A CASE STUDY OF SECONDARY SCHOOL MATHEMATICS TEACHERS EVALUATING THEIR CLASSROOM-BASED ASSESSMENTS FOR THE PURPOSE OF TEACHING FOR MATHEMATICAL PROFICIENCY

by

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DECLARATION

I, Jean-Pierre le Roux, hereby declare that the work contained in this dissertation is my own original work, that I am the sole author thereof, that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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ABSTRACT

Much emphasis has been placed on the role that assessment plays in the relationship between teaching and learning. Current thinking about mathematics teaching and learning encourages teachers to integrate a range of teaching and assessment practices that are receptive to their students' thinking and which promote learning. Reforms in mathematics education, including the Mathematics Teaching and Learning Framework for South Africa (DBE, 2018), have called on teachers to adapt their classroom-based assessment practices towards promoting a learning-centred classroom. The research findings of this study on how teachers can incorporate new ideas into their classroom-based assessments, and by designing classroom-based assessments towards mathematical proficiency, are especially relevant considering that the Mathematics Teaching and Learning Framework (DBE, 2018) draws on Kilpatrick, Swafford and Findell's (2001) five strands of mathematical proficiency to bring about the transformation of mathematics in South Africa. This in-depth study aims to respond to calls that have been made to understand the complexities that mathematics teachers face when they are expected to bring new ideas to the learning environment they create, including their assessment practices. In this study, five mathematics teachers from two secondary schools formed a case study to understand better how teachers can redesign their classroom-based assessments to promote mathematical proficiency for a professional development agenda. The three main concepts of the theoretical framework, which are adapted from Belbase (2012) are: (1) teachers' beliefs; (2) teachers' assessment practices of mathematical proficiency; and (3) teachers' knowledge of mathematical proficiency. In this study I interpreted the relationship between teaching, learning, and assessment from the perspective of developing teachers' assessment as a network, and my intervention was located on the edge between teachers' knowledge and assessment practices. I engaged the participant

teachers on the construct of mathematical proficiency (Kilpatrick et al.,2001) and asked them to adapt their classroom-based assessments for the purpose of teaching for mathematical proficiency. The data, which was gathered from semi-structured group and individual interviews, classroom-observations, and artefact collection, found that mathematics teachers' conceptions of assessment were compelling. Four key aspects (purpose and function of assessment; the perceived curriculum; expectations of students; and school context) shape teachers' conceptions of assessment, which results in the teachers having either societal conceptions of assessment or pedagogical conceptions of assessment. The teachers' conceptions of assessment were the strongest indication of whether the teachers aligned to an assessment culture or a testing culture of assessment. The study found that teachers' pedagogical conceptions of assessment which promotes pedagogy are essential to foster a learning-centred classroom. The study provides an argument about the implications of the research findings for professional practice by discussing four key principles of adapting classroom-based assessment to promote a learning-centred classroom. This study has found that classroom-based assessment drives the teaching and learning which takes place in the mathematics classroom. The research study also makes two theoretical contributions. The first pertains to the distinction between mathematics teachers' beliefs and their conceptions. The second concerns the effect and influence of teachers' beliefs on the teachers' adaption of their classroom-based assessments towards mathematical proficiency by linking the relationships between knowledge and assessment with beliefs, and by expanding on the implications of the research to achieve optimal teacher change.

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LIST OF ACRONYMS

ANA:	Annual National Assessment
CAPS:	Curriculum and Assessment Policy Statement
DBE:	Department of Basic Education
IEB:	Independent Examinations Board
IRR:	Institute of Race Relations
MP:	Mathematical Proficiency
PISA:	Program for International Student Assessment
SACMEQ:	Southern and Eastern Consortium for Monitoring Education Quality
SBA:	School Based Assessment
TIMSS:	Trends in Mathematics and Science Study
WCED:	Western Cape Education Department

CHAPTER 1:

INTRODUCTION

1.1 OVERVIEW

The first chapter provides an overview of the thesis. It begins with a brief description of the research background concerning classroom-based assessments, followed by the rationale of the study, which is divided into four sections: the relationship between teaching, learning and assessment; a shift in classroom-based assessment; mathematics education in South Africa; and teachers' beliefs of teaching and learning mathematics, and their conceptions of assessment. To give a holistic view of mathematics education in South Africa, the study will consider the aims and goals of the current South African curriculum, high-stakes external assessment and systemic tests, and the mathematics teaching and learning framework.

The last two sections in chapter one position the overarching research question with its three subsidiary questions and give an overview of the layout of the chapters of the thesis. By learning how teachers can redesign their classroom-based assessment practices to promote mathematical proficiency, my study contributes to the research literature on the professional development of secondary-school mathematics teachers. I hope to respond to calls that have been made for research into how teachers assimilate new ideas about their classroom-based assessment into their practice. The research question of this study is: How do secondary-school mathematics teachers assess their classroom-based assessments towards mathematics proficiency? The subsidiary research questions are:

(1) How do teachers describe and justify their current classroom-based assessment practices?;

(2) How do secondary-school mathematics teachers adapt their assessments towards assessing mathematical proficiency?; and

(3) What are the challenges teachers experience in incorporating new ideas in the design of classroom-based assessments?

1.2 RESEARCH BACKGROUND

The Department of Basic Education has been transparent in their reflection about the poor quality of mathematics teaching and learning practices in South Africa.

> "The teaching and learning of Mathematics in South African schools are not yielding the intended outcomes of South Africa's education policies and curricula. This is evident from research from many studies conducted by the Department of Basic Education (DBE), universities and other research agencies in South Africa. The low learner achievement levels revealed by national assessments such as Annual National Assessments (ANA), regional assessments such as Southern and Eastern Consortium for Monitoring Education Quality (SACMEQ) and international assessments such as Trends in Mathematics and Science Study (TIMSS) are indicative, at least in part, of current 'ineffective' teaching and learning practices" (DBE 2018, p. 11).

The Mathematics Teaching and Learning Framework for South Africa: Teaching Mathematics for Understanding (DBE, 2018) stresses that a ground-breaking and sustainable intervention, which needs to change the approach to teaching mathematics, is required if teachers are to change how they present mathematics and engage with learners in their classes. It has never been more important to invest in mathematics education in South Africa. We are in the midst of what the World Economic Forum defines as the "fourth industrial revolution". In a speech made by the South African finance minister at the time, Mr Nhlanhla Nene, stated that to prepare for our students to take advantage of the fourth revolution, they will need the skills, cognitive tools and competencies to solve problems unknown to them (Nene, 2017). An important goal for teachers and researchers of mathematics is to change the nature of mathematics teaching, learning and assessment in classrooms to make problem-solving a common goal. It has long been recognised that successful learning and teaching of mathematics consists of more than just knowledge of skills and procedures. Students' 21st-

century skills, their ability to reason mathematically, and to use problem-solving skills creatively to develop *mathematical proficiency* have been universally accepted as overarching goals of mathematics education (NCTM, 2014), and also underlines the aims of the South African curriculum (DBE, 2011). Assessing students' mathematical proficiency has existed for as long as teaching mathematical concepts. As long as there has been mathematics, there has been assessment. One example of this that, when a child is learning to count, a parent or significant person will assess the child's understanding and application of the skill by providing opportunities for the child to count objects. The reason for providing learning opportunities for the child also allows the parent or the significant person to get a sense of how proficient the child is in counting and to identify areas of shortcomings. The quest to find ways to assess mathematical proficiency is ongoing.

Substantial developments have been made on what it means to be proficient in mathematics. "Mathematical proficiency", a term Kilpatrick, Swafford and Findell (2001) used to capture what it means for anyone to learn mathematics successfully, has five strands: (1) conceptual understanding; (2) procedural fluency; (3) strategic competence; (4) adaptive reasoning; and (5) productive disposition. These five strands are interwoven, interdependent, and have implications for how students learn mathematics, how teachers develop the mathematical proficiency of students, and how teachers can assess students' mathematical proficiency. The Mathematics Teaching and Learning Framework (DBE, 2018) draws on Kilpatrick's et al.'s (2001) five strands of mathematical proficiency, and the "dimensions represent a contextualisation and adaption of the strands to the South African context" (DBE, 2018, p. 8). The framework, as illustrated in figure 1, calls for teachers to take steps to bring about the transformation of mathematics teaching in South Africa, and to strive to:

- teach mathematics for conceptual understanding to enable comprehension of mathematical concepts, operations, and relations;

- teach so that learners develop procedural fluency which involves skill in carrying out procedures flexibly, accurately, efficiently, and appropriately;
- develop learners' strategic competence – the ability to formulate, represent, and decide on appropriate strategies to solve mathematical problems;
- provide multiple and varied opportunities for learners to develop their mathematical reasoning skills – the capacity for logical thought, reflection, explanation, and justification; and
- promote a learning-centred classroom which enables all of the above, supported by teachers engaging with learners in ways that foreground mathematical learning for all (DBE, 2018).

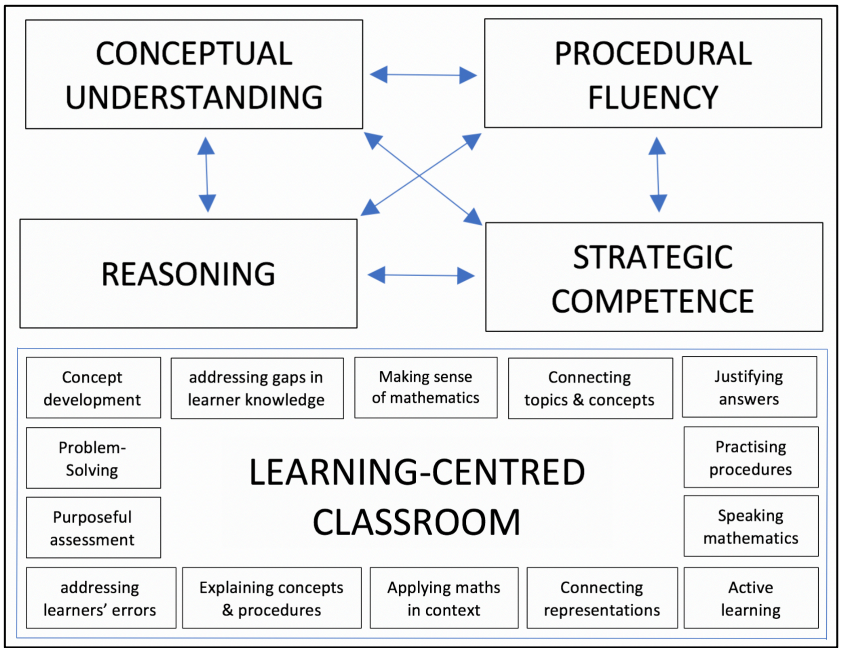

Figure 1: Model for Mathematics learning and teaching (DBE, 2018)

The model of the mathematics teaching and learning framework (see figure 1) constitutes of four key dimensions: conceptual understanding, mathematics procedures, strategic competence, and reasoning; while each of these is underpinned by a learning-centered

classroom. It is important to note that the dimensions can be focused on individually, but they are all interconnected.

It has been my experience, in moderating school-based assessments (SBA) over the last ten years from some of the best performing independent schools across South Africa, as well as from evaluating the nationally set external examinations for Grade 12, that these assessments rarely focus on more than two of the mathematical proficiency strands. The onus does not lie with the nationally set external assessments, which students in South Africa write, to cover all the five strands of mathematical proficiency comprehensively. The nationally set external assessments are high-stakes examinations, and are used for summative purposes to promote and certify students. I believe, thus, that it is the role of formative classroom-based assessments to focus comprehensively on other aspects of learning, including the full range of the mathematical proficiency strands. The South African curriculum encourages teachers to use formative assessment to aid the teaching and learning process, and defines formative assessment as assessment for learning, as opposed to summative forms of assessment which is defined as an assessment of learning. Teachers have been encouraged to be "change agents" by prioritising and developing students' strategic competence, adaptive reasoning, and productive disposition (Collins, 2011, p. 23). Mathematical proficiency will be the lens through which I will grapple with the classroom-based assessments.

The unintended consequence of an assessment-driven educational system is that teachers, both nationally and internationally, tend to focus on "cracking the system" and preparing students by "teaching to the test". Teachers interpret the curriculum according to the demands of the external assessment. Reasons for this include pressure on schools and teachers to prepare students well to achieve high marks in the final examinations to gain entrance to tertiary studies. The problem is that "high stakes testing may be incompatible

with many defensible aims – among them, critical thinking", which is the basis for testing mathematical proficiency (Noddings, 2004. p. 263). It is paramount to note, however, that it is the teachers who play the most crucial role in mediating the reform efforts of curriculum designers and policymakers (Llinares & Krainer, 2006). If we want to get teachers to aim to teach worthy curriculum goals, including problem-solving and mathematical reasoning, teachers will have to start with designing assessments towards mathematical proficiency.

The mathematics community can gain a deeper understanding of what the teachers value in mathematics education by investigating teachers' classroom-based assessment practices. Any approach to mathematics assessment almost certainly reveals a view of teaching and learning, which in turn rests on an understanding of the central features of mathematics (Dunne, Craig & Long, 2012).

1.3 RATIONALE FOR THE PROPOSED RESEARCH STUDY

The rationale of this research study is to investigate and learn how the assessments of secondary-school mathematics teachers can be redesigned to focus on and promote the intertwined strands of mathematical proficiency, to inform a professional development agenda. This study is especially relevant as the Mathematics Teaching and Learning Framework (DBE, 2018) draws on Kilpatrick's et al.'s (2001) five strands of mathematical proficiency to bring about the transformation of mathematics in South Africa. This framework emphasises that "a ground-breaking and sustainable intervention that will change the approach to teaching Mathematics is required" (DBE, 2018, p. 11) for teachers to change the way in which they present mathematics, conduct classroom practices, and engage with learners in their classes. One of the aims of the research is to respond to calls that have been made for research into how teachers incorporate new ideas into their classroom-based assessment practices, since teachers are the last step in a sequence of changes.

