questions,
- Significance as well as limitations and challenges of the study,
- Reflections and recommendations, and lastly,
- Exploring the avenues for further research

6.2 SUMMARY OF FINDINGS

This study explored the student teachers' experiences and perceptions of fraction learning and teaching during their teaching practice. Particularly, the focus was on gaining deeper understanding of the fundamental actions that underline the student teachers' approach to fraction learning and teaching during their teaching practice at schools. The following is the summary of the findings of this study with regard to the research questions as indicated at the beginning in the goals. The main findings of this study are organized according to the three research questions as follows.

6.2.1 Student Teachers' teaching

The first research question looked at participants' practice of fraction teaching, the way they taught, how they prepared and presented their lessons, what methods and teaching strategies they employed in their teaching, and so on.

(a) Doing calculations

The data analysis strongly revealed that student teachers saw mathematics as just about doing calculations. Through their interviews they testified that the learners' practice of doing lots of calculations on fractions would enhance their learners' skills on calculating fraction problems, as they believed that 'practice makes perfect'. They explained that through the skill of drill and practice, the student teachers tested whether their learners could put into practice what they had taught them about fractions or not. Student teachers indicated that different learners learn at different paces and that was the main reason they designed different activities for their learners to carry out different calculations on fractions. Apparently, they believed that 'the more you give, the better the learning becomes', and that was how they learned both in school and from the mathematics education course.

(b) Rules and procedures

The student teachers additionally emphasized in their teaching of fractions the importance of mathematical rules and procedures. Their view of learning mathematics and fractions in particular, is when one masters the rules and procedures provided by the teacher. Most of them saw and believed that knowing mathematics means being able to produce a correct answer that is wanted by the teacher, but with little or no knowledge as to why the algorithm used works; as long as the rule was followed step-by-step. What is suggested here is that to learn mathematics for the student teachers means follow the rules stipulated by the teacher, and do lots of drill and practice, as this was how they experienced the learning of fractions in their early schooling years.

(c) Passive teaching

Evidence through the analysis of data pointed to the use of passive teaching in fraction lessons. This was seen when one student teacher presented a fraction representation in one of the lessons, asked questions, rejected all their responses, but could not help the children to understand and see what was useful for the particular lesson taught. Instead,

as a result of his previous experiences the student teacher just focused on the specific word that he wanted to bring in the taught lesson. As a result, the learners were forced to become passive and listened to what the teacher was telling them about the representation he provided them.

(d) Use of different teaching approaches

Evidently, the data analysis showed that as a result of their experiences on the BETD course, the student teachers used different teaching approaches in their fraction lessons. The positive effect of this was observed when they tried to find out what learners' prior knowledge was and this is in line with the learner-centred approach to starting a mathematics lesson. Data analysis also revealed that in some lessons class discussion encouraged learners' active participation. The data however indicated that the student teachers made use of naive interpretation of the learner-centred education through 'class discussion' and 'group work'. The misinterpretation occurred when they applied an approach to teaching that was seen as not aligned with the learner-centred approach to teaching advocated in their training and teaching of mathematics, whereby a learner is viewed as an active participant in the teaching and learning; as an active thinker he tries to construct meaning and made sense of his personal experience. A learner is also viewed as contributing to what, how and why he learns what is presented to him in the class, but this was not observed through the student teachers' teaching of fractions.

6.2.2 BETD Mathematics Education Course Experiences

The second research question explored the participants' experience in terms of the BETD mathematics education course's influence on their teaching practice. It investigated how the participants related their skills and knowledge they learned on the mathematics education course to their fraction teaching.

(a) To satisfy the course criteria

Some student teachers distributed 'teaching aids' to their learners without incorporating the connection of such teaching aids in the teaching. This evidence showed that the student teacher's thinking in this particular case was that by including this 'teaching aid', it would satisfy the criterion of 'using teaching aids 'in one's teaching of fractions. The reason was that their training on the mathematics education course entails that one

should incorporate teaching aids in the lessons. But the intention of the student teacher here was merely to satisfy the course assessment criteria.

(b) Relevance

Again, the finding that emerged from data was that the student teacher (from part (a) above) could not see mathematics as real, but symbolic as he could not see the connection of his 'teaching aid' to the particular content taught. Even though the learners could see, touch and feel the 'teaching aid', they were not guided as to how to connect what they saw, touched and felt to the lesson on fractions. As a result of this, the particular 'teaching aid' was disconnected from reality. This means though trained and exposed to different use of teaching aids in the mathematics lessons, some student teachers were unable to see the importance of connections in mathematics lessons.

(c) Redirecting learners' misconceptions

Evidence from the data revealed that not all of the student teachers lacked fraction understanding in their teaching. This was revealed when they managed to correct their learners' misconceptions in different cases, for instance, during the addition and subtraction in a fraction lesson, a student teacher redirected the learners and showed them the proper way. This aspect showed that as a result of the BETD mathematics education course, some student teachers were able to teach and show learners what to do about fractions. So they applied and put to use their correct fraction understanding (fraction content) in their teaching.

(d) Lack of understanding leading to fear and anxiety

The participants through interviews greatly appreciated the fact that they furthered their own conceptualization and understanding of fractions through undertaking mathematics education course training in BETD. They however disclosed that they still felt that their mathematical content knowledge as well as pedagogical content knowledge needed to be strengthened. They felt that they lacked some pedagogical skills needed to design appropriate teaching aids for fraction lessons. It means that the student teachers felt that their mathematical content knowledge on fractions was not up to par for them to effectively deliver the fraction lessons with confidence. This lack of proper fraction understanding led them to experience fear and anxiety during their teaching. Student teachers highlighted that they experienced anxiety because they did not know what to do

if, for instance, they were asked different questions by their learners. They were also constantly concerned with whether their learners would grasp what they were teaching them or not.

6.2.3 Student Teachers Previous Experiences of Fractions

The third research question looked at the participants' previous experience related to fractions and fraction teaching. It explored how the participants' previous experience of fractions and the teaching of fractions from schools have impacted on their fraction understanding and fraction teaching.

(a) Symbolic representation

The student teachers indicated that they based their fraction teaching mostly on what they were taught in their early years of schooling (primary and high school). This was done by using few or no manipulatives at all, but they were taught fractions as symbolic representations. Another finding that emerged from data was that the student teachers felt comfortable and at ease using the 'old way' of teaching where no reality was incorporated in their fraction teaching. A significant finding from the data here is that the student teachers viewed mathematics as the use of symbols such as ½, $^1/_3$and so on, and they interpreted mathematics, particularly fractions as having nothing to do with reality. It is suggested here that the training and the teaching that most student teachers went through did not change their beliefs and improve their knowledge of mathematics, specifically fractions.

(b) Use of different terminologies

A common finding during the data analysis process was that most teacher trainees through their use of different fraction terminologies, always used incorrect terminologies such as '1 over 2', '3 over 4', instead of using the correct fraction name such 'half' or 'three-quarters', as guided in BETD. This evidence reflected the student teachers' background of learning fractions as well as their belief and knowledge of what a fraction is. The end result of this was that the student teachers did not completely adopt the knowledge they gained through the fraction teaching offered in their training.

(c) Fraction as a pair of two different whole numbers

Another significant finding that emerged during the process of data analysis was that one participant viewed a fraction as a pair of two different whole numbers. This was seen when this student teacher encouraged the learners to break a fraction such as ½, into parts and treat them as whole numbers rather than part of a fraction. It means that the revelation here is that a student teacher had not made a transition of seeing the composite symbol ½ or 2/4 as representing a unit (one thing). Again, this evidence showed that anything to do with fractions to these student teachers, did not involve reality, but symbols. This suggest that even though the student teacher underwent training, where fraction teaching was done, a misconception from his previous knowledge of fractions led to the notion of seeing a fraction as two different entities that could be dealt with separately, was not altered.

(d) Alignment and reverting

One of the significant findings was shown when some student teachers' intentions when teaching fractions were aligned with the practice on the course. They showed this alignment when they attempted to put into practice the methods and techniques of teaching fractions, using prepared teaching aids, but due to lack of preparation and testing in advance whether these would work, the method was not completely successful. This led the student teacher becoming uncomfortable and frustrated to the extent that she reverted to the 'old way' of teaching, as she found it non-challenging and comfortable. The student teachers felt that when practicing the methods taught on the mathematics education course got too tough to handle, then they resorted to the use of 'traditional ways' of teaching, the way they were previously taught in schools. This happened, but it was seen that the reason for failure was not the new practice, but it mostly a practical matter of preparation on the side of the student teachers (i.e. how they were taught in teacher education).

6.3 SIGNIFICANCE OF THE STUDY

The significance of this study is that it will help to identify the factors which influence the way the student teachers teach mathematics for understanding in upper primary schools in Namibia. It will also help the BETD teacher educators in the teacher training institutions on what steps to take in curtailing the negative factors identified through this research. Teacher educators would then identify their limitations and deficiencies in preparing their student

teachers regarding the teaching and learning of fractions, and make the necessary adjustments. Through this study, the student teachers will be alerted to what positive and negative effects their perceptions and attitudes toward fraction learning and teaching at their level will have on their present and future career as teachers.

The other important aspect of this research study was to try and understand some of the problems the student teachers encountered during their preparation and teaching of fraction lessons to Grade 6 classes and how they handled and overcame the problems. Student teachers' attempts to put into practice their existing mathematical knowledge and skills were also analyzed through this study to enable me as a teacher educator to use this as a guide in my own training of mathematics teachers. Furthermore, the student teachers' understanding, knowledge and background to fraction learning and teaching were considered. Finally, it will help me personally to gain insight to inform my practice and improve the rational number teaching at my institution. This is supported by Tirosh (2000) and Borko, et al. (1992) when they state that it is the responsibility of the teacher educators to pay more attention to and understand the beliefs of pre-service teachers in preparing them for their future role in teaching mathematics topics such as fractions.

6.4 LIMITATIONS AND CHALLENGES OF THE STUDY

This is a small scope research project, a half thesis MEd study, so it has some limitations that are highlighted in the following discussion.

The university campus where this research took place is my place of work, and the student teachers who participated in the study were from one of the classes that I taught the previous years.

Firstly, being a former teacher educator of the respondents, I anticipated that this would tempt student teachers to tell me only those things that they thought I would like to hear. Bearing this thought in mind, I clearly informed them beforehand that our relationship as professionals should not serve as a blockage to free, fair, honest and open interviews. I am very confident that it was the case as I have been objective throughout the study.

Secondly, one possible weakness of case study stated by Cohen, et al. (2007) is that "the results may not be generalizable except where other readers/researchers see their application" (p. 256). Hitchcock and Hughes (1995) also argued that it is possible to generalize from case studies provided that the research is designed with this in mind. They further quoted

Schofield (1990) saying that generalizability depends upon "the fit between the situation studied and others to which one might be interested in applying the concepts and conclusions of that studied" (p. 226). It is therefore important to realize that the nature of each given situation is unique and is not an easy thing to generalize from my research project to other situations. The reason that I only used five participants in this study means the findings of this investigation are not generalizable but this does not mean that the results of case studies are not necessarily applicable to larger and wider contexts.

6.5 REFLECTIONS

This study involved an exploratory kind of research. In this section, I am going to reflect on my experience through this process, looking at how I have developed professionally through carrying out this project.

My role as a researcher and my research relationship with the students was strengthened through the entire process. When I sat and observe these students in their classrooms, I expected to see them doing their best when presenting lessons because they are graded for their SBS performance. As I stated earlier, during the interviews, student teachers were informed beforehand that our relationship as professionals should not serve as a blockage to free, fair, honest and open interviews.

Personally, this study was an eye-opener for me to the world of research as I have gained experience on how to collect data using different research tools, analyze and discuss data. Through carrying out this research study I was scaffolded by the experiences of other researchers, different readings on the researched issue and the variety of conversations with supervisors and friends.

From my findings, I learned that through teacher training as a teacher educator, I need to accommodate the student teachers' beliefs with regard to teaching and learning mathematics. I also learned that to succeed in influencing the student teachers' views of teaching and learning mathematics, first I should consider them as both learners and 'teachers' with different experiences and knowledge, most of which need to be undone if they are to become successful and effective teachers of mathematics. In this I agree with Ma (1999) when she indicates that "teacher preparation programs are the point in a pre-service teacher education where mathematical competence starts to be connected to a primary concern about teaching and learning school mathematics" (p. 145). Pre-service teachers' beliefs are an essential

element in their development as teachers, and through these expectations they will gain teaching skills in their teacher education programs (Ball, 1988; Lampert & Clark, 1990).

I gained so much knowledge through data analysis about the way we teach and present our mathematics lessons on the mathematics education course. Additionally, I learned that mathematics learned from early schooling years serves as a stepping stone and tends to have a huge effect on the student teachers' understanding and teaching of fractions as well as the approaches they take to teach them.

6.6 RECOMMENDATIONS

In this section I propose possible ideas on how to enhance the student teachers' knowledge and understanding of fractions, as well as how to effectively learn how to teach mathematics and fractions in particular.

- In order for the student teachers to teach fractions for understanding, they should emphasize the connections between real-life problems and the fraction notation used to represent the problem. It means fraction problems should be presented in meaningful, real-world contexts as this encourages learners to use their learner-invented problem solving strategies, instead of memorized rules and procedures.
- Student teachers need to have a thorough and deep knowledge of fraction concepts and operations to enable them to teach fractions effectively, and use different appropriate representations for each situation.
- Student teachers should be properly guided in their training as to what approaches to employ in the teaching of fractions, both the how and why.
- Student teachers need to work with units of fractions, such as counting in fractions, e.g. using ¼, ½ and so on, in order for them to conceptualize the meaning of a fraction
- As a teacher educator for mathematics education course, one can take the student teachers' existing knowledge of fractions, challenge and solidify this knowledge to enable them to move beyond the part whole representation of fractions.

I agree with Fazio and Siegler (2010) that it is clear when student teachers have a superficial knowledge of fractions. They view symbols as meaningless and the use of procedures in fraction arithmetic seem arbitrary and easily confused with each other. But I also believe that "by cultivating conceptual understanding", student teachers can understand that "fractions are real numbers and that fraction arithmetic is a meaningful procedure rather than a series of arbitrary steps" (Fazio & Siegler, 2010, p. 23).

6.7 AVENUES FOR FURTHER RESEARCH

Bassey (1993) states that the value of a case study lies in the ability to provide insights that may be trialed in subsequent studies. Some of the issues that emerged from this research may well be topics for further research:

Through this study the methods used provide valuable data to the mathematics educators about the fractional knowledge the student teachers bring with them into the mathematics education course, as well as their beliefs about what representations for instruction are meaningful for the learners.

This research was conducted using only five student teacher participants; I suggest that a similar study could be carried out with a larger population of student teachers. This may provide a bigger picture which could lead to the generalization of the case study's results.

This study did not focus on the learners' input during the investigation. I think it would be an interesting task if one could carry out research that investigates a similar study, but combines the student teachers' input and the learners' input on the experiences of teaching and learning fractions.

References

Ambrose, R. (2004). Initiating change in prospective elementary school teachers' orientations to mathematics teaching by building on beliefs. *Journal of Mathematics Teacher Education,7*, 91-119.

Anders, D. (1995). A teacher's knowledge as classroom script for mathematics instruction. *Elementary School Journal, 95*, 311-324.

Ary, D., Jacobs, L. C., Razavieh, A., & Sorensen, C. (2006). .*Introduction to research in education*(7th ed.). Canada: Thomson Wadsworth.

Artzt, A. F. (1999). A structure to enable preservice teachers of mathematics to reflect on their teaching. *Journal of Mathematics Teacher Education, 2*, 143–166.

Artzt, A., & Armour-Thomas, E. (1999). A cognitive model for examining teachers' instructional practice in mathematics: A guide for facilitating teacher reflection. *Educational Studies in Mathematics, 40*, 211-235.

Ball, D. L. (2003). *What mathematical knowledge is needed for teaching mathematics.* Retrieved 12 October, 2011, from http://www.erusd.k12.ca.us/ProjectAlphaWeb/index_files/MP/BallMathSummitFeb03.pdf

Ball, D. L. (1988). Unlearning to teach mathematics. *For the Learning of Mathematics, 8*(1), 40-48.

Ball, D. L. (1993a). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *The Elementary School Journal*, *93*(4), 373-397.

Ball, D. L. (1993b). Halves, pieces and twoths: Constructing representational contexts in teaching fractions. In T. Carpenter, E. Fennema& T. Romberg (Eds.), R*ational numbers: An integration of research* (pp. 157-196). Allisdale, NJ: Lawrence Erlbaum.

Ball, D. L. (1991). Research on teaching mathematics: Making subject matter knowledge part of the equation. In J. Brophy (Ed.), *Advances in research on teaching: Teacher's knowledge of subject matter as it relates to their teaching practice (Vol.* 2). Greenwich, CT: JAI Press.

Ball, D. L. (1990). Prospective elementary and secondary teachers understanding of division. *Journal for Research in Mathematics Education, 21*, 241-247.

Ball, D. L., & Bass, H. (2003).Toward a practice-based theory of mathematical knowledge for teaching. In B. Davis & E.Simmt (Eds.), *Proceedings of the 2002 annual meeting of the Canadian Mathematics Education Study Group* (pp. 3-14). Alberta, Canada: Canadian Mathematics Education Study Group.

Ball, D. L., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on the mathematics of teaching and learning* (pp. 83-104). Westport, Conn.: Ablex Publishing.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: what makes it special? *Journal of Teacher Education, 59*, 389-407.

Babbie, E., & Mouton, J. (2001). *The practice of social research*. Cape Town: Oxford University Press Southern Africa.

Baroody, A. J. (1987). *Children's mathematical thinking: A developmental framework for preschool, primary, and special education teachers.* New York: Teacher's College Press.

Baroody, A. J., & Hume, J. (1991). Meaningful mathematics instruction: The case of fractions. *Remedial and Special Education, 12*(3) May/June, 54-68.

Bassey, M. (1993). *Case study in educational settings.* Philadelphia, USA: Open University Press.

Bassey, M. (1995). *Creating education through research: A global perspective of educational research for the 21st century*. Kirklington: Moor Press

Becker, J. P., & Lin, C.Y. (2005). *Effects of a computational skills workshop on preservice elementary teachers.* Preliminary report paper presented at the Annual Meeting of the Mathematical Association of America and the American Mathematical Society, Atlanta, Georgia.

Behr, M. J., Khoury, H. A., Harel, G., Post, T., & Lesh, R. (1997). Conceptual analysis of preservice elementary teachers' strategies on rational-number-as operator task. *Journal for Research in Mathematics Education*, *28*(1), 48-69.

Best, J.W., & Kahn, J.V. (2006). *Research in education* (10th ed.). Boston, MA: Pearson Education Inc.