As I explained in the research background, my study focused on classroom-based assessments because of my experience moderating school-based assessments and working with the mathematics teachers to achieve a professional development agenda. I am a teacher at a private school that has a strong relationship and working collaboration with the mathematics teachers at a government school, as is the case with many well-resources private and under-resourced government school collaborations in South Africa. The collaboration between the two schools started in 2015. The first phase of the collaboration consisted of student's being tutored in Mathematics and English on Thursday afternoons. In the second phase of the collaboration, which started in 2016, the Mathematics teachers of the two schools started to work together and collaborated on ideas to advance teaching and learning. It is within this phase that my study is positioned.

I have been frustrated by the lack of thought of assessment from the teachers at my school and at the teachers at the school that we have a collaboration with. It has been my experience working with mathematics teachers that formative classroom-based assessments are used for summative purposes. It is my professional judgement that classroom-based assessments seldom focus on more than assessing procedures. The purpose of the assessments used by the teachers which are branded as classroom-based assessments is to produce quantitative feedback for grading purposes. My study proposes that the only way for teachers to promote constructivism in their classroom, is for their classroom-based assessments to be aligned to the perspectives of constructivism. As I mentioned in the literature review, very little research has been conducted on classroom-based assessments being designed towards the perspectives of mathematical proficiency. My study aims to contribute to the research literature on the professional development of secondary-school mathematics teachers. I decided to focus on

grade 8 and grade 9 teachers. I believe that the only way we can effect change in grade 12 mathematics is to effect change in the earlier years. The current strategy towards teaching grade 8 and grade 9 mathematics is clearly not working when one considers the large number of students who do not take mathematics in grade 10 at many schools across the country[1].

The rationale for the proposed study will be divided into three parts: the study will begin by looking at the relationship between the curriculum, teaching, and assessment (1.3.1), followed by looking at a shift in classroom-based assessments (1.3.2), and finally looking at mathematics education in South Africa (1.3.3). By critically looking at mathematics education in South Africa, the study considers the goals and aims of the current South African mathematics curriculum (CAPS), high-stakes examinations and systemic testing, and the Mathematics Teaching and Learning Framework for South Africa (DBE, 2018). The last section of the rationale examines the need to focus on teachers' beliefs and conceptions (1.3.4). I will argue that, because the purpose of the externally set, high-stakes examinations are of a summative nature, the onus lies on other forms of assessment, such as classroom-based assessments, to assess in a way which will promote the aims of the ambitious goals and aims of the curriculum.

1.3.1 THE RELATIONSHIP BETWEEN CURRICULUM, TEACHING, AND ASSESSMENT

I do not need to try to convince anyone who has attempted to learn something or teach someone that the relationship between learning and teaching is complex. Teaching and

[1] The IRR noted that the ratio of mathematical literacy to maths pupils has changed over time in favour of the former (Roodt, 2018)

assessment are viewed as seamless processes that support students' learning through continuous feedback from teachers and students (Suurtamm, 2004). Current theories on assessment recognise that learning is not linear and one-dimensional but multi-dimensional, and that multi-faceted processes require innovative assessment practices (Suurtamm, 2004; Brookhart, 2003; Gipps, 1999). This leaves teachers in a complex landscape of accountability in which they are portrayed as technicians tasked with implementing a prescribed curriculum, policies, and procedures (Cochran-Smith & Lytle, 2009).

1.3.2 A SHIFT IN CLASSROOM-BASED ASSESSMENT

The nature of assessment is critically important because "what you test is what you get" (Schoenfeld, 2007, p. 72). Assessing students does not result by itself in increased student accomplishment, much like a pig does not fatten because it is weighted (Fulcher, K., Good, M., Coleman, C. & Smith, K., 2014). There have been increasing calls, both in the classroom assessment literature (Stobart, 2008; Gardner, 2012; Suurtamm and Koch, 2014) and in the mathematics education literature (Kilpatrick et al., 2001; Wiliam, 2007), for teachers to make changes to their assessment practices. Although teachers are viewed as essential agents of change in the ongoing attempt to reform education, they are also significant obstacles to change and reforming education. Some of the reasons why teachers are obstacles in efforts to changing education include their adherence to outmoded learning theories, teaching styles, and forms of assessment which emphasise factual and procedural knowledge at the expense of more profound levels of understanding (Prawat, 1992). Teachers are asked to use a variety of assessment practices that are receptive to student thinking and learning. Perspectives on classroom assessment that draw on cognitive, constructivist, and socio-constructivist views of learning have shifted from a view of assessment as an event which objectively measures the acquisition of knowledge towards a view of assessment as a social practice which provides

continual information to support student learning (Suurtamm, 2014; Lund, 2008; Shepard, 2000; Gipps, 1999). I believe that how and what mathematics teachers assess defines what these teachers value. Students' questions, such as "Will that be in the test?", signal their understanding of this basic truth. Students learn that teachers who assess only calculations and routine procedures value procedural competence on routine items and not deep thinking and reasoning in unseen problems. The reality is that teachers and students are generally satisfied with the evidence of routine performance (Steen, 1999).

A shift in designing classroom-based assessment instruments needs to be made, especially regarding designing assessment tasks that enable students to show what they know, understand and can do, particularly with reference to problem-solving and reasoning (Cockcroft, 1982). From the teacher's perspective, assessment should help both student and teacher to understand what the student knows, and to identify areas in which the student needs improvement. In addition, assessment tasks should have curricular value. Otherwise, they steal time away from the job of teaching. Assessments should help students figure out what they know and what they do not know; they should be experienced as and feel fair (Schoenfeld, 2007).

1.3.3 MATHEMATICS EDUCATION IN SOUTH AFRICA

1.3.3.1 THE AIMS AND GOALS OF THE SOUTH AFRICAN CURRICULUM

Across the world, the aspirations exhibited in curriculum documents are strikingly similar (Askew, M., Hodgen, J., Hossain, S., & Bretscher, 2010). Since South Africa's first national democratic elections in 1994, the South African Department of Basic Education has developed and implemented several curriculum-related reforms with the intention to democratise education and eliminate inequalities in the post-apartheid education system (see Jansen, 1998; Crouch & Hoadley, 2018). One of the founding principles on which the

current South African Mathematics curriculum is based is “encouraging an active and critical approach to learning, rather than rote and uncritical learning of given truths”. The current South African mathematics curriculum aims to produce learners that are able to “identify and solve problems and make decisions using critical and creative thinking” and to “demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation”. Specific aims are to “develop learners who are able to be methodical, to generalise, make conjectures and to try to justify or prove them”. The specific aims stress the importance to “develop learners' problem-solving and cognitive skills. Learning procedures and proofs without a good understanding of why they are important will have learners ill equipped to use their knowledge in later life. To develop essential mathematical skills, the learner should use mathematical process skills to identify, investigate and solve problems creatively and critically” (DBE, 2011, p. 5).

It is clear from considering the aims and goals of the current South African curriculum that the curriculum aims to develop students who can use mathematics as a tool to think critically and creatively. It is also evident that the current South African curriculum emphasises the importance of developing students’ ability to solve problems, to share their ideas, to make sense of mathematics, to speak mathematics, to develop fluency in essential mathematical procedures, to connect representations, and to justify thinking.

It is now pertinent to focus on the demands of high-stakes external assessments and systemic tests concerning classroom-based assessments.

1.3.3.2 HIGH-STAKES EXTERNAL ASSESSMENTS AND SYSTEMIC TESTS

In South Africa, grade 9 mathematics students write a systemic test in mathematics, and the grade 12 students write a high-stakes, externally set examination. The grade 12 and grade 9 mathematics high-stakes examinations, which mostly consists of short, closed answer

questions assessing knowledge, routine procedures and complex procedures, as directed by the curriculum and assessment policy document, do not promote the goals and aims of the curriculum as espoused above. It is clear from the Department of Basic Education's annual reports on their members' views and feedback of the mathematics examination papers, that these externally set high-stakes assessments serve a particular purpose:

> "Questions which required candidates to interpret information, explain or provide justification presented challenges to most. This suggests that the 'stimulus-response' method makes up much of the teaching strategy. Consequently, candidates lack the ability to respond to complex and higher-order questions that require a deeper understanding […] It appears that teaching and learning focus too much on previous examination papers. This practice compromises conceptual understanding as learners are not exposed to innovative, fresh questions from other sources" (DBE 2012, p. 121).

Both assessments are classified as summative assessments and fulfil the purposes of student accreditation and certification and school accountability. The results of the externally set grade 12 examinations portray a bleak picture of the quality of mathematics teaching and learning in South Africa. An analysis of the grade 12 students' performance in the mathematics examinations (DBE, 2018a), reveal that the percentage of mathematics students who achieved more than 50% in mathematics in 2017 was merely 22,2% (compared to 21,2% in 2016 and 20,3% in 2015). Only 13,1% of the students' results were greater than 60% in mathematics. There were more students who obtained a mark of less than 10% than students who achieved more than 60%. It is important to note that these marks have already been adjusted and are not raw marks.

Secondary-school students in grade 9 write the Annual National Assessments (ANA). The last report, which was published in 2014, indicate that the mean average percentage mark for the grade 9 secondary-school students was 11%. The results of the grade 12 externally set examinations, the grade 9 ANA results, together with South Africa's poor performance in the

international competitive tests, indicate that we amid a crisis in mathematics education. The DBE has acknowledged the severity of the challenge:

> "[T]he teaching and learning of Mathematics in South African schools is not yielding the intended outcomes of South Africa's education policies and curricula. This is evident from research from many studies conducted by the Department of Basic Education, universities and other research agencies in South Africa. The low learner achievement levels revealed by national assessments such as Annual National Assessments (ANA), regional assessments such as Southern and Eastern Consortium for Monitoring Education Quality (SACMEQ) and international assessments such as Trends in Mathematics and Science Study (TIMSS) are indicative, at least in part, of current 'ineffective' teaching and learning practices" (DBE, 2018, p. 11).

The challenges facing the mathematics teaching community in South Africa are, therefore, compounded and multi-faceted.

Firstly, even though systemic testing is prioritising lower-order routine procedures above assessing students' higher-order problem-solving skills and conceptual understanding, students' performance in mathematics has been dismally low. The Department of Education acknowledge that "too many students struggle with passing the subject and on the top end, even students who perform well struggle at university" (DBE 2018, p. 11).

Secondly, research (Van der Nest, Long, Engelbrecht, 2018) indicates that, through systemic testing, constraining influences of the inevitable "teaching to the test" implies a narrowing of the implemented curriculum and reliance on only one source of assessment for monitoring purposes. Van der Nest et al. (2018) further argues that continued curriculum narrowing has characterised the curriculum over the last two decades with successive curriculum reviews and revisions. Rather than focussing on and addressing the concerns about professional teacher development, the mathematics curriculum is tailored to perceived weakest teachers.

While policy statements, such as the Curriculum and Assessment Policy Statements (CAPS), commonly claim the vital importance of students to be capable of solving real-world problems and communicating mathematically (DBE, 2011), these policy statements will have

no effect unless students are assessed on their ability to identify and analyse problems in real-world settings and communicate their conclusions. If it is true that assessment not only places value on things but emphasises what we value (Biesta, 2015), then, by looking at the NSC and ANA systemic tests and examinations, we clearly value certification above mathematical competency. In today's assessment-saturated environment, mathematics *is* the mathematics that is tested (Steen, 1999).

I do not believe that is the sole responsibility of the high-stakes external assessments to ensure that all the aims and goals of the curriculum are enforced. It is important to consider that the purpose of these assessments is to certify students and to monitor the attained curriculum to some extent. The results of these systemic tests serve an accountability purpose and are not aligned with classroom teaching and learning. Bennett and Gitomer (2009) found that systemic test programmes, such as the No Child Left Behind Campaign, did not enable better teaching and learning because the results and outcomes were not aligned with teaching and learning, as the delayed feedback is received when it is too late to remedy the learning situation. I strongly believe that it is the role of teaching and classroom-based assessment practices to promote the goals and aims of the curriculum, and that there is a need to embolden the relationship between learning, teaching, and assessment.

1.3.3.3 THE MATHEMATICS TEACHING AND LEARNING FRAMEWORK

During the 2016 Mathematics Indaba, the Minister of Basic Education, Angie Motshekga, commented for the need to reinvigorate the teaching of mathematics in its entirety, with special focus on classroom learning practices and assessment. The Mathematics Teaching and Learning Framework for South Africa (DBE, 2018), which calls for a multi-dimensional approach to transforming the teaching and learning of mathematics in South Africa, was developed by a task team to provide teachers with a foundation for a new manner in which

mathematics should be taught, and thus, change the way it is learned. The framework is not a new curriculum and does not replace the CAPS, but instead, it supports the implementation of the current curriculum through introducing a model to help teachers to change the way in which they teach and approach their classroom practices. The framework draws on Kilpatrick's et al.'s (2001) five strands of mathematical proficiency, and the "dimensions represent a contextualisation and adaption of the strands to the South African context" (DBE, 2018, p.13). The Mathematics Teaching and Learning Framework (DBE, 2018) states that if the current South African curriculum (CAPS) were to "be implemented as it was conceptualised, the CAPS has the potential to, firstly equip the South African learners with the skills for the 21st Century and, secondly prepare them adequately for the demands of the 4th Industrial Revolution which emphasises cyber-physical production systems as espoused by the World Economic Forum" (DBE, 2018, p. 12). The lack of effective implementation of the current South African curriculum has had a far-reaching negative impact on mathematics learning and teaching. The Mathematics Teaching and Learning Framework (DBE, 2018) has been developed to assist teachers in paying attention to key features within this curriculum that will enable them to take the necessary steps to transform the manner in which mathematics is taught and learned. The framework focusses on the relationship between teaching and learning mathematics, and emphasises the critical role that assessment plays in this relationship.

Assessment is one of five key areas, which the framework expands on. The framework makes it clear that "school-based Assessment should be designed to address the balance of the dimensions in the framework" (DBE, 2018, p. 81). The framework stresses that assessment should be more than just summative and that appropriate feedback forms an essential part of effective assessments.

> "[I]t should be undertaken for diagnostic, formative or summative purposes and it should be both informal and formal. Whatever the nature of an assessment, regular feedback should be provided to learners to enhance the learning experience. Tests and exams should be central experiences in learning, not just something to be done as quickly as possible after teaching has ended in order to produce a final grade. To let learners show what they know and are able to do is a different business from the all too conventional practice of counting learners' errors on questions" (DBE, 2018, p. 77).

The framework argues that formative assessment serves as an integral component in the learning process, because it can be used as a means for tracking learner progress and ensuring high-stakes test preparedness, but it can also play a significant role in the process of changing instructional practices.

> "The teacher's ability to know what to teach next and how to adapt instruction in the light of evidence is critical to effective formative assessment. Formative assessment instruments (or tests) should be carefully designed to provide intermittent markers at strategic points in the curriculum implementation. A formative assessment test should be a set of carefully designed questions to address learner misconceptions and a tool to address learning targets. These tests should be aligned with the mathematics curriculum but should also test the critical aspects of a topic, drawing on the basic dimensions of the framework discussed, i.e. conceptual understanding, procedural fluency, own strategies and reasoning" (DBE, 2018, p. 77).

Lastly, the framework states that a key implication for assessment is critical and extensive engagement with the assessment instruments on the part of the teachers. Assessments designed to highlight core mathematics concepts, together with reflective implementation of such tasks, will improve the teaching and learning of mathematics.

1.3.4 TEACHERS' BELIEFS AND CONCEPTIONS

I believe that the most effective way that we can make changes to the quality of education in South Africa is to focus on teachers. Teachers are viewed as essential agents of change in the ongoing attempt to reform education, but they are also significant obstacles to change and education reform: "Classroom assessment requires a great deal of time and effort; teachers

may spend as much as 40% of their time directly involved in assessment-related activities. Yet teachers are neither trained nor prepared to face this demanding task" (Stiggins, 1988, p. 363). Teachers' thinking, planning, interactive decision making (the very act of teaching and assessing their students), and implicit beliefs are interwoven facets that affect their classroom practices every day. By extension, then, their implicit theories about assessment inform their thinking and planning, and consequently shape their classroom assessment practices (Bliem & Davinroy, 1997). These beliefs have a significant influence on the characteristics of teaching practices, including classroom-based assessment practices (Thompson, 1992; Schoenfeld, 1998). Handal & Herrington (2003) suggests that teachers' mathematical beliefs originated from their learning experiences in schools, which eventually was reproduced in their classroom teaching and assessment practices. Teachers' beliefs could be seen as a lens through which they make their decisions, rather than just relying on their pedagogical knowledge and curriculum guidelines. The changes of teachers consisted of more than just a change in behaviour, but also a change in conceptualising the teaching and assessment practices. Change is heavily dependent on the context within which teachers have to function (Belbase, 2012). An important amount of research in the field of assessment in mathematics, classroom practices and teachers' conceptions of assessment is focussed on teachers' assessment practices, especially their grading practices rather than on the beliefs on which they may ground the assessment practices (see studies Reynolds & Livingston, 2010; Bowers, 2011). Yet most of these studies conclude by drawing attention to teachers' beliefs or conceptions and point out that teachers' conceptions are one of the key factors that influence classroom practices, including classroom decisions around assessments (see Remesal, 2006; Griffiths, Gore & Ludwig, 2006). Remesal (2011) commented that this is especially critical during periods of systemic school reform as teachers are usually the last step in a sequence of changes.

1.4 THE RESEARCH QUESTION

The research question I want to address is: How do secondary-school mathematics teachers reassess their classroom-based assessments towards mathematics proficiency? To focus on the experiences and challenges of teachers transforming their classroom-based assessment enables the wider mathematics research community and professional development designers to value the complexity of educational change, which is necessary to advance mathematics teaching and learning, and to suggest ways in which teachers can be supported to develop their teaching and assessment practice further.

The overarching research question of this study is: How do secondary-school mathematics teachers evaluate their classroom-based assessments for the purpose of teaching for mathematics proficiency? Three subsidiary research questions will also be addressed:

1. How do teachers describe and justify their current classroom-based assessment practices?
2. How do secondary-school mathematics teachers adapt their assessments towards assessing mathematical proficiency during an intervention?
3. What are the challenges teachers experience in incorporating new ideas in the design of classroom-based assessments?

1.5 THE LAYOUT OF THE THESIS

Chapter two consists of a literature review of teachers' beliefs, knowledge and classroom-based assessment practices. The purpose of the literature review is to research how to effect teacher change. By reviewing the literature on teachers' beliefs, knowledge and assessment practices are essential to analysing and interpreting the data collected to answer the first research question: "How do teachers describe and justify their current classroom-based assessment practices?". Teachers are viewed as essential agents of change in the

ongoing attempt to reform education, but research has also shown that teachers are significant obstacles to change and education reform.

Chapter three presents my theoretical framework. The theoretical framework focusses on the relationship between the three main concepts to understand how secondary school mathematics teachers can design their classroom-based assessments towards mathematical proficiency: (1) teachers' beliefs; (2) teachers' assessment practices of mathematical proficiency; and (3) teachers' knowledge of mathematical proficiency. In this study I promoted teachers' knowledge of mathematical proficiency as described by Kilpatrick et al., (2001). The theoretical framework provided me with a lens to research the teachers' beliefs; knowledge; classroom-based assessments; relationship between knowledge and beliefs; relationship between knowledge and classroom-based assessments; relationship between beliefs and classroom-based assessments; and the context requirements for formative assessments.

Chapter four provides a description of the research design and methodology used to meet the aims of the research. This chapter starts with describing the research aim of this study, which is followed by outlining my research strategy. The research participants of the study are discussed. The case study method, which positions this as an interpretative study from a constructivist perspective is discussed. The research design includes the research design framework, data collection methods, and analysis of the data. I elaborate on my stance as both a researcher and teacher, which is followed the trustworthiness, creditability, and ethical considerations sections.

Chapter five presents the data and the analysis of the data which I collected from the five participating teachers during their journey of redesigning classroom-based assessments that promotes mathematical proficiency. It was explained to the research participants that the research aimed to understand better how classroom-based assessments can be redesigned

towards mathematical proficiency. The final destination of the journey, I told the participants, was less about designing the "perfect" classroom-based assessment item, and more about aiming to understand how teachers can develop classroom-based assessments which promote mathematical proficiency. The chapter starts with an introductory section, which is followed by providing the background information of each of the research participants (5.1) for a theoretical basis; evaluating the participating teachers' beliefs about teaching and learning mathematics in terms of the proficiency strands (5.2); and analysing the participating teachers' assessment practices.

Section 5.3 focusses on how secondary-school mathematics teachers describe and justify their current classroom-based assessment practices. I present and analyse the data I gathered from the semi-structured group and individual interviews I held, the teachers' concept maps on the purpose of classroom-based assessments, the artefact collection of previously designed classroom-based assessments, and the classroom observation. The teachers' beliefs of various aspects concerning assessment are analysed to characterise the participating teachers' conceptions of assessment, by using Delandshere & Jones's (1999) three assertions of assessment: teachers' beliefs about assessment are shaped by assessments' defined functions and purposes; teachers' beliefs about assessment are shaped by what they perceive as the official curriculum within the school structure and where they position themselves to the subject matter; and teachers' beliefs about assessment are shaped by how they understand learning and their students. I then analyse the teachers' conceptions of assessment with the use of a four-continuum model of conceptions of assessment, which was adapted from Remesal's (2011) four-dimensional bipolar model and Brown's (2002) four-dimensional model of trends of conceptions of assessment. The model, which will be described in greater depth in section 5.3.4, includes two opposing orientations: the "pedagogical assessment culture orientation" and the "societal testing culture orientation".

The four continuums are: assessment conceived as a tool for improvement of learning; assessment conceived as a tool for improvement of teaching; assessment driven by school and teacher accountability purposes; and assessment-driven by student accountability and certification purposes. I first locate the teachers' beliefs in one of the four different continuums, then locate each of these beliefs in each of the continuums as a pure pedagogical assessment culture conception or a pure societal testing culture conception, and end by honing into the mixed conceptions of assessment which teachers hold.

The next section of the chapter (5.4) attempts to understand how teachers can adapt their classroom-based assessment practices towards mathematical proficiency, and ultimately, towards a learning-centred classroom. The participating teachers are asked to evaluate critically to what extent their classroom-based assessments are aligned with Kilpatrick et al.'s (2001) five strands of mathematical proficiency. The participating teachers then are asked to design classroom-based assessments towards assessing mathematical proficiency. The data gathered of the teachers designing classroom-based assessment towards mathematical proficiency is analysed by lensing it through the framework's (DBE, 2018) model of mathematics teaching and learning the frameworks' implications of assessment, and by considering their conceptions of assessment in chapter 5.3, which describes how they justify their assessment practices and linking their assessment practices.

The last section of chapter five (5.5) focusses on the challenges which teachers experience in incorporating new ideas into the design of classroom-based assessments. I focus on the data I gathered in the last semi-structured interviews I held with teachers around changing their assessment practices to have a better understanding of the challenges they face in changing their assessment practices. I analyse the challenges they face designing and implementing transformed classroom-based assessments by focussing on their aim for constructivist teaching. I use an adapted analytic framework, developed by Windschitl

(2002), and amended by Suurtamm and Koch (2014). The four types of dilemmas – conceptual, pedagogical, cultural, and political – are aspects of teachers' lived experiences that prevent theoretical ideals of constructivism from being realised in school settings.

Chapter six draws together all the themes and threads which arose throughout the research study. The first part (6.1) provides an overview of the research by briefly outlining the aims and background of the study, the methodology adopted for data collection, as well as my approach to the analysis of the data. The second part (6.2) focusses on understanding the complexities of redesigning classroom-based assessments towards mathematical proficiency, and presents a summary of the results, highlighting key findings of the study. Each of the finding's aspects (the functions and purposes of assessment, the perceived curriculum, the context, the expectations of students) concerning the teachers' conceptions of assessment are considered and forms a model for adapting classroom-based assessments to serve a socio-constructivist purpose. Finally, the last section focusses on the limitations of the current study, theoretical contributions, the implications of research, and recommendation for further research.

1.6 CONCLUSION

The nationally set external examinations should be used only for their intended summative purpose. These summative examinations are important evaluation components to measure curriculum implementation, to accredit and certify, and to hold schools and teachers accountable for the quality of learning that needs to take place. In light of this, high-stakes assessments and systemic testing cannot comprehensively cover all the facets of mathematical proficiency; neither can these assessments all embracingly promote all the goals and aims of the South African Curriculum (CAPS). Schoenfeld (2002) points out that the National Council for Teachers of Mathematics (NCTM) recommended in at least one

publication that decisions affecting students' achievements and educational opportunities should not be made on the basis of examination marks alone; that alternative assessments should be provided where examination and test results may not provide accurate reflections of students abilities; and that assessments should cover the broad spectrum of content and thought processes represented in the curriculum, not simply those that are easy to measure. (NCTM 2000, 2014). It is vital to ask if we indeed measure what we value, or whether we are just measuring what we can measure easily and thus end up valuing what we can measure (Biesta, 2015).

It is the function of formative classroom-based assessments to cover a more holistic view of what a mathematical proficient student should be able to demonstrate. The onus, therefore, lies on mathematics teachers to develop and use formative classroom-based assessments that promote the aims of the South African curriculum towards assessing for mathematical proficiency, and ultimately, to advance socio-constructivism through the learning-centred classroom. I believe it is vital for teachers to design and use formative classroom-based assessments to serve an intended purpose and function of advancing teaching and learning. In view of this, if we are to connect assessment to school improvement in meaningful ways, we must come to see assessment through new eyes (Stiggins, 2002).

CHAPTER 2:

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will provide a literature review of teachers' beliefs, knowledge and classroom-based assessment practices. The purpose of the literature review is to research how to effect teacher change. Reviewing the research conducted in the field allowed me to develop research tools which will assist me in gaining insight into the data I collected to understand better how teachers can adapt their classroom-based assessments to promote mathematical proficiency. I will use literature to learn what the research finds the purpose and functions of assessment is, what research tells us about teachers' assessment practices and why attempting to change teachers' assessment practices are worthwhile. The literature review supports the theoretical framework of this study which is discussed in Chapter 3.

2.2 TEACHERS' BELIEFS

2.2.1 RATIONALE FOR FOCUSING ON TEACHERS' BELIEFS

Focusing on the belief systems and conceptions of teachers is essential, mainly because teachers are viewed as essential agents of change in the ongoing attempt to reform education. Unfortunately, research also shows that teachers are significant obstacles to change and reform education because they adhere to outmoded teaching styles, and forms of assessment, which emphasise factual and procedural knowledge at the expense of more profound levels of understanding (Prawat, 1992).

> ''Attention to the beliefs of teachers should be a focus of educational research and can inform educational practice in ways that prevailing research agendas have not and cannot'' (Pajares, 1992, p. 307).