Bezuk, N. S. (1988). Fractions in early childhood mathematics curriculum. *Arithmetic Teacher, 35*, 56-59.

Booth, E., Abdulla, S., Lingham, G., Singh, G., Wilson, M.,& Armour, L.(1998). *Student teachers' perceptions of teaching and learning conditions in Fiji and Maldives*. Paper presented to Australian Association of Educational Research Annual Conference, Adelaide.

Borko, H., Eisenhart, M., Brown, C. A., Underhill, R. G., Jones, D., & Agard, P.C. (1992). Learning to teach hard mathematics: Do novice teachers and their instructors give up too easily? *Journal for Research in Mathematics Education, 23*(3), 194-222.

Borko, H., & Putnam, R. (1996). Learning to teach. In R. C. Calfee & D. C. Berliner (Eds.), *Handbook of educational psychology* (pp. 673-703). New York: Macmillan.

Brown, C. A., & Borko, H. (1992). Becoming a mathematics teacher. In D. A. Grouws Ed.), *Handbook of research on mathematics teaching and learning* (pp. 209-239). New York: Macmillan.

Chinnappan, M. (2000). Preservice teachers' understanding and representation of fractions in a JavaBars environment. *Mathematics Education Research Journal, 12*(3), 234-253.

Clark, C., & Dunn, S. (1991). Second-generation research on teachers' planning, intentions, and routines. In H. C. Waxman & H. J. Walberg (Eds.), Effective teaching: Current research (pp. 183-201). Berkeley, CA: McCutchan.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). London: Routledge.

Conference Board of Mathematical Sciences. (2001).The mathematical education of teachers. Washington, DC: Mathematical Association of America. Retrieved30 May, 2012, from http://www.clomsweb.org/MET_Document/index.htm

Cooney, T. (1994).Teacher education as an exercise in adaptation. In A.F. Coxford & B. Aichele (Eds.)*, Professional development for teachers of mathematics. 1994 Yearbook of the National Council of Teachers of Mathematics* (pp. 9-22). Reston, VA: National Council of Teachers of Mathematics.

Cramer, K., Post, T. R., & del Mas, R. C. (2002). Initial fraction learning by fourth-and fifth-grade students: A comparison of the effects of using the Rational Number Project Curriculum. *Journal for Research in Mathematics Education*, *33*(2), 111-144.

Creswell, J. W., Ebersöhn, L., Eloff, I., Ferreira, R., Ivankova, N. V., Jansen, J. D., et al. (Eds.). (2010). *First step in research.* Pretoria: Van Schaik Publishers.

Darling-Hammond, L., & Sykes, G. (Eds.). (1999). *Teaching as the learning profession: Handbook of policy and practice*. San Francisco: Jossey-Bass.

Denzin, N. K. (1985). *Interpretive interactionism*. Newbury Park, CA: Sage.

Dewey, J. (1965). The relation of theory to practice in education. In M. L. Borrowman (Ed.), *Teacher education in America: A documentary history* (pp. 140-171). New York: Teachers College Press. (Originally published in 1904).

Ebby, C. B. (2000). Learning to teach mathematics differently: The interaction between coursework and fieldwork for preservice teachers. *Journal of Mathematics Teacher Education*, *3*, 69–97.

Ernest, P. (1989). The knowledge, beliefs and attitudes of the mathematics teacher: A model. *Journal of Education for Teaching*, *15*(1), 13-33.

Fazio, L., & Siegler, R. (2010). *Teaching fractions.* Geneva, Switzerland: International Academy of Education.

Feiman-Nemser, S., McDiarmid, G.W., Melnick, S. L., & Parker, M. (1989).*Changing beginning teachers' conceptions: A description of an introductory teacher education course.* East Lansing, MI: National Centre for Research in Teacher Education, Michigan State University.

Fennema, E., & Franke, M. L. (1992).Teachers' knowledge and its impact. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 147-164).New York: Macmillan.

Fuller, R. (1997). Elementary teachers' pedagogical content knowledge of mathematics. *Mid-Western Educational Researcher, 10(2), 9-16.*

Gallimore, R. G. (1996). Classrooms are just another cultural activity. In D. L. Speece& B. K. Keough (Eds.), *Research on classroom ecologies: Implications for inclusion of children with learning disabilities* (pp. 229-250). Mahwah, NJ: Erlbaum.

Gay, L. R., Mills, G. E., & Airasian, P. (2012). *Educational research: Competencies for analysis and application* (10th Ed.). New York: Pearson Education, Inc.

Geary, D. C. (1994). *Children's mathematical development: Research and practical applications.* Washington DC: American Psychological Association.

Gould, P. (2005). *Year 6 students' methods of comparing the size of fractions*. Mathematics Education Research Group Australasia MERGA, proceedings of the Annual Conference held at RMIT, Melbourne 7th-9th July 2005, Sydney, Australia.

Goudling, M., Rowland, T., & Barber, P. (2002). Does it matter? Primary teacher trainees' subject knowledge in mathematics. *British Educational Research Journal,* 28(5), 685-704.

Grossman, P. (1995). Teachers' knowledge. In L. W. Anderson (Ed.), *International encyclopedia of teaching and teacher education* (2nd ed., pp. 20-24). New York: Pergamon.

Gutiérrez, A., & Boero, P. (Eds.). (2006). *Handbook of research on the psychology of mathematics education: Past, present & future.* Netherlands: Sense publishers

Hecht, S. A. (1998). Toward an information-processing account of individual differences in fraction skills. *Journal of Educational Psychology, 90(3), 545-559.*

Hedegaard, M. (2001). *A new approach to learning in classrooms*. Downloaded August 15, 2012, from www.hum.aau.dk/dk/ckulturf/pages/publications/mh/new_approach.htm

Hiebert, J., & Wearne, D. (1986). Procedures over concepts: The acquisition of decimal number knowledge. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: The case of mathematics* (pp. 199-223). Hillsdale, NJ: Erlbaum.

Hiebert, J., Gallimore, R., & Stigler, J.W. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one? *Educational Researcher*, *31*(5), 3–15.

Hiebert, J., Morris, A. K., & Glass, B. (2003). Learning to learn to teach: An "experiment" model for teaching and teacher preparation in mathematics. *Journal of Mathematics Teacher Education, 6*, 201-222.

Hitchcock, G., & Hughes, D. (1995). *Research and the teacher: A qualitative introduction to school-based research* (2nd ed.). London: RoutledgeFalmer.

Jaworski, B. (1994). *Investigating mathematics teaching*. London: Falmer Press.

Joram, E., & Gabrielle, A. (1998). Preservice teacher's prior beliefs: transforming obstacles into opportunities. *Teaching and Teacher Education, 14*(2), 175-191.

Jegede, O., Taplin, M., & Chan, S. (2000).Trainee teachers' perception of their knowledge about expert teaching. *Educational Research*, *42*(3), 287-308.

JeongSuk, P. (2003). Numbers always make sense: Janie's experience of learning to teach elementary mathematics. J*ournal of the Korean Society of Mathematics Education Series D: Research in Mathematics Education, 7*(1), 25-40.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65-90.

Kahan, J. A., Cooper, D.A., & Bethea, K. A. (2003). The role of mathematics teachers' content knowledge in their teaching: A framework for research applied to a study of student teachers. *Journal of Mathematics Teacher Education, 6*, 223-252.

Kamii, C., & Clark, F. B. (1995). Equivalent fractions: Their difficulty and education implications. *Journal of Mathematical Behaviour, 14,* 365-378.

Kieren, T. E. (1992). Rational and fractional numbers as mathematical and personal knowledge: Implications for curriculum and instruction. In G. Leinhardt, R. Putnam & R. Hattrup (Eds.), *Analysis of arithmetic for mathematics teaching* (pp. 323-372). Hillsdale, NJ: Lawrence Erlbaum.

Kilpatrick, J., Swafford, J., Findell, B. (2001). *Add it up: Helping children to learn mathematics*. Washington DC: National Academy Press.

Koehler, M. S., & Grouws, D. A. (1992).Mathematics teaching practices and their effects. In D. A. Grouws(Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 115-125). New York: Macmillan.

Kumar, R. (2011). *Research methodology: A step-by-step guide for beginners*. London: SAGE Publications.

Lamon, S. J. (2007). Rational numbers and proportional reasoning. In F. K. Lester, Jr, (Ed.), *Second handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 629 – 667). Charlotte, NC: Information Age Publishing.

Lamon, S. J. (1999). *Teaching fractions and ratios for understanding*. New Jersey: Lawrence Erlbaum Associates

Lampert, M., & Clark, C. (1990). Expert knowledge and expert thinking in learning: A response to Floden and Klinzing. *Educational Researcher*, *19(*5), 21-23.

Llinares, S. (2002). Participation and reification in learning to teach: The role of knowledge and beliefs. In G.C. Leder, E. Pehkonen& G. Töner (Eds.), *Beliefs: A hidden variable in mathematics education?*(pp. 195-209).Dordrecht: Kluwer Academic Publishers

Lin, P. J., & Tsai, W. H. (2006). Fourth graders' achievement in mathematics performing in the 1991 IAEP assessment instrument. *Journal of National Hsinchu University of Education, 22*, 273-307.

Litwiller, B., & Bright, G. (2002). *Making sense of fractions, ratios and proportion (Yearbook of the National Council of Teachers of Mathematics)*. Reston, VA: NCTM.

Liu, H.C. (2000). The importance of discussion: From the perspective of the new elementary mathematics curriculum standards. *Elementary Education Bulletin, 50*, 4-8.

Lowery, N. V. (2002). Construction of teacher knowledge in context: Preparing elementary teachers to teach Mathematics and Science. *School Science and Mathematics, 102*(2), 68-83.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum Associates.

Mack, N.K. (2001). Building on informal on informal knowledge through instruction a complex content domain: Partitioning, units and understanding multiplication of fractions. *Journal for Research in Mathematics Education*, *32(3)*, 267-295.

Mack, N.K. (1995). Confounding whole number and fraction concepts when building on informal knowledge. *Journal for Research in Mathematics Education, 26*(5), 422-441

Mack, N. K. (1990). Learning fractions with understanding: building on informal knowledge. *Journal for Research in Mathematics Education, 21*, 16-33.

Mapolelo, D.C. (1999). Do pre-service primary teachers who excel in mathematics become mathematics teachers? *Teaching and Teacher Education, 15*(6), 715-725.

Marshall, S. P. (1993). Assessment of rational number understanding: A schema-based approach. In T. P. Carpenter, E. Fennema & T. Romberg (Eds.), Rational numbers: An integration of research (pp. 49 – 84). Hillsdale, NJ: Lawrence Erlbaum.

Mathematical Sciences Education Board. (2001). *Knowing and learning mathematics for teaching, proceedings of a workshop*. Washington, DC: National Academy Press.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation.* San Francisco, CA: John Wiley & Sons, Inc.

Mewborn, D.S. (1999). Reflective thinking among preservice elementary mathematics teachers. *Journal for Research in Mathematics Education, 30*(3), 316-341.

Miles, M.B. & Huberman, A.M. (1994). *Qualitative data analysis* (2nd Ed.). Thousand Oaks, CA: Sage.

Murray, H., Olivier, A., & Human, P. (1996). Young students' informal knowledge of fractions. In L. Puig & A. Gutiérrez (Eds.), *Proceedings of the Twentieth Conference of the International Group for the Psychology of Mathematics Education*, *4*, 43-50. Valencia, Spain.

Namibia. Ministry of Basic Education, Sport and Culture. (2004). National report on the development of education in Namibia. *International Conference on Education, Geneva*

Namibia. Ministry of Education. (2009). *The Basic Education Teacher Diploma (BETD) Preservice: Broad curriculum.* Okahandja: NIED.

Namibia. Ministry of Education. (2006a). *Mathematics syllabus for BETD level 5-7.* Okahandja: NIED.

Namibia. Ministry of Education. (2006b). *National professional standards for teachers in Namibia.* Windhoek.

National Council of Teachers of Mathematics. (2000).*Principles and standards for school mathematics*. Reston, VA: NCTM.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: NCTM.

National Council of Teachers of Mathematics. (1989*). Curriculum and evaluation standards for school mathematics.*. Reston, VA: NCTM.

National Research Council. (2001). *Adding it up: helping children learn mathematics*. Washington, DC: National Academy Press.

Newstead, K., & Murray, H. (1998).Young students' constructions of fractions. In A. Olivier & K. Newstead (Eds.), *Proceedings of the Twenty-second International Conference for the Psychology of Mathematics Education,3* (pp. 295-302). Stellenbosch, South Africa.

Ni, Y., & Zhou, Y. D. (2005). Teaching and learning fraction and rational numbers: the origins and implications of whole numbers bias. *Educational Psychologist, 40*(1), 27-52.

Niemi, D. (1996). Assessing conceptual understanding in mathematics: Representation, problem solutions, justifications and explanations. *Journal of Educational Research, 89*, 351-365.

Ormrod, J. E., & Cole, D. B. (1996).Teaching content knowledge and pedagogical content knowledge: A model from geography education. *Journal of Teacher Education, 47*(1), 37.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 61*, 307-332.

Peterson, B. E., & Williams, S. R. (2008). Learning mathematics for teaching in the student teaching experience: Two contrasting cases. *Journal of Mathematics Teacher Education. 11,* 459-478.

Ploger, D., & Rooney, M. (2005). Teaching fractions: rules and reason. *Teaching Children Mathematics , 12(1), 12-16.*

Post, T., Cramer, K., Behr, M., Lesh, R.,& Harel, G. (1993). Curriculum implications of research on the learning, teaching and assessing of rational number concepts. In T. Carpenter, E. Fennema & T. Romberg (Eds.), *Rational numbers: An integration of research* (pp. 327-361). Hillsdale, NJ: Lawrence Erlbaum.

Post, T., Wachsmuth, I., Lesh, R., & Behr, M. (1985). Order and equivalence of rational numbers: A cognitive analysis. *Journal for Research in Mathematics Education, 16,* (1), 18-36.

Prawat, R.S. (1992). Teachers' beliefs about teaching and learning: A constructivist perspective. *American Journal of Education, 100*(3), 54-395.

Rowan, B., Correnti, R., & Miller, R. J. (2002). What large-scale, survey research tells us about teacher effects on student achievement: Insights from the "Prospects" study of elementary schools. *Teachers College Record, 104*(8), 1525-1567.

Research in Education and Training. (2001). Perspectives on research: Reading research and reviewing research literature. Faculty of Education Masters program, Deakin University, Australia.

Riddle, M., & Rodzwell, B. (2000). Fractions: What happens between kindergarten and the army. *Teaching Children Mathematics, 7* (Dec.), 202-206

Ruppert, T. J. (2010). Cognitively guided instruction: An alternative way to teach mathematics. *Summation,* May, 21-27.

Schoenfeld, A.H., & Kilpatrick, J. (2008).Toward a theory of proficiency in teaching mathematics. In T. Wood (series ed.) & D.Tirosh (vol. Ed.).*International handbook of mathematics teacher education,* 2. Tools and process in mathematics teacher education. Netherlands: Sense Publishers.

Seidman, I. (1998). *Interviewing as qualitative research: A guide for researches in education and the social sciences*. New York: Teachers College Press.

Shulman, L. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educational Review, 57*, 1-22.

Shulman, L. (1986a). Paradigms and research programs in the study of teaching: A contemporary perspective. In M.C. Wittrock (Ed.), *Handbook of research on teaching on teaching* (3rd ed., pp. 3-36). New York: Macmillan.

Shulman, L. (1986b). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L., & Grossman, P. (1988). Knowledge growth in teaching: A final report to the Spencer Foundation. Stanford, CA: Stanford University.

Siebert, D., & Gaskin, N. (2006). Creating, naming, and justifying fractions. *Teaching Children Mathematics, 12*(8), 394-400.

Silverman, D. (2005). *Doing qualitative research: A practical handbook* (2nd Ed.). London: SAGE Publications.

Simon, M.A. (1993). Prospective elementary teachers' knowledge of division. *Journal for Research in Mathematics Education, 24*(3), 233-254.

Simon, M. A. (1995). Reconstructing mathematics pedagogy from a constructivist perspective. *Journal for Research in Mathematics Education, 26,* (2), 114-145.

Stafylidou, S., &Vosniadou, S. (2004). The development of students' understanding of the numerical value of fraction. *Learning and Instruction, 14*, 503-518.

Steffe, L. P., & Olive, J. (1990). Constructing fractions in computer micro worlds. In G. Booker, P. Cobb & T. N. de Mendicutti (Eds.), *Proceedings of the Fourteenth Annual Conference of the International Group for the Psychology of Mathematics Education* (pp. 59-66). Mexico City: PME.

Streefland, L. (1991). Fractions, an integrated perspective. In L. Streefland (Ed.), *Realistic mathematics education in primary school* (pp. 93-118). Freudenthal Institute, Netherlands.

Thekwane, B. K. (2001). A guide to the teaching of learner-centred mathematics. *Reform Forum: Journal for Educational Reform in Namibia, 14*.

Thompson, A. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127-146). Reston, VA: NCTM

Tirosh, D. (2000). Enhancing prospective teachers' knowledge of children's conceptions: The case of division of fractions. *Journal for Research in Mathematics Education, 31*(1), 5-25

Tzur, R. (1999). An integrated research on children's construction of meaningful, symbolic, partitioning-related conceptions, and the teacher's role in fostering that learning. *Journal of Mathematical Behavior, 18*(2), 123-147.

University of Namibia. Faculty of Education.(2010). Bachelor Degree of Education (Upper Primary). Windhoek.

Van de Walle, J.A., Karp, K.S., & Bay-Williams, J.M. (2010). *Elementary and middle school mathematics: Teaching developmentally* (7th ed.).Boston: Allyn & Bacon.

Van der Sandt, S. (2007). Research framework on mathematics teacher behavior: Koehler and Grouws framework revisited. *Eurasia Journal of Mathematics, Science, and Technology, 3*(4), 343-350.

Vergnaud, G. (1983*).* Multiplicative structures. In R. Lesh & M. Landau (Eds.), *Acquisition of mathematics concepts and procedures* (pp. 127-174). New York: Academic Press.

Ward, R., Anhalt, C., & Vinson, K. (2004). K-8 teacher candidates' use of representations and the development of their pedagogical content knowledge as exhibited in their lesson planning. *FOCUS on Learning Problems in Mathematics, 26*(3), 1-11.

Wearne, D., & Hiebert, J. (1988). Constructing and using meaning for mathematical symbols: The case of decimal fractions. In J Hiebert & M. Behr (Eds.), *Number concepts and operations in the middle grades* (pp. 220-235).Reston, VA: NCTM.

Weinstein, C. S. (1989). Teacher education students' preconceptions of teaching. *Journal of Teacher Education*, *4*, 31-40.