Research has showed that what a teacher does in a classroom is shaped by much more than just knowledge, even if we consider content knowledge, pedagogical knowledge, and pedagogical content knowledge (Ball, Lubienski & Mewborn, 2001; Hill, Sleep, Lewis &

Ball, 2007), school factors, which includes the curriculum (Herbel-Eisenmann, 2006), psychological factors, including goals and efficacy (Speer, 2005) and socio-historic and contextual factors (Sztajn, 2003). Teachers' beliefs are considered to be one of, if not the most influential factor on teachers' instructional and assessment practices (Pajares 1992; Richardson 1996, Philipp 2007).

Two arguments are made in reform literature in reference to teachers incorporating new ideas to assessments, as well as in changing assessment practices. The first argument is that the use of more complex and meaningful forms of assessment will require changes in teaching practices in order for students to be prepared to perform well (Delandshere & Jones, 1999). This argument is of course indicative of what Delandshere & Jones (1999) describes as the "measurement-driven instruction" paradigm which is associated with minimum competency testing. This argument holds the assumption that changes in classroom practices will occur only if these practices are forced, sanctioned or guided by assessment. The counter argument is that assessment should rather be aimed at improving teaching and learning and to promote the learning which is encouraged by reforms, such as the Mathematics Learning and Teaching Framework for South Africa (DBE, 2018). This counter argument holds the assumption that teachers can first change their classroom and teaching practices, and then develop forms of assessment to promote the reforms which will enhance student learning. These two arguments differ significantly on two aspects. Firstly, the assumptions about what changes should occur first. Secondly, on the final outcome: students performing well on the one hand versus enhancing student learning on the other hand. One of the aspects which this study will focus on is to explore teachers' conceptions of assessment with regard to these assumptions. This study will explore the teachers' conceptions of assessment, and to

understand the connections that the teachers make between assessment, teaching and learning.

2.2.2 RESEARCH ON TEACHERS' BELIEFS AND CONCEPTIONS OF ASSESSMENT

Beliefs are in a subset of a group of constructs that name, define, and describe the structure and content of mental states thought to drive teachers' actions concerning assessment. Other constructs in this set include perspectives, perceptions, orientations, theories, and stances (Richardson, 1996). In reviewing the literature, many of the definitions of beliefs conflate beliefs with attitude. For example, Rokeach's (1968) definition of attitudes included the concept of beliefs. Pajares (1992) suggested that such concepts as attitudes, values theories, and images are really beliefs in disguise. Similar to a comparative case study on teachers' beliefs and practices (Kardanova, Panomaryova, Safuanov and Osin, 2014), in this study I am going to apply the term in a broad sense, understanding beliefs as views that teachers hold in their extensive teaching practice.

To have a better understanding of the interrelationship between beliefs, knowledge, perception, and value, I will refer to a study which focused on teacher belief, knowledge, and practice (Belbase, 2012). Belbase explained that the beliefs, knowledge, values, perceptions, and practices form a total system of lifeworld within which an individual behaves in a certain way in certain situations.

In Figure 2, Belbase (2012) illustrated how beliefs, knowledge, and perception partially overlap one another forming a common region at the core constituting personal value. Belbase (2012) argues that the partial overlapping regions constitute sub-constructs with a complexity of one's affective, cognitive, social, and cultural constructs. These overlaps are very fluid regions,

except for the core, which may alter over one's experiences and contexts representing qualitative changes in those constructs (Belbase, 2012).

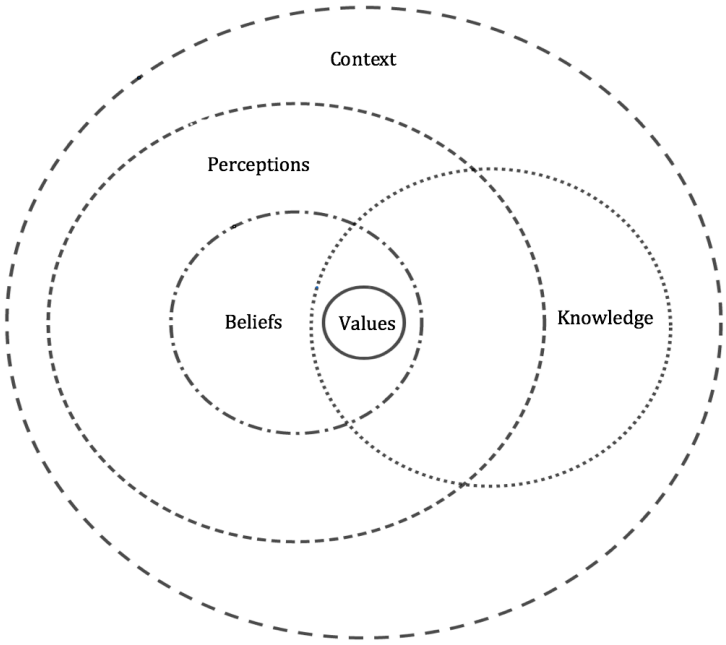

Figure 2: The interrelationship between beliefs, knowledge, perceptions and values (Belbase, 2012)

Green (1971) identifies three dimensions of belief systems, which is still very useful today, not having to do with the content of the belief systems themselves, but the way in which they relate to one another in the system.

Green's first dimension recognises that belief systems have a quasi-logical structure. Beliefs are not held in total independence of all other beliefs, and consists of primary and secondary beliefs, which is also known as primary and derivative beliefs.

The second dimension recognises the degree of conviction to which beliefs are held. According to Green, these beliefs can be viewed either as central or peripheral. Central beliefs are the most strongly held beliefs which are relatively difficult to change, and peripheral beliefs are most susceptible to change. The centrality of a belief is a function of the strength and number of its connections with other beliefs (Beswick, 2006).

In the third dimension, beliefs are seen to be held in clusters, in isolation from other clusters, and protected from forming relationships from other clusters or sets of beliefs. A consequence of beliefs held in clustered groups isolated from one another, is that a person may hold beliefs that contradict one another without being aware of the contradiction. Both Green (1971) and Thompson (1992) explain that, because beliefs are held in clusters, cross-fertilisation among clusters is prevented, and makes it possible to hold conflicting sets of beliefs. This clustering property helps to explain some of the inconsistencies found among the teachers' beliefs, where teachers might simultaneously hold contradictory beliefs that have developed in different contexts. Beswick (2006) explained that the beliefs teachers constructed as a result of the teachers' own experiences of learning mathematics, those formed during teacher education, and others beliefs that have developed as result of classroom experience, may contain contradictory elements that the teacher is unaware of.

In a study on identifying and describing teachers' conceptions of assessment, Delandshere & Jones (1999) found that there are two main ideas of learning.

The first idea of learning presupposes teachers' imparting concepts, rules and facts. In this idea, it is the responsibility of the teacher to impart the curriculum or body of knowledge to the students.

The second idea of learning sees learning as experiential, which arises from specific experiences that are structured to expand students' knowledge through various interactions with the social and physical environment. This idea of learning places significantly more demands on the teacher who is responsible for structuring educational relevant learning and assessment activities for students of diverse learning needs. In this learning idea, the curriculum is less defined than in the first learning idea, but rather emerges from students' specific experiences and the learning activities in which they engage.

Delandshere & Jones (1999) found that when teachers are faced with the inconsistencies between systemic high-stakes externally set examinations which reflect simplistic views of learning and curriculum and incorporating new ideas to their assessment practices, which are encouraged by educational reforms, such as the Mathematics Teaching and Learning Framework (DBE, 2018), one of two assumptions plays itself out. The first assumption is that the reform will encourage teachers to rethink their assessment practices. The second assumption is that teachers will be left in a state of assessment paralysis.

Figure 3 illustrates Delandshere & Jones's (1999) three assertions of assessment:

(a) Teachers' beliefs about assessment are shaped by its defined functions and purposes;

(b) Teachers' beliefs about assessment are shaped by what they perceive as the official curriculum within the school structure and where they position themselves with regard to the subject matter; and

(c) teachers' beliefs about assessment are shaped by how they understand learning and their students.

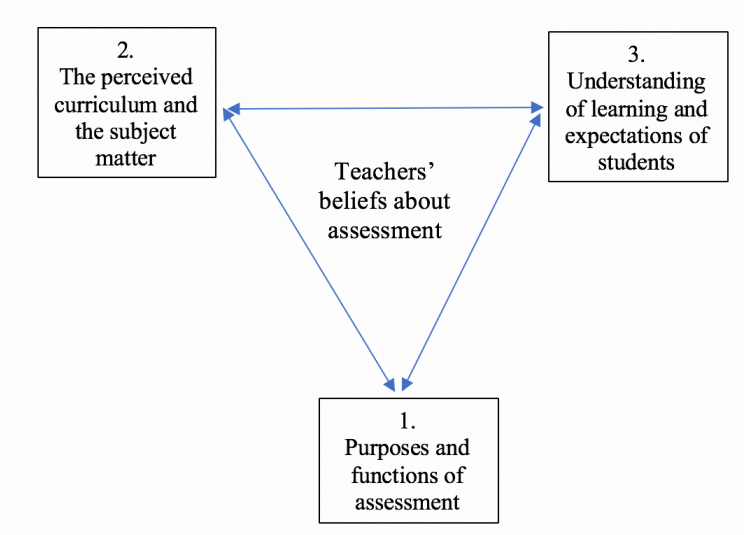

Figure 3: Delandshere & Jones's (1999) three assertions of assessment

Teachers' beliefs about content, curriculum and student learning are most likely to play a substantial role in the formation of their conceptions about assessment, which will have a direct effect on their assessment practices. I expect that these two contrasting conceptions of learning and curriculum will result in distinct types of assessment that will be different in both purpose, form and function. It is therefore essential for this study to compare the participating teachers' assessment practices with their beliefs about content, curriculum and student learning to have a better understanding of their conceptions of assessment.

When learning is seen as the acquisition of facts, rules, skills and concepts, assessment serves the function of verification and sanction, which asks if the students have or have not learned the content. Assessment takes place after learning is judged to have taken place and verifies whether each of the student's responses to the task is correct as defined in the context of a given curriculum. A mark is given to each of the students for completing the assessment and conforming to the task. Scores are used to promote and certify students.

In contrast, when learning is conceptualised as a process of constant development enhanced by purposeful, structured learning experiences, then assessment is more likely to be seen as providing continuous descriptive feedback to the teacher and student of the quality of learning that is taking place. Assessing students' work requires the teachers to make continual judgements, rather than simple measurements, about the quality and validity of the knowledge being demonstrated, and are intended to have educational value. In this conception, assessment is thought of as an intrinsic and integral part of learning process. The assessment will require more than just procedural questions. Students are given greater responsibility for directing their own learning and developing their own meanings.

The roles and responsibilities of teachers effectively changes in the second conception which may be inconsistent with their traditional views of teaching. Teachers also face the challenge of navigating the high-stakes externally set examinations, which are for the most part incompatible and inconsistent with the assessment practices which are encouraged by educational reforms, such as the Mathematics Teaching and Learning Framework for South Africa (DBE, 2018). The types of conceptual learning which is promoted by these reforms and frameworks, urges purposeful assessments, with increased emphasis on contextualised and conceptual construction of knowledge.

2.2.3 DISTINGUISHING BETWEEN BELIEFS AND CONCEPTIONS

Several studies (Pajares, 1992; Remesal, 2011; Opre, 2015) stressed the importance of clarifying and clearly differentiating the terms *beliefs* and *conceptions*, because these terms are often used interchangeably. Yet, other studies (Pepin, 1999) stressed that the distinction between conceptions and beliefs might not be distinguishably important, it is just more 'natural' at times to refer to teachers' conceptions of loaded concepts, such as teachers' conceptions of mathematics or teachers' conceptions of assessment, rather than to speak about the teachers' beliefs about mathematics or beliefs of assessment. I used the definitions of Remesal (2011) to differentiate between beliefs and conceptions.

When beliefs are investigated in relation to assessment, as opposed to fields like personal epistemology, research often prefers terminology of assessment *conceptions*. The term conception was first introduced by Thompson (1992) to describe general mental structures, which encompasses beliefs, meanings, concepts, propositions, rules, mental images and preferences. Beliefs therefore represents a subcategory of the conceptions. I decided to use the term conceptions when it comes to assessment, as opposed to only referring to the

teachers' beliefs of assessment, because to understand the full picture, it is important not to be limited by only looking at beliefs and values of teacher, but also meanings and concepts which support the beliefs. I will, for example refer to teachers' conceptions of assessment, but to a sub-category of assessment, such as the purpose of assessment, I will refer to teachers' beliefs of the purpose of assessment.

2.2.4 TEACHERS' CONCEPTIONS OF ASSESSMENT

Assessment fulfils at least two basic functions: a pedagogical function and a societal function (Stiggins, 2005; Remesal, 2011). The pedagogical function of assessment is a device to promote reflection and change in education by monitoring both learning and teaching. The societal function of assessment sees assessment as a tool for accreditation and certification of different audiences in society, such as the Department of Basic Education and families. It serves for teacher professional accountability, as well as the accountability of student achievement.

The interest in the study of teachers' assessment conceptions is relatively current (Brown, 2002, 2004, 2007; Remesal, 2011; Harris & Brown, 2009; Davis & Neizel, 2011; Barnes, Fives & Dacey, 2015; Opre, 2015) and exists due to the paradigm shift in the approach and understanding of teaching and learning (Opre, 2015). These recent studies on teachers' conceptions of assessment bring important contributions not only to the way in which teachers understand assessment, but also how these beliefs influence their teaching behaviour (Opre, 2015). Table 1, represents a literature review of five studies, which consists of Brown (2004; 2006); Remesal (2007); Karp & Woods (2008); Harris & Brown (2009); Davis & Neitzel (2011), on teachers' beliefs about the purpose of assessment, which forms part of an aspect of teachers' conceptions of assessment.