Wood, E. F. (1988). Math anxiety and elementary teachers: What does research tell us? *For the Learning of Mathematics, 8*(1), 8-13.

Yin, R. K. (2009). *Case study research: Design and methods* (4th Ed.). California: SAGE Publications, Inc.

APPENDICES

APPENDIX A: DESCRIPTIONS OF STUDENT TEACHERS' LESSONS

APPENDIX A1: Student Teacher 1 lesson 1

The following is Student Teacher1's lesson on Comparing and ordering fractions with same denominators

1 Introduction: The teacher asked learners to look at the chalkboard and to listen carefully. She told the class that there were 2 brothers who wanted to share a cake. She further said that these 2 brothers used a knife to cut the cake into 2 parts. She said that they further decided to cut the cake into another parts and stated that they were Simon and Peter (not real name). Peter decided to eat the 2 pieces of the cake. She wrote the fractions on the chalkboard$\frac{1}{2}, \frac{2}{4} and \frac{2}{4}$. She told them that Simon ate all the 2 pieces while Peter ate only one piece. Later on the same brothers got another cake and cut it into eight pieces. She told them that Peter decided to eat 3 pieces of the cake while Simon ate 4 pieces of this cake. She then told the class that these 2 brothers wanted to know who ate more cake than the other. Then they decided to use some arrows >< (she wrote these on the chalkboard). She then asked the learners to tell her who they thought ate more cake, starting with the ("2 over 4 and one over four) $\frac{2}{4} and \frac{1}{4}$. One learner said "Peter because he eat more pieces". The teacher asked "why do you think Peter ate more pieces?" No response from the learner. She asked again and one learner said Peter as he ate 2 over 4. The teacher explained that "because 2 over 4 is greater than one over four." She then said the topic for the day was comparing and ordering fractions with the same denominators, writing it on the chalkboard.

Lesson presentation

2 The teacher told the class that $\frac{2}{4}$ ('2 over 4') and ¼ (one over 4') have same denominator. "4 here is our denominator", she said. She also told them that $\frac{3}{8} and \frac{4}{8}$ still have same denominator. And she said that "for today we are going to focus on comparing and ordering fractions with the same denominators." She then explained the 2 arrows > and < by saying that for them to compare $\frac{2}{4}$and $\frac{1}{4}$, "which sign to you think we can put here?" She asked writing$\frac{2}{4} - \frac{1}{4}$. The teacher called one learner to show this on the chalkboard. The learner put >, then the teacher explained why this sign was used. She asked the class again which sign to be put between $\frac{3}{8}$----------$\frac{4}{8}$ and one learner put <.The teacher commented that 'this time the sign has to be < because $\frac{3}{8}$ is smaller than $\frac{4}{8}$". She then explained to the class that 'by looking at the 2 numbers with the same denominators, you just need to look at the numerators, then place your sign according to biggest or smallest."

Activity

3 The teacher told the class that the activity she was going to write on the chalkboard was for them to write whether one fraction was larger or smaller than the other. She wrote these:

1. Write the larger fraction

(a)$\frac{13}{18}$or$\frac{15}{18}$ (b) $\frac{8}{5}$ or $\frac{9}{5}$.

2.Fill in the sign <, > in the box

(a) $\frac{3}{8}\square\frac{6}{8}$ (b) $\frac{6}{9}\square\frac{5}{9}$ (c)$\frac{2}{5}\square\frac{1}{5}$ (d) $\frac{101}{250}\square\frac{210}{250}$

4 The teacher called learners to come on the chalkboard to give solutions. "Elizabeth* come and do (a)"."Veronica* come and do(b)" (**not real names*), she said. She explained to the class that she only wanted them to choose which one was bigger than the other. She also asked some learners to come and do number 2 on the chalkboard (4 of them). The learners presented their answers on the chalkboard. The teacher looked at one solution where the learner did not choose the larger fraction but wrote both ($\frac{13}{18} and \frac{15}{18}$). She informed this learner that she had to choose which was bigger than the other.

She recalled this learner, but the learner struggled to do it correctly. The teacher called another learner who came and corrected it. The teacher continued with part (b) asking the class if it was correct. They responded yes, then the teacher asked "why are you saying she is correct?" A learner said "because 8 is greater than 9." The teacher then asked whether 8 is greater than 9, the learners corrected this problem. The teacher continued looking at 2, asking whether the sign put was correct a) $\frac{3}{8} < \frac{6}{8}$, learners responded positively. She did the same with the rest of the activity asking different learners whether the given sign was correct and why. One learner responded "Yes, because $\frac{6}{9}$ (6 over 9)is bigger than $\frac{5}{9}$ (5 over 9). "Where

did you look to say $\frac{210}{250}$ is bigger than $\frac{201}{250}$?", the teacher asked one learner. "Because they have the same denominator, where do you look, what did I say?" she asked. The learner said the denominator.

Homework

5 The teacher told the learners to take their exercise books and copy the homework she was writing on the chalkboard:

1) Arrange these fractions from the smallest to the biggest: $\frac{3}{9}, \frac{5}{9}, \frac{1}{9}, \frac{4}{9}, \frac{7}{9}, \frac{6}{9}$ & $\frac{8}{9}$

2) Fill in the signs <; > in the box

a) $\frac{111}{220}\square\ \frac{112}{220}$ (b) $\frac{60}{70}\square\frac{30}{70}$ c) $\frac{12}{19}\square\frac{18}{19}$

Learners copied this homework in their books.

The teacher then read through the homework problems to inform the learners what they were expected to do.

1. "All you need to do is to arrange them in order so that the smallest one is first", she said.
2. "The box is already provided, then all you need to do is just to put the sign in the box", she explained.

The learners continued copying and doing the homework while the teacher looked on. The teacher informed the class that the books were going to be collected and put on the table for her to mark later and ended the lesson.

APPENDIX A2: Student Teacher 2 lesson1

ST2-Lesson: The following is Student Teacher 2's lesson on addition and subtraction of fractions

1 Introduction: The teacher (presented) pasted two flash cards with a + and – signs on the chalkboard then asked "I have two signs on the chalkboard, what are those signs?" Many learners raised their hands to respond and one said "plus", then another one said "minus". The teacher then pasted two other flash cards on with equivalent fractions on the chalkboard and asked "what fraction is this?", pointing to $\frac{4}{8}$. One learner said "four eight". He then asked what the second fraction was, and the second learner said "two fourth." The teacher asked the class whether he was correct, they said no. Then another learner said "two quarters." The teacher then asked "can you add these two fractions together?" One learner then said "$\frac{4}{8}+\frac{2}{4}=\frac{6}{12}$." The teacher asked why six twelfth. One learner explained "because 4 + 2 and 8 + 4 is 12." He then told them that it is true that $4 + 2 = 6$ and 8 + 4 = 12, but that was not the right way of adding it. He then informed the class that they were going to learn about "addition and subtraction of fractions with one denominator as a multiple of another." He referred to 8 a multiple of 4.

Presentation

2 The teacher put these examples on the chalkboard: 1(a) $\frac{3}{6}-\frac{2}{12}$ ("3 sixths minus 2 twelfths"). He asked "what are we going to do first?" Then one learner said "we have to multiply first." The teacher further asked "what are we going to multiply first?" The learner responded "6", then another one responded "3 sixth." The teacher then asked what number they were going to multiply with and the learner said it was 2. So they worked out together $\frac{3}{6}\times\frac{2}{2}=\frac{6}{12}$. The teacher wrote $\frac{6}{12}-\frac{2}{12}$ and asked "what is the final answer, one learner said it was $\frac{4}{12}$ ("four twelfth"). The teacher then explained that "when you have one denominator as a multiple of another, you have to convert one fraction to an equivalent fraction, and make sure you have to have the same denominator". He then referred to the example $\frac{3}{6}-\frac{2}{12}$ explaining how they made it $\frac{6}{12}$. He wrote the second example (b) $\frac{13}{16}-\frac{3}{8}$ asking the class, "what are we going to do?" He pointed to one learner who struggled to answer, saying "we are going to multiply $\frac{13}{16}$." The teacher asked whether he was correct, the another learner said no, but they should multiply $\frac{3}{8}$. The teacher then asked which number they were going to multiply with in order to have the same denominator. A learner said "2." The teacher then wrote $\frac{3}{8}\times\frac{2}{2}=\frac{6}{16}$ with learners giving the answers. He then explained that since they had converted the second fraction to another equivalent fraction, they could work out $\frac{13}{16}-\frac{6}{16}$, asking what the answer was.

One of the learners responded "7 sixteenth." "Any question," the teacher asked, and the class responded "no." The teacher then told the learners that they should look at addition, so he wrote 2(a) 2/5 + 3/10 repeating the same question. The learner responded that they were going to multiply '$\frac{2\times5}{5\times5}=\frac{10}{25}$ and the teacher asked whether they had the same denominator. The class responded that it was not, so the

teacher asked again which number was to be used. One learner said 4, then another one said 2, and they worked out$\frac{2\times2}{2\times5}=\frac{4}{10}$. The teacher then asked the answer to $\frac{4}{10}+\frac{3}{10}$ and the answer $\frac{7}{10}$ was given.

3 The teacher then asked one of the learners to do the second example on the chalkboard: (b) $\frac{5}{10}+\frac{4}{20}$. A learner worked out$\frac{5}{10}+\frac{4}{20}=\frac{9}{20}$. The teacher then requested another learner to come and work out the answer correctly. This second learner wrote$\frac{5\times2}{2\times10}=\frac{10}{20}+\frac{4}{20}=\frac{14}{20}$and the teacher and learners agreed that it was correct. The teacher wrote the last example (c) $\frac{5}{7}+\frac{4}{28}$ asking what they were going to do, the class said they were going to multiply by 4 and they worked it out with the teacher:$\frac{5}{7}\times\frac{4}{4}=\frac{20}{28},therefore\frac{20}{28}+\frac{4}{28}=\frac{24}{28}$. "Any questions," the teacher asked, and the class said no. The teacher then asked them about "how to subtract a fraction with a denominator a multiple of another." No one responded, and then after the teacher pointed one learner, she responded, "you multiply." He told them that it was important to remember this rule of adding and subtracting a fraction with one denominator a multiple of another as this will help them to work with easy.

4 The teacher then gave a class work:

a) $\frac{2}{3}+\frac{4}{12}$ (b) $\frac{4}{6}-\frac{5}{18}$ (c)$\frac{3}{4}+\frac{1}{2}$ (d)$\frac{2}{5}-\frac{2}{15}$ (e) $\frac{2}{5}+\frac{3}{10}$

The teacher walked around the class looking at how learners were writing. The time was up and the teacher told the class to give the books to the class captain. The lesson ended.

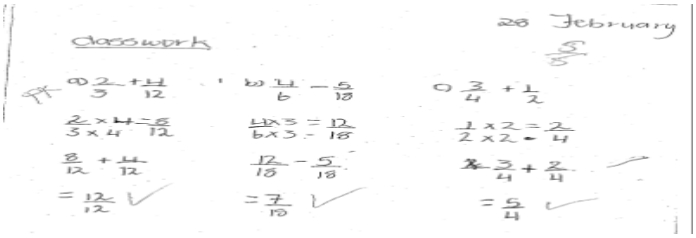


Figure 3: The learner's class works on addition and subtraction of fractions

APPENDIX A3: Student Teacher 3 lesson1

The following is Student Teacher 3's lesson on Comparing fractions

1 Introduction: The teacher introduced a lesson using two prepared papers as 'cakes' with 4 subdivisions each. She pasted these on the chalkboard and then asked the two individual learners to come and take coloured pieces only (pink ones). The teacher then asked the class after the two learners took the pieces who was having lots of pieces than the other (one had 1, (a), the other had 3 pieces, (b). One learner indicated the correct answer. The teacher then informed the class that the topic for the day was comparing fractions of the same denominator.

Presentation

2 The teacher explained about comparing fractions using the pieces taken by the 2 learners previously. "In comparing we use signs greater than (>),less than (<) or equal to (=)," she stated. She asked the class "between learner A and B, who was having the greater part than the other one?" One of the learners indicated that it was learner B. The teacher then showed the learners the different pieces she brought. She wrote on the board the 2 fractions ¼ ('one over four') and ¾ ('three over four') then asked 'which sign can I use here, between greater than (>) or less than (<)? One of the learners said 'less than'. The teacher asked the learner why she said less than. ($\frac{1}{4}<\frac{3}{4}$) The one learner responded that "because 1 is less than 3." The teacher further clarified that because 1 is less than 2 so they should put less than. She then referred to the pieces of cakes taken by the two learners from the total 4 pieces, and "that is why 1 over 4 is less than 3 over 4, and these have the same denominator because we are dividing these cakes in 4 equal parts," she explained.

The teacher pasted some different pieces on the chalkboard, but not in any order. She asked one learner to come on the board and construct a shape with two pink pieces out of 6 pieces (comparing$\frac{3}{6}and\frac{3}{6}$), and then another to do two pink pieces out of 6 (comparing $\frac{2}{6}and\frac{4}{6}$). She later asked them to put a sign (> or <). The teacher instructed the learners that they should put their pieces in a shape of a whole. And asked third

learner to do a similar task, the last one with fractions '3 over 5' and '4 over 5' using the provided pieces on the chalkboard.

3 The 3 learners tried to put their different pieces to make a whole, but it is not easy as the pieces kept falling down. Other learners started laughing, and the teacher keeps on shouting at them to stop making fun of others. Some shapes did not look like wholes.

4 Even the third learner struggled and could not finish as he was unable to fit all the pieces properly ($\frac{3}{5}\&\frac{4}{5}$) The teacher then requested someone else to help this learner to present the two shapes correctly on the board. "Who wants to help her?" she asked. One learner came on the chalkboard to try and fit the pieces to make fractions $\frac{3}{5} and \frac{4}{5}$ even though it did not work as the 'prestick' used did not work. She asked the other learners not to confuse him and told this learner that when he finishes he should tell the class, while other are excitedly looking on.

5 Finally, after the learners' attempted to put the pieces, the $\frac{2}{6} and \frac{4}{6}$, as well as the second one, and third learner struggled as the pieces kept falling down, the teacher told the class to just forget about the pieces and concentrate now on the fractional numbers to make a comparison. She then asked the class which is bigger than and less than between$\frac{2}{6} and \frac{4}{6}$."Who is going to put the sign?", the teacher asked the class. "Is this one correct 4 over 6, imagine this is a whole now and we cut it into equal pieces, is it now correct? She asked. One learner said it is correct and the teacher asked why. The learner struggled to answer. Another learner tried to explain that it is correct because it was a whole divided into 4 pink parts and 2 green parts. (i.e. $\frac{4}{6} > \frac{2}{6}$). The teacher called another learner asking her to put the sign (< or >) to compare ($\frac{3}{5} and \frac{4}{5}$) then asked the class whether it was correct and the learners said yes. She further explained that it means that "3 over 5 is less than 4 over 5".

6 She further explained that is the way they compare fractions where the whole is divided into two equal parts and working with the same denominator."Then we look at which one is bigger than the other one and which one is less than the other one", she explained."Ok, can I give a task now?" The teacher asked. "Yes!" the class responded in a chorus. The teacher asked the learners to take their exercise books to do the class activity in pairs. She puts flipchart on the chalkboard with the activity and explained what they are going to do. She informed them that they should do (a)-(e) in the papers then raise a hand when they complete.
Compare the following pair of fractions. Fill in >,< or =
a) ⅘---- ⅘ b) $\frac{17}{20} - - \frac{19}{20}$c) $\frac{96}{100} - - \frac{69}{100}$
d) $\frac{487}{1000} - - \frac{478}{1000}$e) $\frac{40}{170} - - \frac{40}{170}$

7 The learners started working on the class activity in their papers. The teacher told the learners that they are not drawing the diagrams, but only to fill in the answers. She visited group to group marking the pair work. She told the class that they should try to write the numbers nicely/correctly. The teacher called for some learners to come and present corrections on the chalkboard. "Me, me!" the learners shouting to be picked for the work.

8 After the corrections the teacher gave homework by pasting the flipchart on the chalkboard and learners copy the homework in their books. She emphasized on the point of copying numbers correctly. She reminded them that if they copy numbers incorrectly, she will mark them wrong. The lesson ended.

APPENDIX A4: Student Teacher 4 lesson1

The following is Student Teacher 4's lesson on comparing and ordering of fractions

1 Introduction: The teacher revised part of the homework from the previous day. He asked what was difficult in the homework and the learners responded that nothing was difficult. The teacher wrote part (a) from the homework to indicate the bigger fraction between 2/3 or 4/7. The teacher asked "do we have the same denominator?" "No!", the class shouted out. The teacher explained further that since they do not have the same denominator they could not tell. "What are we supposed to do then? The teacher asked the class. "We are going to find the number that 3 and 7 meet," one learner said. The teacher then agreed and said "the number is lower common multiple", asking what it is. One learner said "21." The teacher then asked these questions, "how many times 3 goes into 21? 7 times, "the class said, then the teacher writes

2/3 x 7/7 = 14/21. How many times 7 goes into 21," he asked, "3 times!" the class shouted out. The teacher then wrote 4/7 x 3/3 = 12/21 with the class. He then explained that now they had same denominator one could decide which fraction was bigger, 2 over 3 or 4 over 7?", he asked. He also asked them to guess the topic of that day. Then one learner said that the topic for the day was about how to compare and arrange fractions; he then wrote the topic on the chalkboard.

Presentation

2 The teacher again told the class that they are going to arrange fractions by starting and looking at which one was smaller followed by the bigger one or the bigger followed by smaller one.

3 He called someone from the class who was 10 years old, 11 years old, 12 years old, 13 years old, and 14 years old to stand in front of the class. He then told the class "those are the ages of the learner out of the total number of learners in our class." Let us take the first learner is 11/33, 2nd is 13/33, then 12/33, 10/33 and 14/33, then asked the class to arrange from the biggest to the smallest. One learner mentioned the learners name (14/33), 13/33, the second learner said until 10/33. The teacher pointed at the denominator and asked "what does this number tells us, 33,33 and 33." The one learner said "the age of 10 comes from the age of 33 learners." The teacher pointed to the next learner to give an answer in terms of fraction, what the denominator tells. "It tells us that in the class of 33 there are some learners who are 10 years old, 11 years, 12 years, like that "one learner says. "It tells us that the age of people is top and 33 is on the bottom," another learner answered. The teacher then told the class to forget about the age and just look at the numbers 14/33 13/33, 12/33, 11/33 and 10/33 then asked what 33 tells them. "You only divide each number by 33," says one learner. The teacher explained that this number 33, means that we are comparing and arranging fraction with the same denominator." He gave the list 14/33,13/33,12/33, 11/33 and 10/33, saying that they are arranged from the biggest. "What does this number tell us," he asked pointing to 33." It tells us that we only look at the numerator," he further says. "The more the numerator, the first that number," he continued to explain. He then told them that is why 14/33 came first.