Table 1: Beliefs about the purpose of assessment (Barnes et al, 2015)

Author	**Beliefs about the purpose of assessment**
Brown (2004; 2007)	Describes abilities
	Improves learning
	Improves teaching
	School accountability
	Student accountability
Remesal (2007)	Assessments' role in learning
	Assessments' role in teaching
	Assessments' role in certification
	Accountability of students' achievement - indicator of teachers' professional ability
Karp & Woods (2008)	Facilitate learning
	Determine where students are with acquiring skills and knowledge
	Show students where they are in relation to goals
	Motivate students
	Show teacher achievement of standards
	Evaluate teacher effectiveness
Harris & Brown (2009)	Joint teacher and student use for individualising learning
	Extrinsically motivating students
	Reporting to parents
	External reporting
	Compliance
Davis & Neitzel (2011)	Evaluate and inform instruction
	Gauge student investment
	Cover material
	Identify students for remediation
	Generate feedback
	Evaluate learning
	Student accountability
	Inform parents
	Teacher accountability
	Prepare for high-stakes assessments

There are studies on the development of and the factors that influence teachers' conceptions of assessment which differ significantly. Brown (2004) deem that conceptions are not necessarily affected by the context in which they develop in, nor by prior experience. Opre (2015) went further to explain that the roles fulfilled by teachers, the number of years in education, the number of years in professional experience and the socio-economic status of the school in which the teachers teach, do not influence the conceptions that teachers hold in relation to assessment. Other studies oppose the view of Brown (2004) and indicate that teachers' conceptions of assessment can be altered by various factors, including the system of education, the manner of understanding the content which is taught (Vandeyar & Killen, 2007), the teachers' beliefs in their students' abilities, community expectations (Bright &

Joyner, 1998). Research has shown that conceptions of assessment, as is the case with other types of teachers' beliefs, significantly influences the decisions of the teachers and their professional activity (Opre, 2015; Brown, 2007). Opre (2015) explained that changing teachers' conceptions of assessment will lead to the alteration of their assessment methods. Vandeyar & Killen (2007) went further to explain that varying conceptions about assessment leads to varying assessment practices

One of the earliest contributions on conceptions of assessment was made by Wolf, Bixby, Glenn, and Gardner (1991) who proposed to distinguish between two opposite poles in a continuum: the 'assessment culture' and the 'testing culture'. The authors found that all the ideas that teachers hold about intelligence, about the process of teaching and learning, the nature of assessment tasks and instruments, and about evaluation criteria, has a direct effect on the teachers' understanding and practices of assessment. The teachers' ideas and beliefs concerning multiple aspects of assessment had a direct influence on their use and design of classroom-based assessments, which significantly effects the learning that takes place in the classroom.

A study by Remesal (2011) on primary and secondary teachers' conceptions of assessment, referred to these two opposing poles which I originally described as 'learning orientated' and 'marks orientated and control' as 'the pedagogical-regulation pole' and 'the societal-accreditation pole'. I decided to analyse the teachers' conceptions of assessment by using Remesal's (2011) four-dimensional bipolar model of conceptions of assessment. I found that there were belief systems, or building conceptions, of assessment informing the teacher and student of teaching and learning, which Remesal (2011) referred to as monitoring of teaching and learning and used to described the pedagogical-regulation orientation. I also found belief

systems of assessment relating to gathering marks for certification and grading, and to hold students and teachers accountable. Remesal (2011) referred to this as the societal-accreditation pole where the focus is on teachers' accountability and certification of achievement. Figure 4 illustrates the four-dimensional bipolar model of conceptions of assessment (Remesal, 2011).

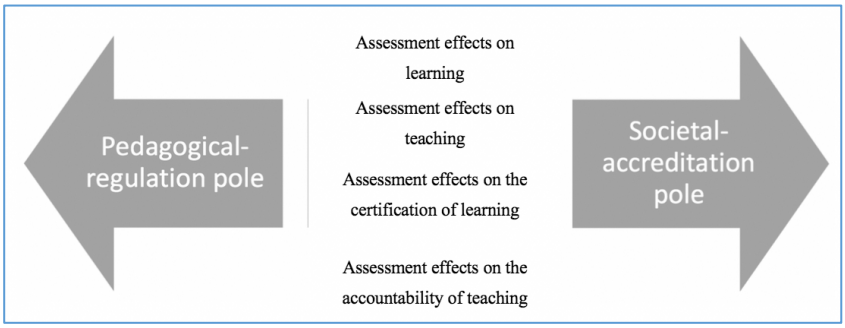

Figure 4: Remesal's (2011) four-dimensional bipolar model of conceptions of assessment

I now want to focus on three phenomena that have emerged in numerous studies. The first is that teachers' beliefs of assessment are formed by acting on school practices, including the learning experience the teacher experienced as a student, and the influences of the environment where the teachers teach (Pehkonen, 1994). The second is that teachers' beliefs of assessment are often inconsistent with their teaching practices. This is due to various constraints, including time and resources, working conditions, and student behaviour (Philipp, 2007). The third is that teachers need to become aware of the beliefs that are currently filling the most influential roles. From this perspective, teachers' belief systems are not simply 'fixed' through a process of replacing certain beliefs with more desirable beliefs. Rather, teachers' beliefs must be challenged in such a way that desirable beliefs are seen by teachers as the most sensible beliefs to which they should cohere (Leatham, 2006). Research suggests that beliefs drive classroom actions and influence the teacher change process (Pajare, 1992; Richardson, 1994).

Ball et al. (2001) shows how the teachers' own understanding of the concepts of the subject matter and commitment to their students influenced the ways in which they understood the students. Morgan and Watson (2002) explain that, when teachers assess students' levels of mathematical proficiency, they rely on their (1) personal knowledge of mathematics and the curriculum; (2) beliefs about the learning of mathematics based on their own mathematics history; (3) expectations on how mathematical knowledge can be communicated; and (4) expectations of their students.

In a study which analysed teachers' belief systems, Bräunling and Eichler (2015) approved with Green's (1971) aspects which characterise a belief system. They also identified different belief clusters. The understanding that central beliefs are not necessarily connected to peripheral beliefs is therefore essential considerations to interpret the teachers' beliefs of assessment. Not surprisingly, Hall & Ponton (2005) found that when teachers believed in the abilities of the students, the students tended to believe in their abilities, and as a result performed better than students where the teachers doubted the abilities of students. Teachers' conceptions are often viewed as the bridge between teachers' knowledge and practice (Schmidt et al., 2007). In this study, teachers' conceptions of assessment must therefore also include the beliefs which teachers hold of their students' abilities, which are essential considerations to understand how they can adapt their assessment practices towards mathematical proficiency.

2.2.5 CHANGING OF TEACHERS' BELIEFS AND CONCEPTIONS

Reform in mathematics education calls for teachers to hold student-centred and learning-centred perspectives (DBE, 2018). The first study I want to focus on was conducted by Chapman (2002), which examined secondary school mathematics teachers' beliefs in the context of changing their practice from a predominantly teacher-centred perspective towards

a more student-centred perspective. He discusses how the teachers went through various stages of development, including realising that there was a difference between teaching mathematics and doing mathematics; going through dilemmas and tensions; making connections; and reflecting on one's own thinking. The study found that teachers can be categorised into three categories: teachers who can change their teaching on their own; teachers who change their teaching with external support; and teachers who are reluctant to change despite being involved in professional-development programmes. He comments that the relationship between thought and action is a significant contributor to teachers' change. From the research, questions arose about belief structure and its relationship to changing the teaching of experienced teachers. One of the dilemmas which he discusses is knowing what alternative experiences one should be exposed to in order to influence all of the appropriate beliefs.

The second is a study on the impact of teachers' beliefs on their ability and tendency to change by Cooney (2002). One of the most significant findings was that change is always dependent on the context within which teachers have to function. It will be difficult for a teacher to experiment with a constructivist approach to teaching mathematics if the school dictates that the classroom be teacher-centred, and if constructivist teaching activities are seen as chaotic lessons. The environment, therefore, constrains or supports teacher change, which are essential considerations to interpret to what extend teachers can adapt their classroom-based assessments towards mathematical proficiency. Wilson and Cooney found inconsistencies between pedagogical beliefs and actual classroom practices, which included classroom-based assessments, and which might have been due to the unfavourable school environment, lack of support, and lack of resources. The research found that, when the emphasis of research is shifted towards a sense-making perspective, the boundary lines between the knowledge and beliefs becomes blurred as one tries to understand the

phenomena of teacher change and what drives that change. The changes of teachers consisted of more than just a change in behaviour, but also a change in conceptualising the teaching and assessment practices. Belbase (2012) argues that the characterisation of the reform-orientated teacher is rooted in the ability of the individual to doubt, reflect, and reconstruct.

A progressive relationship among beliefs, knowledge, and practice leads to change depending on context or environment. Belbase (2012) found that the degree of the teacher change is dependent on the fixed circle of context. Figure 5 illustrates that the scope or the degree of change is independent as it expands, the circle of context possibilities expands too.

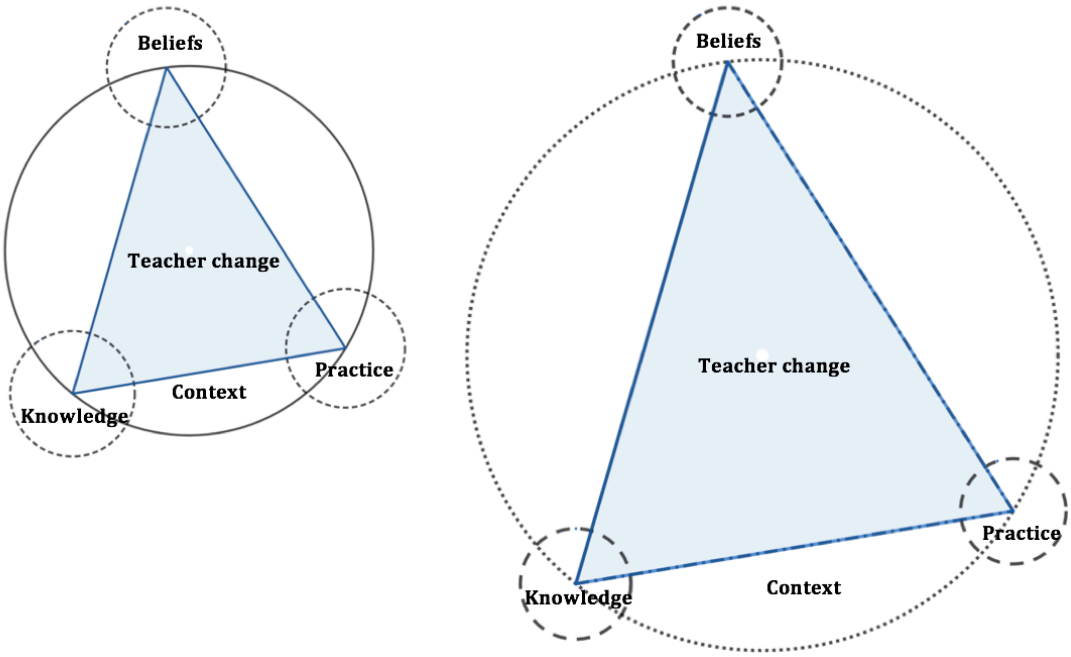

Figure 5: The effect of the environment on teacher change (Belbase, 2012)

Beliefs, knowledge, and practice play a significant role in the process of teacher change, as illustrated in Figure 5, conceptually pulling the vertices of teacher change away, which becomes easier in the flexible school environment compared to rigid and structured environments (Belbase, 2012). In figure 5, the left-hand-side represents inflexible contexts or

environments in schools which limit teachers' generative and reflective activities, and hence prohibits teacher change. This is in contrast to the right-hand-side figure, which represents a flexible context or environment in schools, allowing teachers to develop creative teaching and assessment practices. Belbase (2012) poses the teaching environment as the dependent variable, and teacher change as dependent on the environment.

2.3 TEACHERS' CLASSROOM-BASED ASSESSMENT PRACTICES

2.3.1 THE RELATIONSHIP BETWEEN ASSESSMENT AND LEARNING

I do not need to try to convince anyone who has attempted to learn something or teach someone that the relationship between learning and teaching is complex. Moreover, research on learning has often been conducted independently of research on teaching, leading to a gap in understanding between the two communities of research – those who understand and work on learning, and those who understand and work on teaching (Wilson and Peterson, 2006). Scholars have been intentional about bridging the gap between these two intellectual communities, but with modest success (Romberg and Carpenter, 1986). Suurtamm & Koch (2014) argued that teaching and assessment are viewed as seamless processes that support students' learning through continuous feedback from teachers and students. Current theories on classroom assessment also recognise that learning is not linear but multi-dimensional, and that multifaceted processes require innovative assessment practices (Suurtamm & Koch, 2014; Brookhart, 2003; Gipps, 1999). This leaves teachers in a complex landscape of accountability in which they are portrayed as technicians tasked with implementing a prescribed curriculum, policies, and procedures (Cochran-smith, 2009). Teachers have their own beliefs and established classroom practices that unavoidably interact with current thinking about mathematics education and assessment (Ball, 2008; Wiliam, 2007).

There have been increasing calls, both in the classroom assessment literature (Gardner, Harlen, Hayward & Stobart, 2008; Stobart, 2008; Suurtamm & Koch, 2014) and in the mathematics education literature (Wiliam, 2007; Kilpatrick et al., 2001), for teachers to make changes to their assessment practices. Teachers are asked to use a variety of assessment practices that are receptive to student thinking and learning. Current perspectives on classroom assessment that draw on cognitive, constructivist, and socio-constructivist views of learning have shifted from a view of assessment as an event which objectively measures the acquisition of knowledge towards a view of assessment as a social practice which provides continual information to support student learning (Suurtamm & Koch, 2014; Lund, 2008; Shepard, 2000; Gipps, 1999).