4 The teacher then wrote the example where learners were required to arrange on the chalkboard 1) 3/6, 6/6, 1/6, 5/6 and 2/6 ("3 over 6, 6 over 6, 1 over 6, 5 over 6 and 2 over 6") "which one is the first if you arrange from the biggest," he asked. Different learners gave the answer and the teacher wrote the order on the board: 6/6, 5/6, 3/6, 2/6 and 1/6. The teacher then told the class to go to presentation 2 to arrange from biggest to small using different denominators. A) 5/12, 4/3, 1/3, 5/6. The teacher said that the denominators were different and asked what was to be done first. A learner said "find a number that is 3, 12, 4, and 6 together." The teacher then asked what this number was where 12, 3, 4 and 6 can meet and was called lowest common multiple (LCM). "What is the lower common multiple of these. "One over two," a learner said. The teacher then said this was not correct and asked again. Learners struggled to give the answer for a while, then one learner gave an answer as 12. The teacher then said is 12 because "3goes into 12?" "one time,' the class responded and he wrote on the chalkboard: 5/12, ¾ x3/3 = 9/12; for 1/3 he asked "how many groups of 3 are 12?" Then he continued writing the rest of the fractions 5/12, 9/12, 4/12, 10/12 telling the learners that since the denominators were the same, they only needed to look at the numerator and compare the fractions. He then wrote the answer as given by the learners as they were arranged from smallest to biggest "4 over 12," a learner said. The teacher pointed to the original fractions, then the learner said "1 over 3." [1/3]. Then the other learner said "3 over 4." The teacher and the class disagreed, then one learner said 5/12, "1 over 3," another learner said, but the teacher indicated that 1/3 is already given. The teacher then wrote the rest of the fractions: 1/3, 5/12, ¾, 5/6. He explained that what is important here "if you are given different denominators just put into equivalent fractions, so that you will have a common denominator," he said.

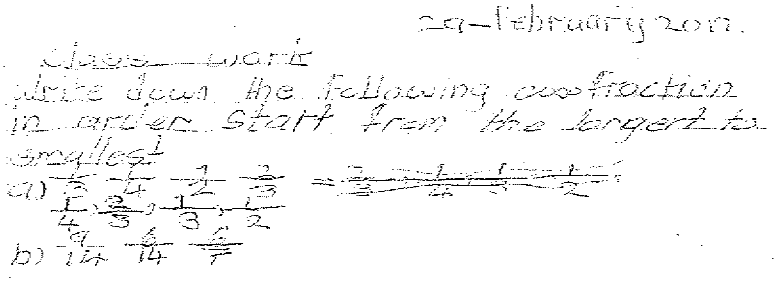
5 The teacher then told the class to go to part (b) ½ (1 over 2), 4/5, 3/10 and asked if they could arrange these since they did not have the same denominator. A learner explained that they should find a number where denominators meet. He emphasized that they should remember this procedure, always if they want to know fractions well. The teacher repeated some questions as for part (a) – the LCM ('the lower common multiple') asking what it is. The learner said it is 10 and then the teacher wrote these equivalent fractions with learners shouting out the answers: ½ x 5/5 = 5/10, 4/5 x 2/2 = 8/10, 3/10 x 1/1 = 3/10. He then said that now they had same denominator they should just look at the numerator to arrange. "Which one should come first, from the smallest, the teacher asks. "3 over 10," a learner said, followed by what?, the teacher asked, "1 over 2." The teacher agreed, and asked the last one "4 over 5," the class said (3/10, ½, 4/5).

6 The teacher asked the learners to take out their exercise books to do the class exercise:

Write down these fractions in order, starting from largest to smallest
a) 1/3, ¼, ½, 2/3 b) 9/14, 6/14, 6/7.

The teacher asked why some learners did not have books and told them to use their homework books instead. The lesson ended.

Figure 4: The learner's work for the clas



APPENDIX A5: Student Teacher 5 lesson 1

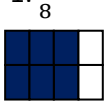
The following is Student Teacher 5's lesson on Comparing fractions with same and different denominators

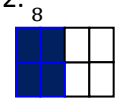
1 Introduction: The teacher introduced the lesson by writing on the board 4*3 then asked one of the learners to tell the class which of the 2 numbers was bigger. One of the learners answered that "4 is greater than 3", then the teacher further asked how one indicates this comparison. The teacher then wrote the answer 4>3 and asked the class what were they doing. One learner answered "rephrasing". The teacher said they were comparing and they were going to compare fractions.

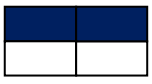
Presentation

2 The teacher then wrote 2 fractions on the chalkboard $\frac{4}{5}$ ('4 over 5') and $\frac{3}{5}$ ('3 over 5') and asked how to compare these two fractions. A learner went to the chalkboard and wrote $\frac{4}{5} > \frac{3}{5}$. The teacher than asked why this learner wrote like this ($\frac{4}{5} > \frac{3}{5}$) and one learner responded that "because 4 is greater than 3". The teacher further asked "what about $\frac{4}{5}$ and $\frac{4}{5}$?." The learners responded that these were equal. The teacher than further said that they were only concentrating on the numerators because the denominators were equal.

The teachers then distributed 4 drawn shapes with subdivisions shaded partly to 4 different learners and asked the learners to compare the fractions written next to the diagrams. He then drew roughly these on the board:

1. $\frac{6}{8}$ 

2. $\frac{4}{8}$ 

3. $\frac{3}{4}$ 

4. $\frac{2}{4}$ 

3 The teacher than asked the class to compare #1 & #2. The learner stood up and said "6 over 8", then the teacher asked why and the learner answered "because 6 is smaller than 4." The teacher agreed and continued asking #3 and #4 where another learner answered that "2 over 4 is smaller than 3 over 4." The teacher asked whether everybody understood, and they responded in a chorus "yes."

4 The teacher then pasted a flipchart written a question on the chalkboard and asked each of the groups of 5 learners to do it in 5 minutes where they were comparing fractions with same denominators using <&>

(a) $\frac{7}{10} \ldots \ldots \frac{5}{10}$ (b) $\frac{12}{100} \ldots \ldots \ldots \frac{25}{100}$ (c) $\frac{487}{1000} \ldots\ldots \frac{478}{1000}$

The teacher demonstrated that the learners could also use their arms to make these signs < and >. He told the groups to exchange papers quickly and he made a correction while they marked the papers. He further asked whether they had some questions, but they said no.

5 The teacher then explained that in the next step they were going to compare fractions with different denominators. He asked a question "which is big (a) ¼ or $\frac{4}{16}$?" ('1 over 4' or '4 over 16'). Two learners went to the chalkboard and both wrote ¼ <$\frac{4}{16}$ and the teacher said it was not correct. The class then asked why it was wrong. The teacher informed the class that they should take note of the denominator in this case. The teacher explained that "you have to make the denominator the same, but how?" He explained that they should turn 4 into 16 and asked the class to give multiple of 4 from 8. The class gave 8,12,16,20. The teacher then said "you just replace 4 by 16", and then said "you ask which number you multiply with 4 to give 16?" He then showed $\frac{1\times4}{4\times4} - \frac{4}{16}$ and they could then answer the question "which is bigger" and these 2 were equal. The teacher gave another example (b) $\frac{2}{5} or \frac{3}{10}$ telling them that they should turn 5 into 10. He called a learner to try on the chalkboard. The learner wrote $\frac{2}{10} < \frac{6}{10}$. The teacher again explained that a learner's answer was wrong, he needed to make multiples of 5 =10, 15, 20,… and should put 5 to become 10 to make denominators the same. He said this learner should have done $\frac{2}{5} \times \frac{2}{2} = \frac{4}{10}$ then compared$\frac{4}{10} and \frac{3}{10}$, therefore$\frac{4}{10} > \frac{3}{10}$.

6 The teacher then gave one more example c) $\frac{5}{8} or \frac{9}{16}$ explaining that if a learner did not know how to multiply then just list multiples of the required number to make denominators the same. He asked "which number was going to put here 5/?? To make the denominator the same?" The class responded "16". The teacher then further said they should list multiples of 8=16, 24… and showed the class $\frac{5}{8} \times \frac{2}{2} = \frac{10}{16}$. The teacher then explained that they should multiply with 2 on top and 2 on the bottom so that the denominators were the same, then decided which was bigger or small, ($\frac{10}{16} > \frac{9}{16}$).

7 The teacher then asked the class to try out this one (d) $\frac{3}{5} or \frac{20}{50}$. A learner came to the board and did it correctly. The teacher then asked this learner to explain the solution to the class. The learner explained how she looked for the same denominator by multiplying $\frac{3}{5}$ by 10: $\frac{3}{5} \times \frac{10}{10} = \frac{30}{50}$ then compare $\frac{30}{50} > \frac{20}{50}$. The teacher then emphasized how one could make the denominator the same by listing multiples and multiplying both numerator and denominator. He then asked whether the class had any problem, and they responded "no".

8 The teacher then gave a class activity by pasting the flipchart on the chalkboard with the following problems:

Which is smaller?

1. 3/5 or 7/10 2. 400/1000 or 100/250 3. 1/3 or 6/6

The learners were to do these problems on the papers handed to them earlier in their groups of 5. The groups copied the 3 problems. Some learners asked the teacher how to do the second problem, and he answered that they should just do it in the same way that he showed them with the examples. The class took some time to copy the problems and started working on them, but the time was too short. The teacher informed the group to complete these during study time and handed it in the next day. The lesson ended.

APPENDIX A6: Student Teacher 1 lesson 2

The following is Student Teacher 1's lesson on how to simplify fractions

1 Introduction: The teacher revised the previous homework by providing correct answers on the chalkboard. The teacher then wrote a fraction on the chalkboard. She then started simplifying the fraction: $\frac{4}{8} = \frac{2}{4} = \frac{1}{2}$ and asked the class to tell/explain to her what she was trying to do. A learner responded that she was subtracting the fractions. The teacher agreed but then asked what else was happening, what they thought she was doing. Then another learner sad she was dividing and the teacher agreed explaining that the correct term used by dividing was called putting the fraction in simplest form.

Presentation

2 The teacher then pasted the flipchart with a heading "Simplifying fractions", and she told the class that it was the topic for that day and they were going to learn about how to put fractions into simplest form. She explained that "when we are simplifying a fraction, we need to find an equivalent fraction using the smallest number for the numerator and the denominator." She gave an example (a) $\frac{4}{10}$ ('4 over 10').
She explained that they should find the smallest number to represent the numerator and denominator by dividing. She showed then $\frac{4}{10}$ by asking them the smallest number dividing both 4 and 10, therefore the answer: $\frac{4}{10} = \frac{2}{5}$. She further asked the learners whether they need a number that divides 2 and 5 to give the final answer. She explained that $\frac{2}{5}$ is the 'last answer' as there is no other number dividing both numerator and denominator, except 1.

3 She then wrote the 2nd example (b) $\frac{18}{24}$('eighteen out of 24'). She asked "which number can divide into 18 and 24?" One learner said "two". She asked the learner to give $\frac{18}{24} = \frac{9}{12}$ and whether is the last answer and they responded "no". She then commented that it was not the last answer so the learners should give the other number to divide. They then gave 3 and the teacher worked out $\frac{9}{12}$.. =$\frac{3}{4}$ and told them that this ¾ ('3 over4') was the final form of the given fraction $\frac{18}{24}$ as there was no other number that would "divide into 3 and 4 except 1 and itself." They worked out the other example (..)$\frac{10}{20}$where the teacher asked the class which number they should use in this case and one learner sand "is 3". The teacher disagreed and continued asking others. The other learner said "2", then the teacher asked her to complete …..$\frac{5}{10}$. She then told them that to write this into simplest form they should take 5 and divide to get $\frac{5}{10} = \frac{1}{2}$ the final answer.

4 The teacher then handed out pieces of papers with a class activity with an instruction:
1. Change into simplest form:
(a) $\frac{6}{8}$(b)$\frac{16}{24}$(c)$\frac{3}{12}$(d)$\frac{8}{12}$ 2. (a) Fill in the denominator $\frac{4}{7}$= $\frac{12}{\square}$ (b) Fill in the numerator $\frac{1}{2}$= $\frac{\square}{16}$
The learners then individually began working out the answers on the papers they were given by the teacher with difficulty. The teacher walked around marking the learners' work from table to table and talking with them. After a while the teacher reminded the learners that they should remember that the sign they were using was not multiplication, but division, and that they should make sure they put everything in simplest form, you do it by dividing, using a number that divided the numerator and denominator without a remainder", she said. She asked the learners if they understood, and they said "yes". The lesson ended.

APPENDIX A7: Student Teacher 2 lesson 2

This is a lesson for Student Teacher 2 on equivalent fractions.

1 Introduction: The teacher asked about what learners recall from previous day's lesson. A few learners responded to what was being asked. The teacher then handed four equal-sized flash cards (congruent), with different colours and names: red, blue, yellow and green. He asked: "who can tell me what is written on the red card?" Red bull", responded one learner. "On the green one?" "Green glass"; and the learners gave the rest of the names written on the flash cards. The teacher then informed the class that they were going to learn about equivalent fractions.

Presentation

2 The teacher wrote the topic "Equivalent fractions" on the chalkboard. He then posed this question to the class: "who can tell me what it means equivalent fractions?" One learner answered "a common fraction", and then the teacher disagreed. "A drawing" another learner stated, but the teacher disagreed again.

The teacher then wrote two fractions on the chalkboard $^{1}/_{2}$and $^{2}/_{4}$, and stated that these two fractions are said to be equivalent fractions. He then gave a definition of what an equivalent fraction is by pasting the flipchart with notes on the chalkboard. He read the definition of what equivalent fractions are: "equivalent fractions are two fractions which are the same". "The fractions $^{1}/_{2}$ ('one half') and $^{2}/_{4}$ ('two over four') are the same, therefore they are equivalent", he said. The teacher explained why these two fractions are the same, and is because one can write $^{2}/_{4}$ as $^{1}/_{2}$ when divided by 2. He then showed the class why this was true $^{2 \div 2}/_{4 \div 2} = {}^{1}/_{2}$, "therefore it is true because $^{2}/_{4}$ and $^{1}/_{2}$ are the same", he further said.

3 The teacher then told the class that one could find an equivalent fraction easily by "multiplying with any number". He explained that they could use 4 then multiply $^{1}/_{2}$ by 4: $^{(1 \times 4)}/_{(2 \times 4)} = {}^{4}/_{8}$, giving another equivalent fraction. The teacher explainedfurther that the smallest fraction in this case is $^{1}/_{2}$, so "it means each equivalent fraction is the same as $^{1}/_{2}$, when divided by your number".

The teacher then gave the following examples for the learners to show other equivalent fractions on a flipchart.

Examples

Give 2 equivalent fractions

1. $^{1}/_{3} = \square = \square$
2. $^{10}/_{12} = \square = \square$

4 The teacher asked the learners whether they understood; they answered in a chorus "yes sir!" he then told them that they should then work out the two examples to find the equivalent fractions in each case. For $^{1}/_{3}$ he asked "which number you want to multiply with?" one learner responded "2". The teacher then agreed and wrote $^{1 \times 2}/_{3 \times 2} = {}^{2}/_{6}$ on the chalkboard. He called one learner to give the second equivalent fraction on the chalkboard and this learner wrote $^{(1 \times 4)}/_{(3 \times 4)} = {}^{4}/_{12}$. The teacher then asked again asked the class whether they understood and they said yes. He then explained that for the second example, $^{10}/_{12}$ can also be written as $^{5}/_{6}$ ('5 over 6') "if you divide by 2". He then explained that $^{5}/_{6}$ could just be multiplied by any number to obtain an equivalent fraction. "Who can tell us the number we can multiply with", he asked. One learner stood up and said "6". The teacher then showed $^{(5 \times 6)}/_{(6 \times 6)} = {}^{30}/_{36}$ on the chalkboard.

5 The teacher asked the class again whether they had questions on what was taught. A few learners responded that they had no questions, but one learner stood up and asked "teacher please I cannot understand the last problem". The teacher then explained how to work out $^{(5 \times 6)}/_{(6 \times 6)}$, asking this learner to give 5 × 6 = 30 and 6 × 6 = 36. He then again asked the class "what is $^{30 \div 6}/_{36 \div 6}$?" So the teacher showed that this was also $^{5}/_{6}$ and that was the main reason that the fractions $^{5}/_{6}$ and $^{30}/_{36}$ were equivalent. Another learner asked him "what if we have an odd number over an even number, e.g. $^{11}/_{28}$?" The teacher responded that it was a good question, but they should take it as part of the homework for everyone to bring an answer the following day.

6 The class was then given some minutes to copy the notes written on the flipchart. After a while the teacher informed the class that they were going to do a class activity. He pasted another flipchart with class work, as shown.

CLASSWORK

1. Write 2 fractions equivalent to ¼.
2. Fill in the missing numbers
   (a) $^{1}/_{5} = {}^{\square}/_{10} = {}^{\square}/_{25}$
   (b) $^{\square}/_{14} = {}^{\square}/_{7} = {}^{4}/_{\square}$

The learners took their exercise books and started copying the class work. This took them some time before they started to work out the solution. The teacher walked from table to table checking whether the learners were doing the work. Some learners told the teacher that they still did not understand how to get equivalent fractions. The teacher explained to some individual learners the procedures again.

7 After about 10 minutes, the teacher realized that there was no more time for the learners to complete the class work. He told them that they would take it home and completed it as homework then bring the books the following day. He then concluded the lesson by stating that "equivalent fractions are fractions that are always the same, as we saw $^{1}/_{2}$ and $^{2}/_{4}$". "When you are given a fraction, e.g. $^{10}/_{12}$, you divide by 2 and then you get a smaller equivalent fraction $^{5}/_{6}$, as we did before", he further explained. He asked them if they had questions, but there were no questions. The lesson ended

APPENDIX A8: Student teacher 3 lesson 2

The following is Student teacher 3's lesson on equivalent fractions

1 Introduction: The teacher introduced a lesson through a story of sharing a bar of chocolate between her and the sister in equal pieces. She further informed the class that since the pieces were equal in size, they did not quarrel. Now the teacher asked the learners to tell/mention the topic for the day. Learners tried to come up with different topics such as: word problems, was about fractions. She asked the class if anyone knew what it means (what fractions are about), the definition. "What are the fractions", the teacher asked. She kept on encouraging learners to try to explain "what is fraction?"