Furthermore, in an extensive survey of the literature on formative assessment in mathematics classrooms, Black and Wiliam (2006) studied more than 580 articles or chapters. They found there is substantial evidence that by improving assessment raises standards; there is room for improving the way teachers assess; and there is evidence on how to improve assessments. All the studies show that innovations which include strengthening the practice of classroom-based assessment produce significant and often substantial learning gains (Black & Wiliam, 2006, p.3). They further found that many of the studies arrive at another important conclusion: “improved formative assessment helps low achievers more than other students and so reduces the range of achievement while raising achievement overall” (Black & Wiliam, 2006, p.3). A number of more recent studies similarly have addressed the degree to which formative assessment affects achievement (Bennett, 2011; Filsecker & Kerres, 2012; Kingston & Nash, 2011; Dunne et al., 2012).

Although the relationship between learning and assessment is complex, and non-linear, extensive research have found that the relationship is not only compatible, but, in harmony and depended on one another.

2.3.2 THE ROLE OF ASSESSMENT IN A LEARNING CULTURE

Before looking at Shepard's learning paradigm, which consists of a significant part of the conceptual framework, I will provide the rationale for focusing on the role of assessment in a learning culture. The Mathematics Teaching and Learning Framework for South Africa (DBE, 2018), which is discussed comprehensively in section chapter 3.5, is a five-dimensional framework, which draws on Kilpatrick's five strands of mathematical proficiency (see section 3.4). The framework has been developed for South African teachers to guide and assist them to teach Mathematics in a way that improves learner outcomes. The model of mathematics teaching and learning presented in this framework is constituted by four key dimensions: conceptual understanding, mathematics procedures, strategic competence, and reasoning, while each of these is underpinned by a learning-centred classroom. The learning-centred classroom is placed as the foundation for all of the other dimensions of the framework. The four key dimensions are closely aligned to the first four mathematical proficiency strands, and represent a contextualisation and adaptation of the strands to the South African context. The framework encourages teachers to strive to (1) teach mathematics for conceptual understanding; (2) teach so that learners can develop procedural fluency; (3) develop learners' strategic competence; (4) develop learners' mathematical reasoning skills; and lastly, (5) promote a learning-centred classroom. The framework spends substantial time on key areas of the implications of teaching for conceptual understanding, such as the curriculum and learning and teaching support, but is very light on the implications of assessment to promote such a learning culture. There is thus not only a need for teachers to adapt their instruction practices, but of equally importance, a need for researchers to understand teachers' assessment practices as teachers will need to incorporate new ideas to their assessments and adapt their assessments to promote the four key dimesons of the framework's model. Considering that teachers will need to adjust their

teaching practices, in order to teach for conceptual understanding, while also considering the strong relationship between assessment and learning, the role of assessment in a learning culture will be an essential aspect of this critically important study.

2.3.3 FORMATIVE CLASSROOM-BASED ASSESSMENTS

Assessing students' mathematical proficiency has been around for as long as teaching mathematical concepts. As long as there has been mathematics, there has been assessment. Classical test theory, originally conceptualised by Charles Spearman in the 1900s (see Spearman, 1904), has been concerned primarily with differentiating between individuals who possess certain attributes, or by determining the degree to which they do so. This 'differentialist' perspective – measuring the performance of individuals on an assessment compared to the difficulty level of the questions in the assessment – is still evident in popular discourse (James, 2006).

For Black and Wiliam (1998), and many other experts in the field (Shepard, 2008; Schoenfeld, 2007), formative assessment should not be seen as an instrument or an event, but a collection of practices with the common feature of leading to action that improves learning. Because of the complexity of defining a broad term such as formative assessment, I will approach the definition of formative assessment from different angles. In this study, I will use the term 'formative assessment' to indicate both informal assessments, which teachers may use, as well as more formal classroom assessments.

By reviewing the literature on formative assessment, the first aspect describes feedback at the heart of this form of assessment. Harlen and James (1997) describe formative assessment as essential feedback both to the teachers and the students about present understanding and skill development in order to determine the way forward. This description is shared by Sadler (1998), who defines a formative assessments as assessments which are

intended specifically to provide feedback on performance to improve and accelerate learning. The second aspect evolves around the immediacy of using the information. Shepard (2008) defines a formative assessment as an assessment which is carried out during the instructional process for the purpose of improving teaching and learning. Shepard further explains that what makes formative assessment 'formative' is that it is used immediately to make adjustments in order to form new learning.

Returning to the description of formative assessment by Black and Wiliam (1998), the common thread, which is woven throughout formative assessment research, is that it is not the instrument that is formative, but rather the use of information gathered to adjust teaching and learning which merits the formative label (Chappuis & Chappuis, 2007). Black and Wiliam explain that, while research shows that assessment can be used to improve learning, it depends on five key factors: (1) providing effective feedback to students; (2) the active involvement of students in their own learning; (3) adjusting teaching to take account of assessment results; (4) recognising the profound influence assessment has on student motivation and self-esteem, both of which are crucial influences on learning; and (5) the need for students to assess themselves and understand how to improve (White, 2010. p.8).

When teachers develop assessment tools, White (2010) explains, a critical factor is a purpose for the use. A key distinction in the research is between assessment for learning and assessment of learning. Formative assessment is also referred to as assessment for learning – that is, an assessment which is part of everyday practice by students and teachers that seek, reflect upon, and respond to information from dialogue, demonstration, and observation in ways that enhance ongoing learning (Klenowski, 2009). Stiggins (2002) explains the difference between assessment for learning, or formative assessment and assessment of learning, or summative assessment, as the difference between assessment to determine the

status of learning and assessment to promote learning. The study stresses that the absence of assessment for learning observed among teachers is an assessment crises.

In reality, summative and formative assessments are often intertwined. When the information from an assessment is used solely to make a judgement about the level of competence or achievement of the student, it is defined as a summative assessment. Chappuis & Chappuis (2007) notes that an assessment could be summative at the classroom level when it is given to students to determine how much students have learnt at a particular point in time, for the purpose of communicating achievement status, in the form of a mark, to students and parents. Chappuis & Chappuis (2007) further argues that an assessment intended to be used formatively could be used as a summative assessment, such as when the evidence indicates that students have attained mastery. It is also possible for an assessment, intended to be used as a summative assessment, to be used formatively, in instances where an assessment reveals significant problems with learning that will need to be addressed through reteaching.

2.3.4 DISTINGUISHING BETWEEN FORMATIVE AND SUMMATIVE ASSESSMENTS

I agree with Shepard (2000) that there is a need for two assessment 'systems' to exist: formative classroom-based assessment and summative external assessments. Each of the two systems will need focus on their intended purpose.

Classroom-based assessments should operate independently from large-scale external assessments because of the different types of information they produce. Classroom-based assessments can provide the teacher with immediate and contextualised data, as opposed to the rigorously comparable results which large-scale external assessments produce. Shepard notes that classroom-based assessments should be formative in nature, aimed more at helping students in taking the next steps in learning than judging the endpoints of achievement. More

importantly, classroom-based assessments should be used only for the purpose they were designed to achieve and should not primarily be used to certify student proficiency levels at a fixed point with precision, but rather to generate hypotheses and guide intervention. In comparison, external assessments must demonstrate higher reliability because they are by nature once-off assessments and used to make critically important decisions.

2.3.5 DISTINGUISHING BETWEEN TRADITIONAL AND CONTEMPORARY ASSESSMENTS

Cox (2011) argued that how the teacher assesses determines what the students learnt. The chosen method the teacher uses directs students to learn superficially or more deeply (Smith and Wood, 2000). The main differences between traditional and contemporary assessment approaches lie in their alignment with learning theories. To best illustrate the difference of the traditional assessment approach to the contemporary assessment approach, I will draw on the findings of the study by Even (2005), 'Using Assessment to Inform Instructional Decisions'. Illustrative cases revealed that teachers' processes of interpretation of students' understandings, knowledge, and their learning of mathematics draw on a rich knowledge base of understandings and beliefs. The study looked at two problems: the first problem relates to teachers' sense-making of assessment data, and the second problem relates to ways of helping teachers adopt contemporary assessment approaches.

The traditional assessment approach is underpinned by behaviourist learning theory, whereas contemporary assessment is based on constructivist and socio-constructivist learning theories. Traditional and contemporary assessment differ on three main issues: (1) the methods and instruments used for assessments; (2) the degree of integration of assessment with teaching;

and (3) the purposes for assessment (Black and Wiliam, 1998; Black, 2000; Clarke, 1997; Shepard, 2000; Even, 2005).

Even (2005) writes that traditional assessment centres on summative assessment, which evaluates students' achievement at the end of a period of teaching. Its main purposes are to certify students' attainment at the end of a period of teaching, and to classify and rank students. The students' marks are addressed mainly to external authorities such as principles and subject intendants. In contrast, Even (2005) explains that contemporary assessments move from the concentration on summative assessment towards an emphasis on formative assessment with the main purpose of advancing students' learning and informing teachers to make teaching decisions. The use of assessment data to make teaching decisions, including adapting the pace of teaching, selecting resources, and challenging students' thinking, is aimed at advancing students' learning.

Even (2005) explains that how teachers make sense of students' understanding, knowledge, and learning mathematics is an effective process of interpretation that draws on a rich base of knowledge and beliefs, and mostly involves ambiguity and difficulties. This implies, then, that the purpose of contemporary assessment to inform teachers as they make teaching decisions is much more complex than anticipated. Even (2005) found that professional development can contribute significantly to enhance teacher knowledge and disposition, so that they raise their ability to make sense of assessment data.

2.3.6 THE PURPOSE OF CLASSROOM-BASED ASSESSMENTS

Shepard's (2000) emergent constructivist framework addresses principles of classroom-based assessment. The underlying principle is that the substance classroom-based assessments must

be congruent with learning goals. Shepard explains that this means that the content of assessments must match challenging subject matter standards and be connected to contexts of application. The questions that teachers put before students demonstrate to the students how they are expected to spend their study time (Smith and Wood, 2000). Smith and Wood (2000) argue that, regardless of the chosen pedagogy, any instructional method contains certain assumptions about the student. Classroom-based assessments must mirror the important thinking and learning processes which are valued and practised in the classroom. Shepard further notes that standardised tests, which teachers are forced to use as formative classroom assessments, can de-skill and disempower teachers. Teachers should be in control of using, selecting, and designing classroom-based assessments to inform learning and teaching, and not be reliant on drilling students to prepare them for traditional basic tests which are summative in nature.

The degree of integration of assessment with teaching, as well as the methods used for assessment, are related to the purpose of the assessment. Shepard notes that the purpose of developing and conducting classroom-based assessments is to help students to learn, and to improve teaching, rather than to rank students or to be used as an administrative tool. In classrooms where participation in learning is motivated by its use and value, Shepard explains, students and teachers have an understanding of working together to finding out what makes sense and what does not. To serve this, classroom-based assessment requires that expectations and intermediate steps for improvement be made visible for students. Shepard argues that changing assessment practices is more difficult than changing teaching practices for two reasons. Firstly, because of the continued influence of external standardised assessments and, secondly, because most teachers have had little training beyond objectively writing and familiarity with traditional assessment formats to assist them how to assess their

students' understanding. Shepard notes that classroom-based assessments should be formative in nature, aimed more at helping students take the next steps in learning than judging the endpoints of achievement. More importantly, classroom-based assessments should only be used for the purpose they were designed to achieve. Classroom-based assessments should operate independently from large-scale external assessments. The purpose of classroom-based assessment is not primarily to certify student proficiency levels at a fixed point with precision, but rather to generate hypotheses and guide intervention.

2.3.7 TEACHERS' CONCEPTIONS OF ASSESSMENT AND THEIR ASSESSMENT PRACTICES

Classroom assessment is a complex process of collection, analysis and evaluation of evidence about the teaching and learning process and learning outcomes (Remesal, 2011). Assessment involves decisions made by the teacher which affects both the teaching and learning processes for a pedagogical function (reflection and monitoring teaching and learning) and a societal function (certification, accountability of students' achievement and teachers' professional work (Coll & Remesal, 2009). Classroom assessment practices have been studied extensively around the world. Most of the studies on classroom assessment practices attempt to determine what effect factors such as class-size, school-size, socio-economic school contexts, different subject areas, have on classroom assessment practices. A study of secondary school teachers in Canada (Duncan and Noonan, 2007) have shown that factors such as class-size have not had a significant impact on teachers' classroom assessment practices as originally thought, whereas the subject area does have a major impact on classroom assessment practices.

Teachers' beliefs and thought processes directly influence their actions in the classroom (Clark & Peterson, 1986). Thompson (1992) explains that a belief is never held in total independence of other beliefs. Teachers' thinking, planning, interactive decision making (the very act of

teaching and assessing their students), and implicit beliefs are interwoven facets that affect their classroom practices every day. By extension, then, their implicit theories about assessment inform their thinking and planning, and consequently shape their classroom assessment practices (Thompson, 1992; Bliem & Davinroy, 1997; Schoenfeld, 1998). Teachers' beliefs are indissolubly interconnected. In their professional practices, teachers rely on a whole system of views which, in turn, are based on deeply rooted beliefs. Researching beliefs require that we do not classify or differentiate between beliefs, but try to extract the common teacher-specific understanding of mathematical education and purpose of assessment (Kardanova et al., 2014; Pajares, 1992).

Handal & Herrington (2003) suggests that teachers' mathematical beliefs originated from their learning experiences in schools, which eventually reproduced in their classroom teaching and assessment practices. Handal & Herrington (2003) further argued that teachers' beliefs could be seen as a filter or lens through which they make their decisions, rather than just relying on their pedagogical knowledge and curriculum guidelines. Many researchers have claimed that the educational system is unsuccessful to changing teachers' beliefs and, therefore, practices, which results in producing behaviourist mathematical beliefs (Handal & Herrington, 2003; Belbase, 2012). Beliefs and classroom practices, including classroom-based assessment, are seen as a two-way transaction where the one influences the other (Belbase, 2012).