Presentation

2 The teacher then told the class that "fraction is a way when you divide a whole number into parts" the teacher said. She further continued explaining that fraction "is a way of representing division, we divide that whole into parts." The teacher informed the class that the topic for the day was fractions, but the main focus was going to be about equivalent fractions. The teacher then explained that when talking about equivalent fractions "these are the equivalent that look different but they have the same value", she said. She referred to numerical values representing a fraction and asked the learners to name them top/bottom numerator/denominator} she then wrote the learners' answers on the chalkboard. She clarified that "in the equivalent fraction the numerator and denominator may look different but they have the same value". She then told the learners that this was the definition of equivalent fractions. She explained an example where she referred to an apple (supposing that she had one apple) and divided it into 4 parts. She then asked the learners how she would put this into a fraction. One learner responded that it was one over four – the teacher wrote ¼ and explained that ¼ was numerator/denominator. The teacher talked about equivalent fractions again, then wrote the definition on the chalkboard: "these are the fractions that may look different but have same value." The teacher presented an example of an equivalent fraction. She gave a ½ ("a half" – she said not 1 over 2). She then asked "which fraction is equal to ½ or "which fraction is equivalent to ½?" She explained that she "can use any number to times both numerator and denominator. She showed that $\frac{1\times2}{2\times2} = \frac{2}{4}$ (she asked learners to give answers then explains that "2 quarters equal to 1 half". She also explained that they could use 3: $\frac{1\times3}{2\times3} = \frac{3}{6}$ and told the class that $\frac{3}{6}$ is the equivalent to ½ because they got the same value. She further explained that when they looked at equivalent fractions, they look different but they are equal, they have the same value. She repeated again that ½ can be multiplied by the same number both numerator and denominator such as 3 or 2 then it gives a different number with the same value as ½.The teacher then asked whether the learners understood or she could put one more example. The learners said yes.

3 The teacher gave this example to find equivalent fraction (she wrote on the board) of the following $\frac{2}{6}$. She then explained the procedure asking the learners to choose any number. The learners chose 4. $\frac{2\times4}{6\times4}=\frac{8}{24}$. She wrote the learners' answers on the chalkboard. The teacher then emphasized on how she knew that $\frac{8}{24} and \frac{2}{6}$ are equivalent by repeating the same explanation as above.

4 She then decided to give the class activity to be done in pairs (pair work). She wrote the exercise on the chalkboard: "Give 2 fractions that are equivalent to 1/3". The learners started doing the work in their groups. (about5 minutes): the teacher walked from group to group marking the learners' work (those who raised their hands). Some learners told the teacher that they did not understand equivalent fractions. The teacher explained to them again.

5 The teacher then informed the class that they were now going to do a correction of the class activity, because not all of them got it right. She asked the 2 fractions equivalent to a $\frac{1}{3}$ from the class. She wrote on the board $\frac{1\times6}{3\times6}=\frac{6}{18}$ then asked for another $\frac{1\times4}{3\times4}=\frac{4}{12}$.She then explained again how one obtained an equivalent fraction that it did not matter which number one multiplied with as long as it multiplied the numerator and denominator. She asked one learner (Rachel – not real name) if she understood and whether they had questions – they said no. She concluded her lesson by asking any learner to give an equivalent fraction that is equivalent to $\frac{2}{5}$ (she writes $\frac{2}{5}$ on the board). One learner went on the board to find it: $\frac{2}{5}\times\frac{4}{4}=\frac{8}{20}$. She asked class whether it was correct/incorrect and for them to explain how they knew it was correct, "what are you going to do."

Homework

6 The teacher wrote the homework on the chalkboard and instructed the learners to copy it in their books,

1. Give an equivalent fraction to (a) ¾ (b) $\frac{4}{5}$

2. Complete the following $\frac{1}{4}=\frac{2}{8}$=__=__

Learners asked the teacher to explain the last one as they did not understand. The teacher asked the learners if they had some questions, they continued copying the homework in their books. The lesson ended.

APPENDIX A9: Student Teacher 4 lesson 2

The following is Student Teacher 4's lesson on writing fractions into simplest form

1 **Introduction**: The teacher asked the class about what was previously learned. The learners shouted out "common fractions!" One learner said "we talked about equivalent fractions." The teacher agreed with this learner as well as with those saying "proper fraction,' "improper fraction," "decimal fraction," numerator,' and common denominator." The teacher wrote the topic for the day on the chalkboard and informed the learners that they were going to learn about writing fractions into simplest form.

Presentation

2The teacher told the learners that they were going to learn about new words today such as a 'factor" He then asked them "do you know what is a factor?" They responded that they did not know what it was. The teacher defined a factor as "a number that divides another number without a remainder. He also wrote this on the chalkboard and gave examples of factors such as 1, 2,3,4,5,6,7,9 and 10.

3The teacher then told the class that before they did the factors, they should do the changing of equivalent fractions into an equivalent fraction. The teacher said "suppose we have a fraction ½ ("one over two"), so this is equivalent to?"One learner said "2 over 4". The teacher agreed with the class, then asked "and then is equivalent to what again?" One learner said "4 over 8" (4/8).The teacher continued asking learners "4 out of 8" is equivalent to? Learners gave answers until they had this list: ½, 2/4, 4/8, 8/16, 16/32, 32.64, 64/128…

4The teacher then asked what the big fraction was, and one learner said "32/64" ('32 over 64'), one learner said"64/128" ('64 over 128').The teacher then asked the learners to look at these fractions moving from ½ to 2/4, 2/4 to 4/8 and so on whether they "divide, multiply or add?" "2, 4, 8, 16, 32, 64?" "We multiply or we add". The teacher then showed on the chalkboard 2+2=4, 4+4=8, 8+8=16, 16+16=32, 32+32=64, and concluded that it was obvious that the rule here was that they add when moving from fraction ½ to 2/4.The teacher further asked the learners how they knew that they had to add e.g. 2/4 to 4/8, which number can be added, the class responded that it is 2, because 2+2=4.The teacher then explained that one has to add the number itself. He further continued saying they

were going to look at how to turn an equivalent fraction (a) 2/4 into the simplest form. He then gave an example where one had to give it into a simplest form. The teacher then stated that the learners should remember about the 'factor', he told them about earlier. He then asked learners to find a number that divides both 2 and4 without a remainder, which could be a 1, 2, 3,4,5,6. He asked them to take one number, the one learner said "one." The teacher then asked "what happens, 2 divided by 1 = 2", "4 divided by 1 = 4" with learners giving answers. The teacher then said that since those numbers did not change they should pick another number. "Which one?", he asked. One learner responded "let us take 2." "Let us take 2, then 2 divided by 2 = 1, then 4 divided by 2 = 2," where learners gave out answers. The teacher then wrote $\frac{2}{4} \div \frac{2}{2}$= ½ and pointed out that this was what is called the simplest form starting from big into small.

5 The teacher then asked them to go to (b) 4/8, whether it could be arranged into a simplest form." Which factor can divide 4 and also 8 without a remainder?" he asked. One learner said "two", the other one said "four". The teacher then told the class to take 4 and showed the division 4 divide by 4 = 1 while learners gave out the answers. One learner said28 divided by 4 is 1 over 2", when asked for the answer.

6The teacher then tried to explain using a situation where he had 8 sweets and wanted to put this into groups of 4, then asked how many groups he would make. Many learners wanted to give the answer, but this particular learner still did not understand. The class gave an answer as 2.The teacher then explained that "2/4 divided by 2/2 = ½" and "4/8 divide by 2/2 =??"Was the simplest form.

7 The teacher also explained example (c) 4/6 ("4 over 6") asking how it could be put into simplest form. "What I have to do here is take a factor that divides 4 and also divides 6, which factor here that could divide both without a remainder?" the teacher asked. One learner said "9". The teacher then asked the class if this was true. The teacher then repeated for the class to comprehend the question, again asked for the number. Many learners raised their hands eager to give it as 2. It was worked out 4/6 divide by 2/2 = 2/3 (2 over 3).

8 The teacher then asked the learner to look at the example of the equivalent fraction and started explaining what is equivalent about: $\frac{3}{5} = \frac{6}{10} = \frac{9}{15} = \frac{12}{20}$. He asked learners "if we look at this sequence do we add or do we multiply?" He pointed out that learners should look at numbers 3, 6, 9, 12 asking whether they add or multiply. The learners responded that they add. The teacher also said that they add 3 because 3+3=6, 6+3=9, 9+3=12, so "here the denominator 5,10,15,20 now we multiply but how many numbers we add?" he asks. The learners respond "5," then the teacher continues asking 5+5= "10" the learners responded, "10+5=?", "15"and so on. The teacher then referred the learners back to the current topic, "how are we going to write a fraction into its simplest form, for example, (a) $\frac{9}{15}$, to write it into its simplest form, we need a factor dividing both numbers, so which factor is that?" He asked. The learners responded that it was 3 then the teacher wrote on the chalkboard, $\frac{9\div3}{15\div3} = \frac{3}{5}$ the answer given by the learners. The teacher then indicated that the simplest form is 3/5, then requested learners to do part (d) together. "Let us do number 'd". (d)$\frac{6}{12}$. The teacher then called for someone to do (d). A girl was given a chance to do it on the chalkboard. The learner wrote $\frac{6\div2}{12\div2} = \frac{3}{6}$. The teacher asked "which factor divides 6 and also divides 12?" The learner says "6". The teacher then told this learner to work out the answer correctly, showing her how $\frac{4}{8}$is simplified. This learner still did not get it, so another learner was called on the board to explain the procedure. The learner then explained "6 divided into 3 groups is 2, and 12 over 4", he said. The teacher then told the learner to take another factor that divides 2 and 4 in order for him to give the last answer. This learner said "1", and then the teacher helped to correct him. The teacher asked the class whether they got the picture of what was taught, they shouted "yes". The lesson ended.

APPENDIX A10: Student teacher 5 lesson 2

The following is Student teacher 5's lesson on equivalent fractions

1 **Introduction:** The teacher informed the class that the previous week they finished with multiplication and division of the whole numbers and wrote a test. "This week we are going to embark upon a new topic or a new chapter".

The teacher drew square on the chalkboard (subdivided into 4 equal blocks), then asked the class "can somebody tell us what you see on the chalkboard?" George* replied "A square with 4 blocks." The teacher then asked the class whether they all saw a square with 4blocks. Then one learner said "A square with 2 lines inside." The teacher stated that the square has a name "is a fraction" he said. He further said that "those blocks that we divide in a square are fractions, so we have a square divided into fractions". "So what is our topic for today?" he

asked. Then one learner said “common fractions.” The teacher then explained that within common fractions “we have a topic, equivalent fractions. [George*- not real name]

Presentation

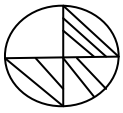
2 The teacher said that before they started one should give a definition of a fraction. A learner said “it is 1 over a number”. The teacher then asked the learner to use the square on the chalkboard to identify/define a fraction, “what fraction can you see there?” The learner answered that “is 1 over 4”. The teacher agreed that it was ‘1 over 4’. He then explained that “within 1 over 4, we have 2 names, this number has a name and also this number has a name”, “what are those names?” One learner said 4 is a divisor. The teacher asked about the other number. A second learner said “a numerator”. The teacher then asked this learner to identify which of the 2 numbers ($\frac{1}{4}$) is a numerator. The learner said 4. The teacher disagreed with that learner and gave a chance to another learner. This other learner said “4 is a denominator”. The teacher wrote on the chalkboard: ¼→denominator (divisor) then asked what 1 was, “the opposite of denominator is?” He then said that 1 was a numerator and wrote on the board. He further said that they had a fraction, “but now we are going to turn a fraction $\frac{1}{4}$ into equivalent fraction.” “But first of all a fraction is a part of a whole,” he said. The teacher explained that they had 1 as a part of a whole square (pointing to the square drawn on the board).
“Now we are going to turn an equivalent fraction, 1 over 4 into equivalent fraction” the teacher continued. He said “here we have 1 over 4, now to turn it into equivalent fraction,” he wrote on the chalkboard. He then stated the definition of an equivalent fraction that “equivalent fractions are equal but not exactly the same. Now we are going to turn 1 over 4 into equivalent fraction, to show how they are equal but not the same”, he continued. The teacher explained by repeating that to turn equivalent fraction, learners should remember that they are equal values, but not exactly the same. He asked whether learners understood what ‘equal value’ means.

3 “To turn $\frac{1}{4}$ (1 over 4) you’ve to multiply both the numerator and denominator by the same number, any number of your choice”. The teacher told the class that they were going to use 2. He wrote on the board: $\frac{1\times2}{4\times2}=\frac{2}{8}$ asking the learners the answer for top and bottom. The teacher then told the class that it was the way to turn $\frac{1}{4}$ into equivalent fraction. He explained that “we can multiply with 3 to turn it into another fraction”. He wrote $\frac{1\times3}{4\times3}$, asking learners to give the answer ($\frac{3}{12}$). He further repeated that this fraction $\frac{1}{4}$ was turned into an equivalent fraction. The teacher asked the learners again whether they understood equivalent fractions and pointed to the definition written on the board: “they are equal, but not exactly the same”. The teacher explained what it meant ‘not exactly the same’ $\frac{1}{4}$ and $\frac{2}{8}$ “because 4 and 8 are not equal but at the end they are going to give the same value”, he said. “You understand the same value?” He explained that when one divides $\frac{1}{4}$ by 1 it gives the same as dividing $\frac{2}{8}$ by 2. He asked the learners if they had any question then one learner stood up asking “where do you get the number that you multiply with?” The teacher commented “you mean the number such as 3 (pointing at$\frac{3}{12}$), you pick any number you want”. He further explained that “it is not that they are somewhere you pick any number 2, 3, 4, 5… as long as you multiply both numerator and denominator by the same number”. He explained again that one could not do $\frac{1\times2}{4\times3}$ as this would not give the same value. He asked whether they still had questions, but they said no. commonality

4 The teacher put a flipchart on the chalkboard with drawings showing 2 equal shapes: 1 cut into halves and the other cut into quarters. He referred the learners to look at the denominators $\frac{1}{2}$and $\frac{2}{4}$, then asked what was done to get $\frac{2}{4}$. One learner said “we double”. The teacher said “the scientific word from1 to 2 and from 2 to 4?” He continued asking. “What number we use or what way we use to get here?” He asked again. Another learner said “we multiply”, then the teacher asked by what number. The teacher then explained that “we multiply 1 by 2 and 2 by 2 ($\frac{1\times2}{2\times2}$), denominator and numerator by the same,” he said. Then finally one has the same value, the teacher explained. The teacher further explained that if one ‘reverses’ by 2, there would be the same value.

5 Since there were no questions asked, the teacher again explained pointing to the diagram cut into halves, saying “suppose you have an apple, and divide it into pieces and you take one and eat it, there was 2 pieces and you eat one, then there is only one left”. The teacher told learners to take their books to do the activity. He said in the activity they were going to (1) fill in ‘the missing letter’, pointing on the flipchart pasted on the chalkboard, and (2) ‘What is the numerator?’ The learners worked on this activity individually:

Fill in (a) $\frac{1}{2}=\frac{3}{\_}$ (b) $\frac{2}{3}=\frac{\_}{9}$ (c) $\frac{4}{8}=\frac{8}{\_}$(d)What is the numerator?



(3 shaded)

6 The teacher monitored the class work and marked the learners' work moving from table to table. The teacher informed the learners that the time was up, so he was leaving them to complete and bring the books to the office later. →Lesson ended

Figure 2: The learners' homework on equivalent fractions for ST5.

APPENDIX B: INTERVIEW QUESTIONS (SEMI-STRUCTURED)

APPENDIX B1: STUDENT TEACHERS' INDIVIDUAL INTERVIEW QUESTIONS

A) Introductory Questions

1. What have you found to be the most important aspects (parts) about fraction teaching that an upper primary teacher should know?
2. Can you tell me about what were your fears, for example, your frustrations in teaching fractions?
3. When teaching fractions, what were your weaknesses and strengths in the mathematics classroom, with regard to the different topics you taught such as
   (i) Equivalent fractions
   (ii) Comparing fractions
   (iii) Addition and subtraction of fractions?

   Why do you think is a weakness/strength?

B) How and why Questions about <u>teaching methods, approaches/strategies, T/L aids,</u> etc.

4. Let us talk about the activities you designed for your fraction lessons, what skills, what knowledge and the kind of behaviour (in terms of attitudes + beliefs) were you encouraging to develop among your learners through your teaching?
5. Looking at your lesson plans, you used teaching methods such as **<u>mention these methods</u>** to teach fractions. Why did you choose these specific teaching method/s over the others? What influenced you to use them?
6. Looking at your lesson plans on different topics, I noticed that you used diagrams drawn on flipcharts and paper-made teaching aids. What prompted you to choose these kinds of teaching aids? Why not other different teaching aids? E.g., Why not use concrete teaching aids? OR most of the times in the lessons, w**hy not use any teaching aid in your teaching of fractions?**
7. In your teaching of fractions to Grade 6 learners, through my observation, I noticed that you mostly used and adopted questioning techniques involving the 'what' and 'how' questions. Why did you opt to use these techniques?
8. I observed that when you taught fractions you used a lot of examples & exercises, where learners did a lot of drill practice of different calculations, both individually and group work. <u>Why</u> did you do that, what encouraged you to do this?
9. I noticed in your teaching of fractions that you emphasized on following the rules and procedures of finding solutions. An example is when <u>comparing fractions</u> with different denominators or <u>finding equivalent fractions</u>. Why? What motivated you to do this? What made you decide to use only this method?

C) Questions about the mathematics course

10. Looking at what you have learned about fractions on the mathematics education course both content and pedagogical parts, what effect does it have on your knowledge of understanding and teaching fractions?
11. Do you think the teaching of fractions offered on the mathematics education course equips you enough for teaching the topic of fractions? Why or why not?
12. What do you suggest the mathematics education training should offer you and other teacher trainees in terms of improving the teaching of fractions? Why? Elaborate.

APPENDIX B2: FOCUS GROUP INTERVIEW QUESTIONS

1. Did you find the mathematics education course useful? Name the 3 most important/interesting/useful things you have learned from the course.

2. What was your experience of being taught fractions as a school pupil (learner)?

3. Can you give 3 highlights of the teaching experience in those schools when you were teaching mathematics?
4. When teaching different subtopics of fractions to the Grade 6 class, did the learners possess the required prior knowledge? How did you incorporate the learners' prior knowledge in your fraction teaching?
5. I noticed through observation that most of you did not incorporate real life examples of fractions into your lessons. Why is that?
6. In most cases in your lessons on fraction topics, you asked learners to define new terms, e.g. equivalent fractions. Why did you choose to use this specific approach where learners have to define terms (terms they have never heard of before)? What influenced you to do this?
7. What are the errors and/or confusions you noticed that learners tend to have when learning different fraction topics? How did you address learners' errors and/or confusions in your teaching of fractions? (i.e. can you discuss some of the problems that you faced in the teaching of fractions? What suggestions did you try to employ to find a viable solution to the problem? Why?)
8. When teaching some of these fraction topics, you might have had to teach and re-teach, but pupils still could not grasp that particular fraction concept. What did you do in such situations?