It has been found that the beliefs of teachers and students mirrored one another. In a study by Chan and Wong (2014), which focuses on mathematics teachers' worldviews and beliefs about teaching and learning, teachers' beliefs about mathematics education is a factor in how students' learning experiences are formed. The teachers' beliefs about teaching and learning mathematics influence their teaching and assessment practices, which in turn influence students' beliefs about mathematics and how students develop mathematical proficiency. Although the authors acknowledge that there are other factors, including professional

development, professional knowledge, and school contexts at play, the study found that students' and teachers' beliefs mirrored one another. It is vital to acknowledge that the belief-practice relationship is complicated, and that the relationships should be interpreted in terms of contextual factors such as school environments and cultures.

Fig 6 below represents an adaption of a schematic by Sullivan, Clarke & Clarke (2012) that describes the relationships between aspects of knowledge, situational factors, and teachers' intentions.

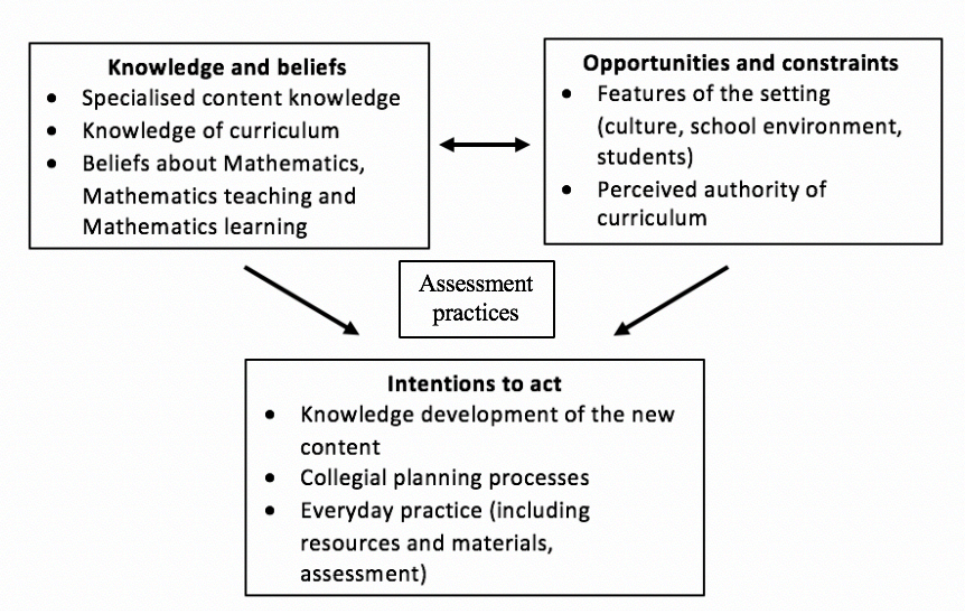

Figure 6: The relationship between aspects of knowledge, situational factors and teachers' intentions on teachers' assessment practices (adapted from Sullivan et al., 2012)

Although assessment practices are not centred in the framework of Sullivan et al. (2012), the framework describes influences on teachers' knowledge and practice, and especially on the ways teachers interpret and implement curriculum documents. The knowledge of the subject, combined with an in-depth curriculum informs planning and the designing of classroom activities, including classroom-based assessments. How teachers come to enact curricular knowledge in their planning and designing of assessments is both an individual process

influenced by teachers' beliefs of teaching and learning (Chan and Wong, 2014), and highly dependent on school contexts. The power struggle between the teachers' knowledge and beliefs with the constraints and opportunities, as was the case in this study with the contrasting learning-environments at the two schools, has a direct impact on the knowledge development, planning, and designing of assessments. To understand how teachers' assessment practices are influenced by the relationships between aspects of knowledge and beliefs, situational factors and teachers' intentions, I adapted Sullivan et al.'s (2012) framework by placing teachers' assessment practices at the centre of the relationship. The three dimensions (knowledge and beliefs, situational factors and teachers' intentions) act on each other, and directly acts on teachers' assessment practices. It is essential not to see the teachers' knowledge and beliefs in terms of assessments, as independent from teachers' intentions and situational factors.

2.3.8 ASSESSMENT DATA AND FEEDBACK

The idea that assessment data can be used as a powerful tool to guide teaching and learning is not new. Shepard (2000) explains that an area which has not received adequate attention is what it means in practice to use assessment data to enhance teaching and learning.

It is evident that assessment is used for many different purposes, and the purposes of designing and utilising assessments are important. It is therefore pertinent to review the literature on the purpose of education, as this will be the lens through which I will analyse and interpret the teachers' beliefs about the purpose of education. The book, *Assessment in Mathematics Education* (Suurtamm, Thompson, Kim, Moreno, Sayac, Schukajlow, Silver, Ufer and Vos, 2016), comprehensively discusses the distinction between the purposes of large-scale summative assessments and classroom-based assessments. In the first part, Suurtamm et al., (2016), describes the purposes and importance of the use of large-scale assessment in terms of accountability:

> "Large-scale assessment informs systems. It is often used for system monitoring, to evaluate programs, or to make student placements. In many jurisdictions around the world, students are assessed in mathematics using some form of large-scale assessment that may take the form of national, state, or provincial assessments but could also take the form of international assessments. For accountability purposes, such large-scale assessments of mathematics are used to monitor educational systems and increasingly play a prominent role in the lives of students and teachers as graduation or grade promotion often depend on students' test results. Wilson and Kenney (2003) indicated that teachers are sometimes evaluated based in part on how well their students perform on such assessments" (Suurtamm et al., 2016, p. 3).

In the next part, Suurtamm et al. (2016) explained the purposes of designing and using classroom-based assessments:

> "Classroom assessment gathers information and provides feedback to support individual student learning (De Lange 2007; National Research Council [NRC] 2001b) and improvements in teaching practice. Classroom assessment usually uses a range of teacher-selected or teacher-made assessments that are most effective when closely aligned with what and how the students have been learning (Baird et al., 2014). Current perspectives in classroom assessment (e.g. Brookhart, 2003; Klenowski, 2009; National Council of Teachers of Mathematics [NCTM], 2014) encourage the use of a range of assessment strategies, tools, and formats, providing multiple opportunities for students to demonstrate their learning, making strong use of formative feedback on a timely and regular basis, and including students in the assessment process" (Suurtamm et al., 2016, p. 3).

The reason for honing into the purposes of assessments is critical because what you what you test is what you get. Swan and Burkhardt (2016, p. 2) report that large-scale and high-stakes assessments play three roles:

> Role A: measures levels of performance across the range of problem-types used.
> Role B: exemplifies performance objectives in a clear form that teachers and students understand and through this,
> Role C: determines the pattern of teaching and learning activities in classrooms.

If the assessments, whether large-scale or classroom-based, fail in their purpose, roles B and C will result in the classroom-based teaching and assessment reflecting those shortcomings.

Attention must be paid to the purpose of the assessment so that the results of the assessment is interpreted and used appropriately for that purpose (Suurtamm et al., 2016). The literature alludes to the importance of the results of the assessment being used solely for the purposes for which the assessment was designed, and that the inferences need to be appropriate to the assessment design (Koch, 2013; Rankin, 2015).

The purposes of assessments are often not clearly distinguishable. Studies indicate that teachers regularly cross the lines between summative and formative assessments, where they will use summative classroom-based assessments for formative purposes to understand the misconceptions of students to inform their teaching, or when the teachers use parts of previously designed large-scale assessments as teaching resources (Kenney and Silver, 1993; Parke et al., 2003).

An important part of the classroom-based assessment process for students to achieve the learning goals rests on the feedback the student receives. Recent studies have demonstrated the value of classroom-based assessment, as classroom-based assessment can lead to feedback during the process of learning (Wiliam, 2011).

In Hattie and Timperley's research (2007) on the power of feedback, feedback is defined as information provided by an agent, which can be a teacher, peer, parent, self, regarding aspects of one's performance or understanding. It is clear from their definition of feedback that feedback is not limited to the marks students receive after writing tests and exams. Hattie et al. focus on giving feedback as information about the content and understanding of the constructions that students have made from the learning experience. In a study of principles for good feedback practice (Nicol and Macfarlane-Dick, 2006), feedback can also be seen as information about how the student's present state (of learning and performance) relates to the goals to be achieved.

Research has been conducted on how assessment and feedback should be used to empower students as self-regulated learners (Nicol et al., 2006). Although my research will concentrate on the feedback the teacher provides to students, it is important to note the comments made by Hattie et al. (2007, p. 86) that effective feedback provided to students by teachers must enable students to answer three major questions: 'Where am I going? (What are the goals?)'; 'How am I going? (What progress is being made toward the goal?)'; and 'Where am I going to next? (What activities need to be undertaken to make better progress?)'. By using this model, teachers and students reduce the discrepancy between the student's current understanding and performance, and the goal. Such research suggests that it is vital for teachers to be able to articulate their intentions and goals set for students. Similar to Hattie et al. (2007), Susan Brookhart (2008) indicates that feedback could be powerful if done well, but for her the power of the feedback lies in its double-barrelled approach, addressing both cognitive and motivational factors at the same time:

> "Good feedback gives students the information they need so they can understand where they are in their learning and what to do next – the cognitive factor. Once they feel they understand what to do and why, most students develop a feeling that they have control over their own learning – the motivational factor" (Brookhart, 2008, p. 54).

2.3.8.1 FEEDBACK AS PART OF CLASSROOM CULTURE

For Brookhart (2008) good feedback should be part of the classroom assessment environment in which students see constructive criticism as a good thing and understand that learning cannot occur without practice. She explains that if part of the classroom culture is to always 'get things right', then if something needs improvement, it's 'wrong'. Brookhart proposes that classroom culture should value finding, identifying, and using suggestions for improvement so that students can use the feedback, plan, and execute steps for improvement.

She concludes that it is not fair to students to present them with feedback and no opportunities to use it.

Classroom culture is not only vital for effective feedback but also pivotal for students taking responsibility for their learning. Shepard, Davidson and Bowman (2011) states that the most obvious reform in assessments must be to devise more open-ended performance tasks to ensure that students are able to reason critically, to solve complex problems, and to apply their knowledge in real-world contexts. The study found that when classroom cultures were not aligned or consistent with social-constructivist learning perspectives, students took little responsibility for their own learning.

2.3.8.2 STUDENTS PERCEPTIONS OF CLASSROOM-BASED ASSESSMENT FEEDBACK

In *Visible Learning for Teachers*, Hattie (2012) highlights studies which focused on how students receive feedback. Kung (2008) found that while both individualistic and collectivist students sought feedback to reduce uncertainty, collectivist students were more likely to welcome self-criticism 'for the good of the collective' and seek developmental feedback, whereas individualistic students decreased such feedback to protect their egos. Individualistic students were more likely to engage in self-helping strategies because they aimed to gain status and achieve outcomes (Brutus and Greguras, 2008). Hyland and Hyland (2006) argue that students from cultures in which teachers are highly directive generally welcome feedback, expect teachers to notice and comment on their errors, and feel resentful whey they do not.

Studies have also raised the importance of realising the variation of students' reception of feedback (Yorke, 2003; Sadler, 1998). Research on students has shown that they vary considerably in the way they face up to difficulty and failure, contrasting students who

are mastery-orientated with those who are helpless (Dweck and Leggett, 1988). The mastery-orientated student is characterised by a positive and resilient orientation to problems, seeing them as challenges and learning opportunities, while the helpless student has a more negative disposition, seeing failure as a reflection on his/her (perceived) low ability, and gives up easily. These differences are related to personality (Yorke, 2003). Elliott and Dweck (1988) also differentiate between the student's performance goals (Is my ability adequate?) and learning goals (What is the best way to make progress?). Failure produces different effects: for students working with learning goals, it is merely information to direct studying, whereas for student's working to performance goals, it is a crushing defeat (Yorke, 2003).

2.4 TEACHERS' KNOWLEDGE

My study of the relationship between teachers' knowledge and assessment practices is based on the use of the five strands of mathematical proficiency as a lens to view current practice, the teachers' ideas of redesigning assessments and the challenges teachers face designing assessment. I will start by looking closely at what is meant with assessing for mathematical proficiency, and will then review the literature of Bloom's taxonomy which is prescribed in the current South African Mathematics curriculum to distinguish between the levels of cognitive demand. I will then clearly distinguish between teachers' knowledge and teachers' beliefs.

2.4.1 ASSESSING FOR MATHEMATICAL PROFICIENCY

Up to this point, numerous references have been made about the teachers' responsibility to developing adept and mathematically proficient students. The term 'mathematical proficiency' has been described broadly. I will delve more deeply into what is meant by

'mathematical proficiency', and provide insight into studies that have been conducted on mathematical proficiency.

Mathematical proficiency, conceptualised by Kilpatrick, Swafford, and Findell (2001), is a theory of what a mathematically proficient student is able to do. I will elaborate on the five intertwined strands which Kilpatrick et al. (2001) developed, and review the research conducted on the five strands of mathematical proficiency concerning assessment. Recognising that no term captures all aspects of expertise completely, competence, knowledge, and facility in mathematics, Kilpatrick et al., (2001) have chosen the term mathematical proficiency to encapsulate what they believe is necessary for anyone to learn mathematics successfully.

Kilpatrick et al. propose five 'intertwining strands' of mathematical proficiency, namely:

- *Conceptual Understanding* – comprehension of mathematical concepts, operations and relations;
- *Procedural Fluency* – skill in carrying out procedures flexibly, accurately, efficiently and appropriately;
- *Strategic Competence* – ability to formulate, represent, and solve mathematical problems;
- *Adaptive Reasoning* – capacity for logical thought, reflection, explanation and justification; and
- *Productive Disposition* – habitual inclination to see Mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy. (Kilpatrick et al., 2001)

A student's successful learning in Mathematics is characterised by comprehension of ideas; ready access to skills and procedures; an ability to formulate and solve problems; a capacity to reflect on, evaluate, and adapt one's knowledge; the ability to reason from what is known to what is wanted; and a habitual inclination to make sense of, and value, what is being learnt (Kilpatrick et al., 2001).