9. In hindsight, what would you have done differently if you had to do the teaching experience of fractions over again? I.e. understanding the teaching situation and everything that happened, what would you have done.....?

APPENDIX C: STUDENT TEACHERS' INDIVIDUAL INTERVIEW TRANSCRIPTION

APPENDIX C1: Student Teacher 1 (ST1) interview transcription

NV: Thank you very much for agreeing to be interviewed for my study. I appreciate what you are contributing towards my research.

ST1: Mhh.

NV: I am going to ask you questions which are in 3 parts. The first part is the general one about what you are doing and then second is about what you were teaching about fractions when you were teaching about fractions when you were at school, then the last one is on the course, how helpful the mathematics education course. What have you found to be the most important aspects or most important parts about fraction teaching that an upper primary teacher should know? In your teaching?

ST1: Especially how to change the fractions with different denominators to equivalent fractions so that learners won't get confused when rearranging them.

NV: Mhh

So now you as a teacher, what is important for you to know? What do you think is important for you?

ST1: Is very important for me to know if I am not aware of changing fractions then I will end up teaching wrong things to the learners.

NV: What do you mean?

ST1: I mean content is very important for me.

NV: Can you tell me what were your fears, for example when you were teaching fractions in the classroom, what were your fears or your frustrations?

ST1: I was always afraid of making mistakes in front of the learners.

NV: I see.

ST1: Especially there is a point when they have to ask many questions and you almost get confused. So I was always afraid of giving wrong answers to the learners.

NV: Mhh

Now let us go to the teaching, when you were teaching fractions, there were some times when you have weaknesses or strengths. Now with regard to different topics, you taught a topic of like, comparing fractions, equivalent fractions. What do you think were your weaknesses there or your strengths there?

ST1: My weakness part comes from especially when I was teaching how to change from fractions with different denominators then later you have to ask the learners to arrange them in order. So my weakness point is I forgot to tell learners or to teach them how to put the numbers in order, although we discussed something similar the previous day, learners easily forget what you taught them previously. They fail to arrange numbers in order.

NV: Any strength?

ST1: Especially when I was teaching them to put the fractions in simplest form, so I think I taught them well as I can really see from their work that they understood.

NV: Ok

So why do you think this is a strength for you?

ST1: It is strength because they did well in the activity that I give them and the homework as well, and for example, when I ask them some questions, I can see that they really understand.

NV: Ok. Now let us talk about the activities that you designed for your fraction lessons. When you designed those, what skills and what knowledge were you encouraging to develop among your learners through your teaching?

ST1: I wanted them to learn how to think very fast not always to wait for the teacher to get answers from them.

NV: Now I looked at your lesson plans, you also used teaching methods like, discussion, individual work, and somewhere you also used lecturing, when teaching fractions. Why did you choose these specific teaching methods over the others? What really influenced you to use those?

ST1: I think through those methods is where the learners can learn easily, especially in class discussion, most learn most through interaction because sometimes when they have to help one another or discuss, they easily pick up something.

NV: So if you were to tell me what really influenced you to choose these, what would you say? What motivated you to pick them?

ST1: I think that I have noticed that it is the only way any learners can learn best.

NV: Let us go back to your lesson plans again, when you teach this theme of fractions. I also noticed that you used diagrams that are drawn on a flipchart and you also use paper-made teaching aids. What prompted you to use these kinds of teaching aids? Why not other different teaching aids, for example these concrete ones?

60 ST1: Because that was the only one I could find, and by drawing diagrams learners learn best, some learners learn best not only learning with numbers, but by looking at it.

NV: You were not able to find concrete materials?

ST1: Not really, I could not.

NV: In your teaching of fractions in Grade 6, when I was observing you I noticed that you mostly used and adopted this questioning technique where you asked questions involving 'what' and 'how' only. Why did you opt to use only these techniques, because you could ask learners 'what …..?' or 'how to do this?'

ST1: Ok. Especially the 'how' question, I choose to use this, the moment you ask the learner to explain in more detail or explain how she/he obtain the answer. The teacher can really see that the learner understand the concept.

71 NV: What about these questions like 'why'? Why don't use those also?

ST1: There are times when I am required to use why, but especially in mathematics if the learner did something or give a right answer, sometimes maybe she/he did not show the way how, then you now have to ask 'how did you do that?' you have to show all the calculations.

NV: Mhh. I also noticed that when you taught fractions, you used a lot of examples and exercises, where your learners did a lot of drill and practice of different calculations, like you used individual work, sometimes you did group work. Now why did you do that?

ST1: I have to give different activities to the learners.

NV: But why? What encouraged you to do this?

80 ST1: Because I know especially if I give them individual work, most of them fail to do that. Maybe I would give another activity on the chalkboard whereby everyone has to give attention while one of the learners is giving the answer on the chalkboard. Then maybe they will understand it better than by doing it individually. Or maybe they have to do in a group.

NV: So the way learners can learn fractions is by doing a lot of exercises?

ST1: Yes I think that they can learn fractions better this way when they do a lot of practice. Even when we learn fractions in our math course, we did lots of exercises and learned a lot.

NV: Ok. I also noticed in your teaching that you put an emphasis on following rules and procedures when one is finding a solution. An example is when you taught the topic of comparing fractions with different denominators as well as finding equivalent fractions; you showed learners the procedures of how to get an equivalent fraction for instance. Why?

91 ST1: Especially I showed them on how to get an equivalent fraction because sometimes learners get confused to know where to change is even sometimes difficult to us.

NV: What are you saying about the rules?

ST1: I am saying that these rules and procedures are important to them as they help them to do calculations correctly. Especially with fractions, the learners have to stick to the use of rules and apply them many times. Even when I learn fractions in secondary school I had to learn these rules.

NV: Ok. Let us look at the course now, the mathematics course that you are still involved with. Looking at what you have learned about fractions in this course both the content and the pedagogical part. What effect does it have on your knowledge of understanding as well as the knowledge of teaching fractions?

101 ST1: I haven't really heard you properly Ms.

NV: I am saying does it help you in a good way or it does not really change what you know?

ST1: What the course did for us. I think it help us a lot especially when we have to know fractions in order to be able to deliver the lessons of fractions in the class. Because if you don't know you will end up failing the learners.

106 NV: Mhh.

ST1: (continues..) What they are doing per grade the teacher should know and understand.

NV: So do you think that the teaching of fractions offered on the course here equips you enough for teaching the topic of fractions?

ST1: Yes

NV: Why are you saying that?

112 ST1: I am saying it because when I went for my SBS (School Based Studies), I did not find it very

difficult on how to plan lesson on fractions. I have not really struggled to plan only sometimes I went to ask a few questions from my support teacher, but most of it was ok. The course has helped me quite a lot, because for example, modeling fractions helped me to make sense of parts of a whole being shared

117 NV: Ok. So do you suggest now as a student teacher for mathematics this training of mathematics education should offer you and other teacher trainees in terms of improving the teaching of fractions?

ST1: I think they have to provide us with a lot of things, especially they have to teach us more about teaching aids, because some student teachers have problems about fractions because some of our colleagues still do not know, they can ask you what am I to teach. Meaning there was a lack of understanding amongst some students in the class on fractions during teaching.

NV: What do you mean?

125 ST1: I think that the training of mathematics education still needs to be improved. I also think that the content of the area of specialization should be well focused at least at the level at which the teacher trainees is studying. The methodologies should be given, for example, Grade 6 mathematics teachers should not really just be taught methods of a Grade 12 class.

NV: I see. Anything else that you would like to add?

ST1: Not really, but I think the training has to do more.

NV: Ok thank you very much for your time.

132 ST1: Ok Ms.

APPENDIX C2: Student Teacher 2 (ST2) interview transcription

1 NV: Thanks again for agreeing to be interviewed for my studies

ST2: Ok Ms

NV: Ok so I am going to ask you questions that are in 3 sections, one is on the general part of teaching, then the other one is your teaching in the classroom, and then the last part is on the mathematics course that you are doing here, your experience with it. So firstly, let me ask you what you have found to be the most important aspects or parts about teaching fractions that you think an upper primary teacher should know?

8 ST2: First I am saying a primary teacher who is responsible for teaching fractions; first of all you have to make sure that you focus on the teaching Medias. For me I say for you to deliver or to make sure that your learners understand the concepts of the fractions whatever topic, by the help of teaching Medias you will be able to cover whatever you are expected to do according to the syllabus.

NV: So now can you tell me when you were teaching, what were your fears, for example or your frustrations in teaching fractions?

15 ST2: I can't say really is fears or frustrations, but I was just having doubts, asking 'am I really making my learners come to the point where I am trying to bring them?' Or 'are they really getting my way of teaching?' 'Am I really getting the message across?' that was mostly the question I always asked myself, it always came into my mind.

NV: Mhhh. Ok now let's talk about teaching, you were teaching fractions.

ST2: Yes

NV: The topics such as comparing fractions and equivalent fractions. So what were your weaknesses or strengths in the classroom of mathematics with regard to these?

23 ST2: Ok my weakness was, can I say my weakness?

NV: Yes you can

ST2: My weakness roughly was that I did not really come up with teaching medias. The point is that I couldn't really make my learners get my point when it comes to comparing fractions. This is so because most of them could not see something demonstrated, you know most learners learn something well when seeing something. By that I failed so that is where my weaknesses are at.

NV: Any strength then?

ST2: The strength is that I did not loose focus at least, I managed to move on, used the example here and there, at least I managed.

32 NV: Right. Now let us talk about the activities that you were preparing and designing for your fraction lessons. So when you were designing those, what skills or what knowledge were you encouraging, you know, to develop among your learners through the teaching of fractions using these activities?

ST2: Come again?
NV: When you were teaching fractions,
ST2: Yes
NV: You designed activities for your learners. So what did you want them, I mean what skills did you want them to developer what knowledge you wanted to be brought by the use of those activities?
ST2: Alright. Let me try to think about the way I understand your question. I try at least to take time to set the activities in such a way that learners will be able to recall the knowledge that they act out of my explanations and out of my demonstration. I was trying to test their knowledge, what they have learned whether they can at least put in practice what I have taught them.
NV: Ok. I also looked at your lesson plans and I noticed that you used these teaching methods, one is the lecturing method, and the other one is the discussion method. Why did you choose these specific teaching methods?
ST2: First of all I used a bit of the lecturing method to allow myself to explain to the students what I have prepared for them. And again on the discussion method is to give them a platform so that I get them more involved so we discuss a bit.
NV: Mhh
ST2: So that at least I get any question from them.
NV: Are you saying your learners have also to contribute?
ST2: Yes the learners should definitely contribute to what is taught in the class.
NV: Ok. The other thing that I noticed, on the fraction topics that you taught is that you used diagrams that are drawn on a flipchart
ST2: Yes
NV: And you also used these paper-made teaching aids
ST2: yes
NV: What prompted you to choose these kinds of teaching aids?
ST2: I understand that the lesson without teaching media is not really a good lesson. So I chose those ones because they are the only ones I got, but of course I needed more. I chose those to be able to cover what I am expected to do, for me to make it easy to explain what I mean when we are saying 'common fraction', even 'comparing fractions'. Is just for me to be able to explain for them to understand what I am trying to teach them.
NV: Why not these concrete ones? Why only the paper-made ones?
ST2: I couldn't get the concrete ones, is a pity, but at least if I could get the concrete ones of course I will use them
NV: Ok. Now in your teaching of fractions to Grade 6, when I was observing, I also noticed that the questioning technique that you used involves mostly 'the what' and 'the how questions. So why did you opt only to use these kinds of techniques?

ST2: Is for learners at least to think more critically, say for example, I put a problem out there, so if I say what is it, how is it done? I am trying to critically test them and bring them closer to the competency that I want them to reach. That is why I chose these kinds of questions.
NV: What if you were to use the 'why' type of questions? Because I did not notice you using questions like 'why are we doing what?'
ST2: Is also possible. Is only that you did not notice but I used it for some time, but not so many times.
NV: I also observed that when you taught fractions that you used a lot of examples, you used a lot of exercises, where you learners have to do a lot of drill and practice of different calculations. Now why did you do that? What encouraged you to do that? What encouraged you to do this?
ST2: I believe that practice make it perfect. So through examples learners will understand. They develop questions and answers, you clear their doubts. You make time to find out those hidden questions and by giving a lot of practice they become very good instead of just sitting there without doing anything. You must keep them busy doing fraction calculations in order to learn. And that is how I learned fractions previously in schools where teachers gave us exercises, even on the course. It was not easy but we tried our best. I tell you on our math course we did so many exercises on fractions and learn so much.
NV: I see.
And when you teach I noticed there you put a lot of emphasis on like following the rules or the procedures when doing things.
ST2: Yes
NV: Especially as one is finding like an equivalent fraction or one is comparing fractions you said

'you do this and then you do that' in steps. Why?

ST2: I believe that the primary phase is the foundation so you have to lay the foundation that's why I have to use the rules. Even the goal in their textbooks I have to teach what the syllabus is saying, I have to follow the rules, from where they are learning specific things exactly as they are. Even they grow up things are exactly as they are taught from the primary phase. That was how it was when we went to school, learning fractions at primary and secondary school.

NV: What are you saying exactly?

99 ST2: I am saying that it is very important when it comes to teaching fractions to do it according to procedures and rules. Through teaching fractions, I show them the rule of doing for example, subtraction of fractions, and then they will remember it when practicing these calculations.

NV: Ok. Let's look at this course, the mathematics course that you are still doing.

ST2: Yes

104 NV: Looking at what you have learned about fractions on the course, that is both the content and the pedagogical part of it, what effect do you think it has on your knowledge of understanding fractions as well as on your knowledge of teaching fractions?

ST2: First of all I must say that there are a lot of effect about teaching it brings the awareness of what you have to consider. I must say it is not easy to teach the topic like fractions. Honestly it is not.

110 NV: Why are you saying that?

ST2: Especially if you are not well prepared and if you are able to give really what is expected. And then another thing if you bring in the teaching media which are not easy to get. So there are a lot of things I think you have to consider.

NV: Ok, so now do you think that the teaching of fractions that is offered mathematics education course in this has equipped you enough for teaching the topic of fractions?

ST2: Oh yes.

NV: Why are you saying that?

ST2: Before I found this course.

NV: Mhh

120 ST2: I couldn't know where to start.

NV: Ok.

ST2: But since like in the 2nd year with the help of any learner, the she do and the way she has been teaching us, now I am putting myself in her shoes. Now in my lesson on fractions, I use to give a lot of examples, a lot of exercises. I have the notion on my lecturer. That is why when it comes to teaching of fractions is not tough anymore because I am equipped. At least I have the knowledge and the foundation.

NV: So now what do you suggest this training should offer you and other teacher trainees you know how who will be coming here in terms of improving the teaching of fractions?

129 ST2: I must suggest, I don't know how or from where but anyone can teach that topic but I must say that it should focus from and the area of teaching media, that is number one on my list. If the lecturers could teach more student teachers on how to approach this. This is really a serious problem as most where can I find this teaching aid, how can I deal with this if they could really focus and teach more on this I think student teachers will be able to deliver lessons with easy.

NV: What else are you suggesting on the improving?

136 ST2: Again on the method of teaching

NV: Yes what about the method?

ST2: You know sometimes the topic of fractions you don't need to just do chalk and talk. You should give learners practice, involve them, they must discuss.

NV: Mhh.

141 ST2: From there you will be able to find out who is struggling here, who needs help here. I don't know how but the training should give students teachers techniques and strategies on how to help slow learners during this remedial teaching. that is student teacher should be guiding on how to give learners the help they need to meet the adjectives of the lesson. The student teacher does this microteaching so I think that they should do microteaching more on fractions?

147 NV: Why more on fractions?

ST2: I think that this is the right platform where they will be guided on fraction teaching in terms of methods and teaching media.

NV: Do you have anything else that you like to add?

ST2: I can say mathematics especially on the fraction topic is one of my favorite topics. I really

hope that I'll gain more knowledge in this. That's why I like the mathematics education course teaching content to include in the fraction topic: things like examples that student teachers will be able to explain clearly to learners you know, real life examples and also the importance of fractions in life where and how they are used in life.

NV: Thank you

157 ST2: You welcome.

APPENDIX C3: Student Teacher 3 (ST3) interview transcription

1 NV: Thanks a lot for agreeing to this interview

ST3: Mhh

NV: It is contributing to my study and I really appreciate your time. I am going to ask you an interview which is divided into three parts. The first one is on general teaching of fractions, second is when you were in class or preparing lessons on fractions, then the last part is for the mathematics education course we are offering at our campus.

7 ST3: Mhh

NV: Ok tell me, what have you found when you were teaching fractions, what have you found as most important aspects that you think a mathematics teacher should know?

ST3: In teaching fractions I think what a teacher should know before he/she starts a lesson plan she has to think of what about the teaching aids she has to use that will bring reality in the classroom. So I think that is the important thing.

NV: Now can you tell me when you were teaching fractions, what were your fears, what were your frustrations then?

14 ST3: When I was teaching fractions, especially the equivalent fractions and comparing fractions with different denominators, my fears to that was that learners only know with regard to convert fractions to simplest form.

NV: Mhh

ST3: They only know how to convert just especially when you give them a big number, they only go to the next number, but to go to the last number they really have difficult there. It always takes time to say 'no still you did not reach the final answer'.

21 NV: So when teaching fractions then, what do you consider as your weaknesses or strengths for example, to the teaching of equivalent fractions or comparing fractions?

ST3: Yes weaknesses, for me is just the teaching aids because you have to think hard and deeply to come up with something. You also have to think about the side of the learners as well whether they will be able to understand. My weakness was that the way I was teaching

NV: Mhh, what happened?

ST3: The teaching aids that I used, I thought it would be easy for the learners to understand, but later on it just brought confusion among the learners.

NV: So why do you consider this as a weakness?

30 ST3: It was a weakness because I failed to make the right or the easiest aid that will be used and understood by the learners.

NV: Any strength?

ST3: The strength is that I tried to correct most of the mistakes that came up in the lessons. I tried even though I did not really make everyone to understand, so I never gave up.

35 NV: Alright. Let us talk about the activities that you were designing for your fraction lessons. So when you designed those activities, what skills or what knowledge were you encouraging to develop among your learners?

ST3: Can you please repeat the question Ms?

NV: You know when you were preparing your fraction lessons for fractions,

40 ST3: Mhh

NV: You designed activities for the learners,

ST3: Yes

NV: In designing those activities what skills did you want to develop in your learners or what knowledge were you aiming to come out through teaching using those activities?

45 ST3: What I wanted learners to have knowledge of is that I really wanted them to know that fractions involve a whole divided into parts. I just wanted them to fully understand what fractions really are, not by just memorizing, but I wanted them to know and understand what a fraction really is.

NV: I also looked at your lesson plans and noticed that you used teaching methods such as

individual, pair work, and group work, and I also noticed through observation that you used lecturing somehow. Why did you choose these specific teaching over the others?

51 ST3: individual, lecturing, group work and pair work?

NV: Yes, what influenced you to choose those?

ST3: Ok, let me start with lecturing first. I decide to lecture first because through just my questioning I realized that learners do not really have correct information about what fractions are, that is why I first explain to them a little bit about what a fraction is, before we go ahead on how to work with fractions. I then decide to work with a group work where learners will work together sharing ideas so that those who do not understand will listen to others on how to do it right and so on. Also by pairs I decide to put them in pairs as well just again to work with each other. By individual, there I wanted to know how each individual learner by himself/herself doing her work according to what we did. We did most of these methods and approaches in the math course.

62 NV: I also went through your lesson plans and then looked at the different topics that you taught. I noticed that you used diagrams that are drawn on flipcharts and that you also used paper-made teaching aids. So what prompted you or what encouraged you to choose these kinds of teaching aids?

ST3: Drawing as I have mentioned earlier, I just draw to show for example, we draw a circle or a rectangle on a flipchart to show them that this is a whole divided into parts. I wanted learners to do and work with fractions. To see if they understand I cut those papers then ask questions like 'who can come and do fraction 2 out of 10 or 9 out of 10'.

70 NV: What is the purpose of this?

ST3: I wanted them to work with their own hands and their own understanding.

NV: So why not use these concrete teaching aids beside papers?

ST3: I did not use that, I think that is one of my weaknesses.

NV: What is really the reason then?

ST3: The reason is that I failed to come up with the concrete ones. I did not really have ideas on how to come up with these. I hope by next time I will look for ways of how to come up with concrete teaching aids, then hopefully I will succeed.

78 NV: Mhh. So in teaching fractions to Grade 6 learners, through my observations I noticed also that you mostly used and adopted this questioning technique of using the 'what' and the 'how' questions. Why did you choose this technique, because the questions I noticed you asking in the class are like "what is …?" or "how do we do …?" Why did you choose this kind of questioning?

83 ST3: I used them with the purpose of knowing how far learners understand the concept. Or like for example 'what is a fraction' I wanted then to know if they can explain or they really do understand a fraction or 'how do we compare'. I wanted them to give me a clear picture whether they really do understand or not then maybe I have to go back and teach the topic again.

88 NV: So why not using questions involving the 'why', and the 'when' for instance?

ST3: I thought maybe the questions are not really the same if I used 'why' like 'why do we compare these fractions' or 'when do we convert these fractions in simplest form'. It was just like the answers would be just the same.

NV: What does this imply?

ST3: It means that regardless whether I used why or how the answers would be .the same. So that is why I used some (what and how).

95 NV: I also observed, you know, when you taught fractions that u used a lot of examples and you also used a lot of exercises, where your learners did a lot of drill practice, whether it is individual work or group work. Why did you do that?

ST3: I believe that practicing makes the teaching or learning easier.

NV: How is that? Explain more.

100 ST3: Because when learners are doing or practicing by calculating everything that you give them, that will be better than just doing things theoretically where they are just being told 'that is how this is done'. They wouldn't know how to maybe give their own ideas because by practicing is where learners give their own work, is where you see that this particular learner knows how to do this way and clearly shows the work. In our math course we did a lot of exercises when taught fractions and it helps, we learn so much.

106 NV: The other thing I noticed is that when you teach fractions, you put an emphasis on like the rules or the procedures of finding something, finding a solution to something.

ST3: Mhh

NV: For example, when you taught the topic of comparing fractions with different denominators so you do this, followed by that and that. Or finding an equivalent fraction, you also taught them that 'you do this, then you do that' in steps. So why? What really motivated you to do this?

112 ST3: Yes as a teacher I have to show learners on how to work out something or how to find a solution to a specific problem, but I should indicate the steps on how it is done. It means I should show them step by step so that when I give them something to do, they will just remember exactly how I showed them and work exactly the same way.

NV: What are you saying exactly about procedures and rules?

117 ST3: I am saying that procedures and rules are very important in the teaching and learning of fractions. The learners have to learn and use rules when calculations as they make them remember what to do, what step to take next. That is how we learn mathematics in our schooling years and I think it helps.

NV: Let us talk about the mathematics education course that you are still doing.

ST3: Mhh

123 NV: Looking at what you learned on this mathematics course, whether it is the content or the pedagogical part of it, what effect, what cause does it have on your knowledge of understanding fraction as well as teaching them?

ST3: Mhh. I am sorry the question is not quite clear Ms.

NV: Do you feel this mathematics education course has a negative or it has contributed somehow to your knowledge of understanding and teaching fractions?

129 ST3: Let me say that it contributed too much to my knowledge because; I was not really having an understanding of fractions. I was unable to even compare fractions or convert them into simplest form. When we did so many things about fractions on this course, including these parts, I understand it especially that this how to compare, this is how to simplify, this is how fractions are. I really understand better more than before. While I was teaching fractions, in the class, I realized and found out that fraction is not one of the easiest topics for the learners, even though some of them are already aware of it in life.

136 NV: How is that, why do you say it is difficult?

ST3: When they are introduced to it in class, they tend to be confused since it is taught theoretically instead of practically. I realized that the learners find it hard to relate to even what they already know.

NV: So do you think that the teaching of fractions offered in this course has equipped you enough for teaching fractions?

ST3: Yes I really think so.

NV: Why are you saying that?

144 ST3: Let me say I now know many important things about fractions from this course. Even now when I have to think that this is what needs to be taught or this is how I have to teach fractions according to what I have learned here and this is how I should deliver my lesson about fractions, and that experience or that knowledge I got from what I learned well. So it from what I learned here that I can teach well.

149 NV: Now what do you suggest this mathematics course training should offer you and the other teacher trainees in terms of the teaching and learning of fractions?

ST3: In terms of improving teaching I think if it was just possible for even, I don't know because I believe anyone standing in front of a class is a teacher. But I think if everyone or maybe each teacher educator who is going to teach a subject, especially the mathematics education course if she/he could help to teach about teaching aids related to the topic of fractions that will be better. I think so because still I now realized that teaching aids and everything you are going to use in your teaching is important, but one should need to use evidence in terms of teaching aids. There should be skills offered on how to develop and create teaching materials including concrete ones on teaching fractions.

159 NV: Beside teaching aids, what about the content part?

ST3: I think that the teaching of the content should be based on the current syllabus including the fraction objectives and competencies taught in schools.

NV: Mhh. Is there anything that you would like to add?

ST3: Yeah, just a little bit that mathematics is really a good subject. I only came to realize that it is a good subject when I got a good teacher on this course. To teach mathematics I think you need to have experience on how to teach and knowledge about it, not just by saying I know mathematics. But as a teacher one should also know how to teach the subject and why it is important. That is why I see some students running away from the subject just because at the beginning the teacher did not really give a clear picture of what mathematics is. In addition, I

think that the student teachers who are majoring in mathematics should be trained on teaching mathematics without using a calculator. It is important so that when they start teaching they will have proper techniques and steps to give the learners on how to calculate fractions, addition, subtraction and especially converting fractions.

NV: Thank you very much for your time.

174 ST3: Yes Ms.

APPENDIX C4: Student Teacher 4 (ST4) interview transcription

1 NV: Thank you very much for agreeing to this interview, I am going to ask you an interview which is having 3 parts, the general part, the teaching part, you know about what you were teaching in the classroom, and the course that you are doing here, the mathematics education course.

ST4: Ok Ms

5 NV: So firstly, let me ask you now when you were out there at the school. What have you found to be the most important part about fraction teaching that you think an upper primary teacher has to know?

ST4: First of all let me focus on the fraction itself, the common fraction as we normally know it. What is important for the teacher to know is the difference between the kinds of fractions we have: proper fraction, improper fraction, mixed number, common fraction. When a teacher gives these to the learners, he should know their differences.

12 NV: What are you trying to say?

ST4: The teacher should know more about the content part of the fraction

NV: Ok. Let me ask you to think back when you were in the classroom. What were your frustrations, you know when you were teaching fractions?

ST4: Yeah, the fear is that especially myself was that maybe learners do not know or maybe as a teacher I could not explain clearly what a common fraction is , what is a proper fraction, for the learners to know.

NV: Mhhh

20 ST4: The fear is learners may need assistance because when you ask them to differentiate these, they just confuse.

NV: Let us now look at when you were teaching fraction topics such as equivalent fractions, or comparing of fractions.

ST4: Mhh

NV: So what do you consider as your weaknesses or strengths in the mathematics classroom?

ST4: It goes like for the equivalent fractions especially to me as a teacher, a student teacher, I don't think really there is a challenge, only the fact that I have the children at heart. To talk of this topic, for example ½ ('1 over 2') equivalent to ¼ ('1 over 4'), ok for the teacher to explain to the learners how I come up with 2 over 4 is a big challenge for me.

30 NV: Mhh. Why do you say that?

ST4: Because like in that topic learners were not taught exactly about how to multiply the numbers, so that they can get the next number the equivalent one.

NV: And which do you think as your strength? Any strength at all?

ST4: Yeah my strength is that I do manage it and when I give the task to the learners most of them got it. The weakness is that some of them have failed. I am guessing that maybe I did not clearly explain it to them.

37 NV: Ok. Let us look at the activities that you designed while you were teaching fractions. When you were designing those activities to use in the lessons, what skills or what knowledge were you encouraging to develop among your learners through teaching fractions?

ST4: Honestly I did not encourage the learners to come up with anything is only when I brought flipcharts with pictures, then sometimes we divided those pictures in parts. Like ½ (one over two) , 2/4(2 over 4) and then give it to the learners so that they can see these numbers on pictures.

44 NV: Yes, but why did design those activities for them? What did you want them to develop from these activities? Any skills or knowledge?

ST4: Really, it is clear that learners learn at a different pace. Some are good when they are seeing the picture; they can remember it whenever you ask them in the future. Some are good in listening, that is why I came up with those activities so that I can develop their knowledge to help them remember.

51 NV: And when I looked at your lesson plans I noticed that you used teaching methods such as

lecturing method, class discussion, as well as the individual work. Now my question is why did you choose these specific teaching methods over the others?

ST4: Ok thank you very much. I started to use those 3. I can say that they are the best among the others.

56 NV: Mhh. Yes?

ST4: I just think that they are suitable for what I am going to teach.

NV: Why?

ST4: Example the lecturing method, first of all a teacher, I have to give a description to the learners of what we are going to do.

61 NV: Yes

ST4: Then I can move a step onward to go for like a class discussion whereby I have to give a task Or a certain question to the learners. Then I ask them to discuss it. Then later on when I give the activity I want learners to do them individually for the teacher to know and see which learner understands and which learner does not understand and then decide what to do with those who do not understand.

67 NV: Ok. And the other thing I noticed in your teaching, I did not really see a lot with regard to teaching aids except I saw that you gave them handouts or you used diagrams that are drawn on flipcharts while you were teaching fractions. So why did you choose not to use these kinds of teaching aids, where you used children standing in front of the class as your teaching aids?

71 ST4: Thank you very much. I did not use them so often. The fact is some learners if you give them like something as a teaching aid for example a flashcard, some of them will just play with them, and they won't concentrate onto what is on that card as a teaching aid. That is why I normally used a flipchart whereby a teacher just hanged it on the chalkboard so that everybody would look at it or pay attention. I hope that if I spread them among the learners some won't pay attention.

77 NV: So why couldn't you use like concrete teaching aids, these real materials as part of your teaching aids?

ST4: Ok like the real one as a teacher I could not get time to prepare for them.

NV: Mhh

ST4: I also did not think of them honestly. Maybe next time I will do something.

82 NV: So in your teaching of fractions to these Grade 6 learners, I also observed that you mostly adopted the questioning techniques where you involved questions like "what is…" or "how is something done?" Why did you opt to use this kind of questioning technique only, this questioning style?

ST4: To me I understand that a question gives the clue of what a person wants to ask. An example if I ask a learner like 'who can tell me what a fraction is?' The word 'what' tells the learner what a teacher wants. Or if I say e.g. for equivalent fractions, if I have ½, 2/4, then ask them how do I come up with the next fraction? Then the learner can know that a teacher wants the process maybe.

90 NV: Ok.

ST4: Mostly I used 'what' and 'how' to differentiate between the different questions.

NV: Why didn't you include the 'why' questions? Like asking 'why we do this' for instance?

ST4: I was not really like focusing on the level of the learners. Some learners don't know if you are asking why, they couldn't really differentiate whether you use what or how or why. Some are not good in English, so that is why I used this simple English which is the same as applied in the textbook. Because the textbook also uses what and how.

97 NV: I also observed that when you taught this topic of fractions you used a lot of examples and exercises where learners have to do a lot of drill and practice, doing different calculations. Why did you do that? What encouraged you to really do this?

ST4: For me to give more activities and exercises for the learners, it says "the more you give the better the learning becomes". I mean is better for me to give a lot of exercises then I will know exactly where different learners have problems instead of just giving one or two exercises. This is the only way they learn. I remember doing many exercises with fractions in the math course, it taught me so much.

105 NV: Ok. Also when you were teaching I noticed that you put really an emphasis on rules, Following the rules and procedures of doing or finding solutions, for example, when you were doing the topic of comparing fractions, when they have to compare fractions with different denominators or when they have to find the equivalent fractions, you told them that this is the procedure: you do this and then that ….. Why? What motivated you to do this?

110 ST4: From the courses that I did so far we are told that if you tell a learner to do something that is

what the learner will develop. An example is that you have to follow procedures in mathematics that a learner will know. If you go beyond that then you mislead this learner.

NV: What does this have to do with doing fractions?

ST4: I am saying that it is the right way when learners are doing fractions that they should do it in steps that the teacher provides them. They should follow the exact rules to get their answers. This way they learn best. It is how I learned fractions in primary and secondary school that rules are important.

118 NV: Now looking at the mathematics education course that you are still doing.

ST4: Mhh

NV: Now if you are looking at what you learned about fractions on the course, both the content part and the pedagogical part of it. What do you consider as the effect or outcome it has on your knowledge of understanding fractions as well as on the knowledge of teaching fractions? Has it contributed to what you know now about fraction or has it contributed to your teaching of fractions?

125 ST4: Of course it contributed to what I know.

NV: How?

ST4: Let me say through my course I did not know fractions as much before from high school.

NV: Yes

129 ST4: Added to my knowledge from the mathematics course are many new things about fractions that are in my mind now. The way I delivered the lessons of fractions, and the way I question my learners like I was taught here on the course.

NV: Mhh. So do you think that the teaching of fractions that is offered on this course has equipped you enough to teach fractions?

ST4: Of course

135 NV: Why? Can you explain a bit?

ST4: I can say it has equipped me, but a person has to learn more. The student teacher has to be taught how to explore more about fractions. I can't say it is enough student teachers should be taught different methods in order to teach fractions properly to their learners.

NV: Now what do you suggest as a student teacher who is doing this mathematics education training, what do you consider this training should offer you and other teacher trainees in terms of improving the teaching of fractions?

142 ST4: I think that like now we are going back to our SBS, the course should provide and guide us on the use of teaching aids. I am not saying they have to provide teaching aids for us, but to really guide and train us how to come up with correct teaching aids for fraction lessons. Secondly, I think we student teachers need help when we are out there, teaching fractions sometimes we do not understand the topic, so we need help.

147 NV: Ok do you have anything you want to add?

ST4: Let me just say the topic of fractions, I like it and I know that we are not perfect. I know we can give unnecessary information, but is because we are new in this profession and need all guidance to teach fractions well.

NV: Thank you very much

152 ST4: Thank you Ms.

APPENDIX C5: Student Teacher 5 (ST5) interview transcription

1 NV: Thanks a lot for agreeing to this interview. I am going to ask you an interview that is grouped into 3 parts, first part is about the general teaching of the fractions, second is on how you were teaching and then lastly about the mathematics education course that you have been doing, the course we are offering here on this campus.

5 ST5: Ok Ms

NV: Let us start off with when you were teaching in the school there, what have you found to be the most important part that you think when one is teaching fractions should know as a teacher?

10 ST5: Mhhh. (struggles with response)

NV: What things do you think are important for a mathematics teacher who is teaching fractions has to know?

ST5: I think what you should know as a primary math teacher one should have a knowledge of how to teach the content of fractions and how to use different ways in the class. I remember when I was teaching the fractions on this topic of equivalent fractions, I did not use much examples,

but learners could not understand until my support teacher came and gave them some examples of how to identify some of these fractions.

NV: What should the teacher have then?

ST5: The teacher should have something written for the learners to see.

NV: Can you tell now when you were teaching fractions, what were your fears for example, or your frustrations when teaching fractions?

ST5: The good thing was most of my learners understood easily, but I was always having the fear when I introduced a fraction topic that maybe they will not get me.

NV: There were times when learners struggled?

ST5: Yes and that counts as part of my fear as I sometimes did not know what to do.

NV: Ok, let us talk about when you taught fractions, what were your weaknesses or your strengths then, for example let us refer to the topic of equivalent fractions or comparing of fractions? What do you consider as your strengths or your weaknesses there?

ST5: My weakness is just to do with the use of concrete materials

NV: Any strength?

ST5: My strength is that I know fractions I can teach them, but just that I don't really have a knowledge of different ways to make learners understand.

NV: What does this mean?

ST5: I mean my content is ok, but the way of teaching and presenting fractions to the learners is not.

NV: I see. Let us talk about the activities. You designed activities for your fraction lessons. What skills, or what knowledge were you encouraging to develop among your learners through your teaching?

ST5: The purpose was for my learners to come up for example drawing pictures divided into parts, they should come up with denominators and numerators.

NV: Ok. I also looked at your lesson plans and I noticed that you used different teaching methods such as class discussion, group wok and question and answer. Why did you choose these methods over the others? What influenced you to pick them?

ST5: Is because we do it together.

NV: What do you mean?

ST5: Like when I used class discussion method when teaching fractions, we talk I move around the class and we discuss together. I think this makes it easier for them to understand what is taught.

NV: And the question and answer as well as group work?

ST5: The question and answer method is a kind of testing them after I discuss with them to see if they have picked up the new content. Group work is for them to mingle and share ideas, teach each other.

NV: I also noticed through looking at your lesson plans of the different fraction topics that you taught, you used diagrams that are drawn on a flipchart or you used paper-made teaching aids. What prompted you to choose these kinds of teaching aids?

ST5: I thought through using these diagrams drawn on flipcharts as teaching aids learners see what is really happening when you paste a picture on the chalkboard that they know. These diagrams looked like real to me.

NV: So why not use other teaching aids, beside the paper-made ones? Why not concrete ones?

ST5: Is just that I did not get enough time like to share the apple in the class or things like that.

NV: Mhh. What is the problem with that?

ST5: Is just that from SBS we came so late that one can hardly find time to collect materials.

NV: Ok. In your teaching of fractions to these Grade 6 learners, I noticed in my observation that most of the questioning techniques that you used involved the 'what' and 'how' questions. Why only those?

ST5: Is to do with the level of understanding of the learners.

NV: What about using 'why' questions, e.g. "why are we doing what?"

ST5: The learners will struggle to answer those ones that is why I do not include them in my teaching.

NV: I also noticed that when you taught fractions, you used a lot of examples and exercises, where learners did lots of drill and practice of different calculations. Why did you do that? What encouraged you to do that?

71 ST5: Because they say that 'practice makes perfect'. That is why I gave my learners many tasks so that they can solve different fraction problems. Is just a way that when you do something over and over, you cannot forget, it becomes like a poem in your head, so you really master the skill. In schools we did it like this, we solve so many exercises in fractions to learn. Also in the course we calculate with fractions.

76 NV: Ok. I also observed that when you taught fractions, you put an emphasis on following the Rules and procedures when doing things, for example, when you were doing the comparing of fractions using different denominators, or how to find equivalent fractions, or the adding and subtracting of fractions. You told the learners that 'this is the way you have to do this', 'you do this, then this, followed by that, remember this very well'. Why? What made you decide to use this kind of method?

ST5: That is the way, when it comes to for example writing an exam and learners put just answer, and they are marked by someone from outside, then it is wrong.

85 NV: You think following rules and procedures is important for examination purposes?

ST5: I think that following procedures in mathematics is the only way. But is very important to show exactly steps the teacher gives in the class to show that you follow and remember what was taught. My teacher from primary school told us for like addition and subtraction of fractions for example, one uses the rule of lowest common multiple, is important that you do it step by step to show the answer. I remember how my primary teacher told me so many times to remember the rules.

92 NV: I see. Let us now look at this mathematics education course that you are doing. Looking at what you have learned on the course here, about fractions, both content and pedagogical part, what do you think is the effect of that is on your knowledge of understanding fractions as well as your teaching of fractions?

ST5: Well the effect?

NV: Yes, does the course have a positive effect on you or it does not help at all?

98 ST5: The effect is positive. It really helps as I did not have the basics especially with fractions from the lower grades. For me it helps when I go out there to teach even if I am not perfect.

NV: Mhh. Ok, so you think the teaching of fractions taught on the course has equipped you enough to teach fractions?

ST5: Yaa, a bit here and there.

NV: What do you mean?

104 ST5: Because we are taught things that I did not know before from high school, e.g. addition and division of fractions.

NV: What do you suggest the mathematics education training here should offer you and other teacher trainees in terms of improving the teaching of fractions?

ST5: I think we need to be taught more fraction content and explore this and train us more on designing teaching aids.

109 NV: Anything else you like to add?

ST5: Not really.

NV: Ok thank you very much.

112 ST5: Ok Ms.

APPENDIX D: FOCUS GROUP INTERVIEW TRANSCRIPTION

The following is a focus group interview between N Vatilifa (NV) and five student teacher trainees (R1, R2,.., R5)

1 NV: Welcome everyone. I only have very few questions that I'll ask you, only 9 of them. Ok the first one is I want to find from you, did you find the mathematics course useful? Name 3 things that you find as useful to you that you learned from the course. Anyone can just give his/her opinion.

Respondent 1 (R1): Thank for the chance. I found this mathematics course very useful. Let me just of the knowledge experience in terms of what are gain, the more you are given activities to do, the more tasks you do, or anything in the lesson you gain more experience on that you did not know.

NV: Mhhh

R1: You know from what you don't know. The second thing mathematics is very useful in everyday situation, like we counting, which form part of our everyday life. Thirdly this course gave us ideas about anything we do; using phones, for example is all about mathematics. Using numbers, watches, reading and our daily routine, is all about mathematics.

NV: Ok, specifically now referring to this mathematics course that you are still doing was it really useful in a way? Is it still useful to you that you are still learning things?

R1: Yeah because I am still learning, it is still useful. Because what we have learned in the lessons here it has given us knowledge and experience of fractions, how to give it to someone else.

NV: Anyone else? Three things that you think are most important to you and you learned them from the course, the mathematics education course?

R2: Ok thank you for the chance. Something like, we learned a lot so to say for example the topics like ratios, we'll be able to apply them in our daily life situations, not only in a classroom, but one will apply these in his own environment. By the help of mathematics we learned here we know that this is to applied here and even in terms of money, I am saving here or loosing, them can make a right decision.

NV: Ok anyone else? If you have any point at all. (No one responds). OK let us move to the next one. Now from your experience, from your own individual what was your experience really of being taught fractions? Now I am talking of when you were at primary school, what was your experience being taught fractions as a learner? If you look back?

R1: Let me start. If I recall back, I only came to know the division of fractions by one fractions of using pictures here, where you divide these pictures by the other picture. I only came to know it when I joined this course.

NV: Mhh. So you did not know this like in primary school or even secondary school?

R2: No, not at all. At least now, even coming up with a correct picture of using fractions. I only came to learn it in this mathematics course. Now I can even do it myself using pictures with fractions.

NV: I see. Anything from you? (the 3rd participant).

R3: Nothing Ms.

NV: What do you mean? Let's imagine now you are in Grade 10, what was your experience of fractions when the teacher was teaching you? How did you find it??

R3: It was difficult for me. I did not even know things.

NV: What do you mean difficult?

R3: That time I thought fraction was useless.

NV: (laughs, together with participants). You never thought you will become a teacher?

R3: Not really.

NV: Anyone else?

R4: From my experience almost the same as he said.

NV: Mhh

R4: (continues...) Like when I was in primary school I did not really know even when the teacher was teaching fractions. I did not really understand. I only came to know something about fractions when I was in Grade 12,but much more I learned it here. For example, I did not know there is a difference maybe we have equivalent fractions and now to put it into simplest form. Therefore I learned all this here and I can even show these to the learners.

NV: Mhh. Interesting.

Ok now let us talk of your teaching. Can you give like 3 highlights of the teaching experience when you were at those schools teaching mathematics? Just 3 highlights you experienced there.

Anyone? Highlight your experience, you know, when you were teaching mathematics.

R3: On the topic of fractions, the same fraction even though different numbers, now to change it, when I taught this to the learners, you know to use pictures to show them how to divide it correctly, I could not do it.

NV: So how did you do it? Was it easy for you or was it difficult?

R3: It was very difficult; I could not do it until my support teacher came in and showed the learners how it is done.

NV: So the support teacher gave assistance on this one?

R3: Yes, she did.

NV: Ok. Anyone else?

R1: Yeah. To me I experienced like numbers like 1 over 3 there, is easy for learners to relate, but if you give them like 5 over 50 then it is difficult for them.

NV: You mean a fraction $\frac{5}{50}$ ('five fiftieths'). To do what?

R1: For example you ask them to put it in simplest, then numbers like $\frac{5}{50}$ to reduce this big number is a challenge for my learners. And for me I know there is a need for providing these learners extra assistance, maybe then they can manage to do these. But if you give them a simple one, like ½ to give an equivalent fraction, they can work it easily.

NV: Because those are small numbers?

R1: Yes and also if they have to do an addition it is easy for them if the number is small.

67 NV: Ok. Alright now when teaching different topics of fractions. You know you did different topics such as equivalent fractions, comparing fractions and others to your Grade 6 classes. Did the learners possess the required prior knowledge? From your opinion when you were teaching, did you think they possessed the required prior knowledge and if they do how did you incorporate that in your teaching?

(No response)

NV: Did they have prior knowledge that is required?

R3: Yes like in my grade, like, mhh.

R2: Ok maybe while he is thinking, let me come in.

75 NV: Mhh

R2: I think maybe if I can remember when I was teaching the topic of comparing fractions.

NV: Mhh.

R2: I came up with flashcards having different pictures. I drew them in such a way that I shaded some of the parts. I only pasted them on the board and started posing questions to the learners.

NV: Mhh.

R2: Just made it general and they already started talking about fractions. By that time they know about fractions.

82 NV: Ok. How did you now incorporate that now, knowing that they have some knowledge of what you are Going to talk about? How did you put it together with what you wanted to teach?

R2: I started by when I was doing the training I have to consider in my plan that learners would detect from the pictures drawn on a flipchart what will be discussed.

NV: So you already know from your plan that from this you go that one?

R2: Yes, it is part of the lesson plan.

NV: Can we come back to you?

R3: Yes, addition of fractions, that one my learners did not know before.

90 NV: They have not done it already?

R3: No, and that was difficult to teach because I need to come up with different ways to help them.

NV: How did you manage with this teaching of addition and subtraction of fractions?

R3: I think I did ok. I struggled with the teaching aids, that one I cannot do it. I mostly teach using numbers like 1 over 4, 5 over 12 and so on to make them understand.

NV: Can you tell me about your learners' level of prior knowledge, how was it?

R4: I think they have knowledge, because sometimes when you are doing the introduction and you ask them some questions, you can already tell that they have some knowledge as they give you correct answers to what the topic is about. Only some give wrong answers to the questions asked.

NV: OK, anybody else?

(Silence)

We are talking of whether your learners have a required knowledge. Just think back. Did they struggle when you introduced a new topic?

103 R1: Ok, learners in my grade have prior knowledge I can refer for instance, to the equivalent fractions, after introduction I first explained what an equivalent fraction is. Then from there I wrote fractions on the board, like a tree. I then started asking them like I write one fraction e.g. ½ then asked them to identify one fraction equivalent to it and they could do it right away.

NV: So they were able to identify the equivalent ones?

108 R1: Yes, they did it many times.

NV: Alright. The other question I have is that what I noticed from your teaching of fractions when I was observing you was that most of you did not really incorporate real life examples of fractions. So why is that? Because more of you were just teaching numbers, you did not really relate to real life situations where people can use fractions. Why is that? Or what is the problem of not doing that?

R4: Maybe it is lack of teaching aids.

NV: Mhh

115 R4: Most of the time we teach just using the fractions as numbers. The reason is that most of us follow the way were taught in schools. Teachers out there do not teach real life so we are used to for example, to add or subtract fractions, I just take $\frac{1}{2}+\frac{1}{3}$ without thinking real life.

NV: Don't you think it is necessary?

R4: Yes I think is needed.

120 R5: For me I do not bring reality in the classroom because of lacking experience. We do not know enough. Many times I use what I know from primary school and secondary school, is not easy.

NV: (facing others). Anyone else who wants to add something?

R1: Sometimes I think because we lack experience we just follow examples from the textbooks and give it to the learners. Hopefully these are simple, so if you bring in something extra, maybe learners will not understand.

126 NV: And then you relate that to real-life situation, because Math is part of us just like respondent 4 said before. Don't you really think this is required of you?

R1: I do think it is required, but maybe sometimes the teacher is not well prepared just following the examples in the textbooks using the fraction numbers provided.

NV: Mhh.

R5: Let me come in. I think ... can you repeat the question, Ms?

NV: The question is while I as observing your lessons, what I noticed is you did not really relate what you were teaching to real life situations. You did not incorporate the examples from our real-life situations. Why?

134 R5: By that I think that we do not really have experience or how to bring in real life examples. I mean maybe We do not really have an idea on how to incorporate real life examples to engage learners with those. Teachers in schools out there taught us fractions you know mostly this way.

NV: Mhh.

R5: I think because of this we were unable to really bring something to the class so that our learners can really see that this is how fractions are used in real life.

NV: Ok. In most cases in your lessons on fractions you asked learners to define terms, new terms that they have never heard of before. Why did you have to choose this approach? Why did you have to ask them questions like "what is an equivalent fraction?

143 R5: I think the reason to ask learners these is not really to get a right answer, but to know or to see how they understand according to their background. So deducing from how they answer these questions, the teacher can then decide on where to start explaining whether is from the very beginning or just a little bit.

NV: So you are sort of checking their background?

R5: Yes, then you decide how to teach the topic at hand.

NV: Anyone else?

R2: Just on top of that I think is required for learners to have knowledge of the new concepts. Anyway you have to ask them and then if they do not know then the teacher has to explain the definition of the concept to them.

152 NV: Ok, so when you were teaching these fraction topics, what errors or confusions that you noticed learners Tend to have when you were teaching them fractions or when they were learning fractions?

R3: My learners got confused, let us say you taught them and you did examples together, now you give them exercises, I remember when they were changing to equivalent fractions, they could not get it correct as they do not remember whether they multiply or add two functions together.

R5: I realized that especially my learners; they get confused if you give them a big number to write into simplest form. They will not do it to the last number, they just did it halfway. So I had to explain over and over to them how to simplify to the last step. With addition and subtract with different denominations, they struggle; it was not easy when they looked for an LCM. I think they still do.

161 NV: Mhhh. Errors (talking to other participants). The problems that you found your learners have.

R1: Some learners have a problem to identify which is proper and improper fractions.

NV: Mhhh. What do you think is the cause of that?

R1: I think the words, the concepts, they do not master properly. They struggle I think because of their English most of them cannot speak well.

NV: I hope by now they have, you taught fractions.

R1: Yah

168 NV: Again when you were teaching fractions, you know different topics of fractions. In some cases you may have to teach and re-teach those topics, but the learners couldn't really get what you are trying to say. They could really grasp the concept you were teaching. What did you do then in a situation like this?

R2: Ok, for me when some of my learners did not understand, I used to call some of the learners who I think did understand to come on the chalkboard and explain to their classmates and then later I also have to ask them questions. Still if I realize that they did not understand, I have to call them to the office and explain again. But when it comes to addition and subtraction of fractions, they struggled and made errors like $\frac{2}{5}+\frac{3}{7}=\frac{5}{12}$. I could hardly get them to understand the correct steps.

176 NV: (To Respondent 3) You were saying something?

R3: When I teach them using big numbers and they did not understand, I have to reduce the numbers.

NV: Ok, for the one who did not understand?

R3: Yes.
R5: I think this refers to the teaching method used, because different learners learn in different ways depending on the method used.
NV: Yes, everyone is unique.
R5: As a teacher I have to know my learners, some are slow and others are fast. So far those who are slow I have to come to them. So if you see that some of the learners did not understand when taught using a particular method, maybe you need to change to cater for those. You can also talk to them after class to find out where they have difficulty and then help them. But use a different method when helping them, because if you still use the same method then is no use to them.
188 NV: Mhh.
R1: In my case I noticed that some learners did not understand what we discussed. I have to give a short homework. Then from tomorrow before I start with the next lesson have to give a chance to my support teacher to explain it to them so that maybe those who did not understand then may understand when explained better.
NV: About the homework that you gave?
R1: Yes.
195 NV: Alright now after this teaching of fractions it has passed no, and you have gone through the process of teaching fractions. What would you have done differently if you have to do the teaching of fractions all over again? From looking at what you did when teaching fractions, what would you have to do if you have to re-teach fractions?
R2: I think on my side what I would do is to use more appropriate teaching aids.
NV: Mhh.
R2: I mean change my teaching methods and teaching aids.
NV: So are you saying your teaching methods and teaching aids were not so effective?
R2: Yah because I do not want to get the same results as I had last time when I taught fractions.
NV: Ok.
205 R5: From my side I think if I have to teach fractions again I have to look for appropriate teaching aids.
NV: Mhh.
R5: Making sure that those teaching aids are in line of what is to be taught not just to have teaching aids in the classroom, but to make sure it is something that is appropriate and also relates to real life situation. I will read more content of fractions to teach well.
NV: So you will incorporate real life examples?
R5: Yah for my learners to be able to use than in the classroom and also relate to their real life situations.
208 NV: Anyone else?
R2: Almost the same as her.
NV: Which is what? I like to hear your own.
R2: If I have to teach fractions again I will try to design the real teaching aids in the classroom. I will bring for example an apple to the class, then instead of me cutting it I will let a learner to cut it into pieces and ask them to identify the fraction. And I will also improve my content of fractions to teach better.
214 NV: So the learners have to be involved in the teaching aids?
R2: Yah.
NV: Ok. I just hope they won't eat the apple.
R3: For me it is about giving learners different ways to solve fractions. Then they can choose whichever they want. Subtraction and addition is challenging, so I will give them many exercises to practice.
NV: I see.
220 R1: My change will be on using different methods.
NV: Different from the ones you used?
R1: Yes, and teaching materials.
NV: Ok. Thank you very much we have come to the end. I appreciate it and thanks a lot for your time.
224 Group: You are welcome Ms.

APPENDIX E REQUEST TO CARRY OUT RESEARCH

Enquiries: N. Vatilifa

24 October 2011

To: The Deputy Dean

Dear.....

RE: Request for permission to conduct Research

As the Deputy Dean is already aware I am currently a part time student with Rhodes University, Grahamstown, in South Africa, (Student no. 609V6600). I have been studying for the Master's degree in Mathematics Education since January 2011. I am required to undertake a research project in my field of study, Mathematics education.

The aim of my research is to gain insight into the influence on student teachers, of the teaching of fractions and fraction pedagogy in the teacher training course. The research will involve year 3 BETD student teachers, level 5-7, Class 3D during their SBS session 1, starting January 2012. The research will utilize narrative methodologies including interview of student teachers, observation of classroom activities and use of student teachers' records (tests and assignments). The focused students will be provided with participant consent forms in advance before carrying out the data collection process. This will not interfere with their normal SBS activities. At no time during this research will participants' names be used, nor will any of the activities pose any risk of physical, mental or social harm to either participants or the institution itself.

The purpose of this letter is to request your permission to grant me an approval and give consent to the research to take place at..... campus. Many thanks for your support in this matter and I would be most grateful if you grant me permission.

Yours sincerely

N.Vatilifa

Ndamononghenda Vatilifa

APPENDIX F GRANTED PERMISSION TO CARRY OUT RESEARCH

OFFICE OF THE DEPUTY DEAN

[redacted]

October 25th, 2011

To: Mrs. N. Vutiliy

Re: Permission to conduct research

I hereby acknowledging receipt of your letter dated October 24th 2011. Against this background it's my pleasure to inform you that permission has been granted to conduct research as per your request.

Thank you and wishing you all the best in your research.

Yours in Education

APPENDIX G STUDENT TEACHERS' CONSENT FORM

Student informed consent form

I, ……., agree voluntarily to partake in Ms. Ndamononghenda Vatilifa's research project. I am aware that the information to be collected will be reflected in her report, but I am being assured that confidentiality and anonymity will be strictly considered throughout the handling of such information. I am aware that I can withdraw my participation any time during the research process.

…… ……..
Signature of participant Date