Professional mathematicians tend to think it strange that some trends in mathematics education at school level isolate mathematical reasoning and problem solving as separate topics within mathematics instruction (Schoenfeld, 2007). Similar to seeing problem-solving as a separate topic in mathematics instruction, conceptual understanding is seen either as separate from mathematical proficiency or as interchangeable with mathematical proficiency (see Hull, Balka & Miles, 2009; Devlin, 2007). Mathematical proficiency strands are not independent but instead, 'represent different aspects of a complex whole', thus leading to the notion of intertwined strands (Kilpatrick et al., 2001).

In reviewing the literature, a high number of studies have focused on some aspects of mathematical proficiency (Suh, 2007; Samuelson, 2010; Langa and Setati, 2007; Moodley, 2008; Pillay, 2006; Ally, 2011). These studies found that procedural fluency is the dominating proficiency strand not only when it comes to classifying questions in assessments, but also when considering the problems teachers do with students. These studies additionally focused on the use, promotion, analysis, or advancement of the strands associated with mathematical proficiency.

Productive disposition has been at the centre of a few studies. A study by Siegfried (2012) focused on identifying the hidden mathematical proficiency strand: defining and assessing for productive disposition. Seven essential indicators for assessing for productive disposition were conceptualised: (1) mathematics as a sense-making endeavour; (2) mathematics as beautiful or useful and worthwhile; (3) beliefs that one can, with appropriate effort, learn mathematics; (4) mathematical habits of mind; (5) mathematical integrity and academic risk-taking; (6) positive goals and motivation; and (7) self-efficacy. A study by Jacobson and Kilpatrick (2015) on understanding teacher effect, knowledge, and instruction over time focused on their research on the productive disposition for teaching mathematics. They found that teachers affect an essential element of productive disposition, which is often

defined in opposition to purely cognitive traits such as mathematical knowledge, and which includes partial cognitive traits such as attitudes and beliefs, as well as non-cognitive traits such as motivation and grit. The researchers wrestled with how to conceptualise and measure constructs that are sensitive to the content and context of instruction. The central conjecture is that change in practice is deeply entwined with simultaneous, interdependent change in teacher knowledge and effect.

A study conducted by Awofala (2017) focused on assessing senior secondary school students' mathematical proficiency and its relation to performance in mathematics in Nigeria. Not surprisingly, the study found significant correlations among secondary school students' conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, productive disposition, and performance in mathematics. In a study on classroom data analysis with the five strands of mathematical proficiency, Groth (2017) describes how prospective teachers used the five strands to analyse and reflect upon qualitative classroom data from a series of lessons they taught. Groth constructed a protocol to take advantage of the abundant sources of qualitative data that are available in every classroom each day. The protocol enables practising and prospective teachers to develop the fundamental habit of mind of basing daily teaching decisions on observations of their students' strengths and needs along the five strands of mathematical proficiency.

The Australian Curriculum: Mathematics (F-10), has adapted and adopted the first four of Kilpatrick et al.'s (2001) proficiency strands in order to emphasise the breadth of mathematical capabilities that students need to acquire (see Woodward, Beswick, & Oates, 2017. Similarly, the Singapore Mathematics Framework (Ministry of Education, Singapore, 2006) places problem-solving at the centre of the mathematics learning pentagon, with concepts, processes, metacognition, attitudes and skills placed around the sides of the pentagon. Kilpatrick notes the similarities: "Both their framework and our strand model get at

the same notion: that proficiency in Mathematics is more than simply skill or understanding and that learners need to develop all five components simultaneously" (Kilpatrick, 2001, p. 11).

Kilpatrick et al's strands of mathematical proficiency is not new in South Africa. The Department of Education released the Mathematics Teaching and Learning Framework for South Africa: Teaching Mathematics for understanding (DBE, 2018), which is a five part framework that has been influenced by the conceptualisation of Kilpatrick's five strands of mathematical proficiency. The framework dimensions represent a contextualisation and adaptation of the strands to the South African context. The framework is comprehensively discussed in the next section.

In a South African study, Ally (2011) looked for empirical evidence of the promotion of the five strands of mathematical proficiency in four grade six classes. The findings revealed that the extent to which the five strands of mathematical proficiency were promoted was far below expectation. Over 90% of the 242 video-recorded five-minute lesson segments from 30 lessons contained opportunities for developing procedural fluency, with only 17% for conceptual understanding, 8% for adaptive reasoning, less than 2% for strategic competence, and 20% for productive disposition. Ally (2011) found that, despite the continued rhetoric regarding the need for students to develop conceptual understanding, opportunities for this to happen do not occur frequently in regular classrooms.

The five-part mathematics teaching and learning framework (DBE, 2018) draws on Kilpatrick's et al's (2001) five strands of mathematical proficiency to represent a contextualisation and adaptation of the strands to the South African context. The framework calls for a balance in mathematics teaching between four key dimensions: teaching for conceptual understanding, developing procedural fluency, developing mathematical reasoning, and developing strategic competence, and proposes the implementation of this

teaching in the context of a learning-centred classroom, where learners and teachers engage actively, discussing and experimenting with mathematical ideas.

Reviewing the literature on studies conducted on mathematical proficiency raises two important aspects which will affect this study. The first is that very little research has been conducted on developing classroom-based assessments which promote mathematical proficiency. The second aspect is that the findings of the studies confirm my suspicion that the bulk of mathematics classroom-based assessments focuses only on two of the five strands: procedural fluency and conceptual understanding. My research on learning how to adapt the classroom-based assessments of secondary mathematics teachers, to promote mathematical proficiency, therefore, will be significant research in the field.

2.4.2 TAXONOMIES AND FRAMEWORKS FOR ASSESSMENT DESIGN

2.4.2.1 DE LANGE'S ASSESSMENT PYRAMID

De Lange regards assessment as an important part of the teaching and learning process and emphasises assessing for understanding. De Lange (1999) deliberately chose to connect his framework of assessment with the OECD (1999) framework, designed for the Program of International Student Assessment (PISA). The framework allows that all assessment questions could be located in the pyramid according to (a) the level of thinking called for; (b) mathematical content or big ideas domain; and (c) degree of difficulty.

De Lange (1999) found that because assessment needs to measure and describe a student's growth in all domains of mathematics and at all three levels of thinking, questions in a complete assessment programme should fill the pyramid. There should be questions at all levels of thinking, of varying degrees of difficulty, and in all content domains.

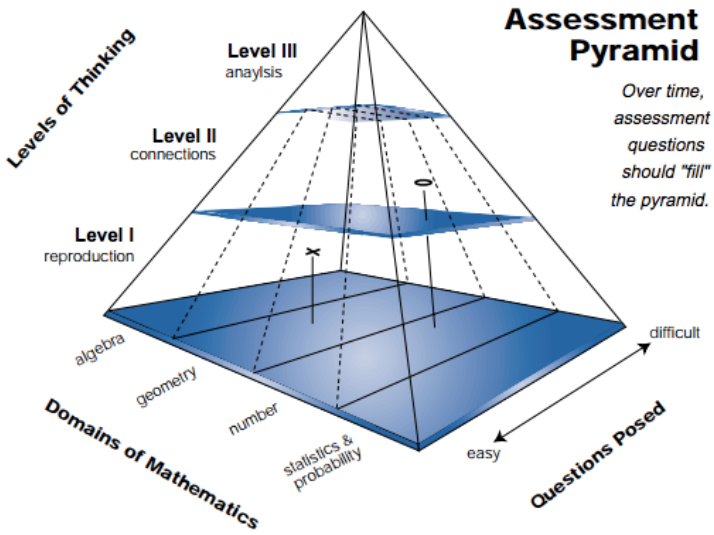

Figure 7: Assessment Pyramid (De Lange, 1999)

The three levels of mathematical competency are: Level 1: Reproduction, procedures, concepts and definitions; Level 2: Connections and integration for problem-solving; and Level 3: Mathematisation, mathematical thinking and reasoning, generalisation and insight. I value that De Lange's framework views assessment as multi-dimensional.

2.4.2.2 BLOOM'S TAXONOMY

For over 60 years, Bloom's taxonomy (Bloom, 1956) has heavily influenced assessment throughout the world and is still common in mathematics education. The Curriculum and Assessment Policy Statement (DBE, 2011) prescribes an adaption of Bloom's taxonomy to analyse and categorise the cognitive levels of both formative and summative assessments knowledge, routine procedural skills, complex procedures, and problem-solving.

Studies by Kastberg (2003) and Vidakovic, Bevis & Alexander (2003) provide examples of how high school mathematics teachers use Bloom's taxonomy to develop test items. Bloom's taxonomy is widespread across different fields. A study by Morton and Colbert-Getz (2017) focused on the importance of categorising an assessment by Bloom's

taxonomy to measure the impact of a flipped anatomy classroom. Numerous studies have used Bloom's taxonomy as the standard for judging whether assessments are lower-order thinking or higher-order thinking (Thompson, 2008; Lindstrom, 2017). Other studies (Kastberg, 2003; Vidakovic, Bevis & Alexander, 2003) indicate that Bloom's taxonomy can be used effectively by mathematics teachers to support learning and teaching. I want to focus on a study investigating mathematics teachers' interpretations of higher order thinking in Bloom's taxonomy (Thompson, 2008). In the study of thirty-two high school teachers, most of the teachers had difficulty interpreting the skills in Bloom's taxonomy and developing questions to be used in assessments for higher-order thinking. The study further indicated that although mathematics teachers had knowledge of Bloom's taxonomy, and were able to identify various characteristics of lower-order thinking and higher-order thinking, most of the teacher did not know how to develop higher-order thinking assessments. Studies have found that teaching and assessing higher-order thinking is very difficult, even with extensive professional development (Silver & Stein, 1996; Harpster, 1999). The research findings called for further research which is needed on creating models for professional development that support teachers' efforts to assess for higher-order thinking.

In the 1990s, Lorrin Anderson, a former student of Bloom, along with David Krathwohl created a revised taxonomy which was published in 2001 in the book, *A Taxonomy for Learning, Teaching, and Assessing* (Anderson & Krathwohl, 2001). One of the major differences between the original taxonomy and the revised taxonomy is that the original taxonomy consisted of a single dimension. The revised taxonomy reflects a dual perspective on learning and cognition. Having two dimensions to guide the process of stating the objectives and planning and guiding instruction leads to sharper, more clearly defined assessment, and a stronger connection of assessment both to objectives and instruction

(Airasian and Miranda, 2002). The knowledge dimension relates to the nature of the subject matter being considered or learnt. The four levels of knowledge are:

- *Factual (declarative) knowledge:* discrete pieces of elementary information, required if people are to be acquainted with discipline and solve problems with it;
- *Procedural knowledge:* the skills to perform processes, to execute algorithms and to know the criteria for their appropriate application;
- *Conceptual knowledge*: interrelated representations of more complex knowledge forms, including schemas, categorisation hierarchies, and explanations; and
- *Metacognitive knowledge:* knowledge and awareness of one's own cognition as well as that of other people (Anderson & Krathwohl, 2001).

2.4.3 DISTINGUISHING BETWEEN TEACHERS' KNOWLEDGE AND BELIEFS

Although the interrelation of beliefs, knowledge, perception, and values has been discussed earlier, it is essential to take in consideration that these constructs are constitutive of one another and affect one another (Belbase, 2012). It is therefore essential to distinguish knowledge from beliefs to understand how the one affects the other.

Leatham (2006) explains the relationship between beliefs in and knowledge of something creatively. Leatham's (2006) distinction between knowledge and beliefs makes it manageable to clearly establish between teachers' beliefs of aspects of assessment and their knowledge of assessment.

> Of all things we believe, there are some things 'we just believe' and other things we 'more than believe – we know'. Those things we 'more than believe' we refer to as knowledge and those things we 'just believe' we refer to as beliefs. (Leatham, 2006 p. 92)

I am of the view that it is essential to clearly distinguish between knowledge and beliefs to accurately interpret the scope of the participating teachers' beliefs and knowledge of aspects concerning assessment, and not to confuse these two aspects in my analysis

It is also vital to distinguish between different types of knowledge. Pehkonen and Pietilä (2003) note that, when beliefs of teachers are considered, it is advisable to distinguish between two parts of knowledge: objective knowledge and subjective knowledge. Objective knowledge can be seen as formal, official knowledge, whereas subjective knowledge is seen as informal, personal, and private knowledge. Pehkonen and Pietilä (2003) explain that this theoretical dichotomy assists us in situating and understanding beliefs and knowledge together, and, at the same time, distinguishing them from each other.

I was astonished to note that research has found no clear relationship between teachers' formal mathematics education and their students' learning of mathematics (Drageset, 2010; Askew, 2008; Ball, Lubienski and Mewborn, 2001). Drageset (2010) argues that the reason this relationship has not been found might be that measuring teachers' mathematical knowledge just in terms of their qualification level of formal education is not precise enough because there are probably aspects of such knowledge that are more important than others. It is therefore also essential to distinguish between subject matter knowledge and pedagogical content knowledge, which will be vital considerations in interpreting how teachers can adapt their classroom-based assessments. I predicted that one of the most significant hurdles in the way of the teachers adapting their classroom-based assessments would be challenges and constrictions relating to their subject matter knowledge and pedagogical content knowledge. Figure 8 illustrates the framework of Ball, Thames & Phelps (2008) where subject matter knowledge are separated from pedagogical content knowledge and divided into three parts.

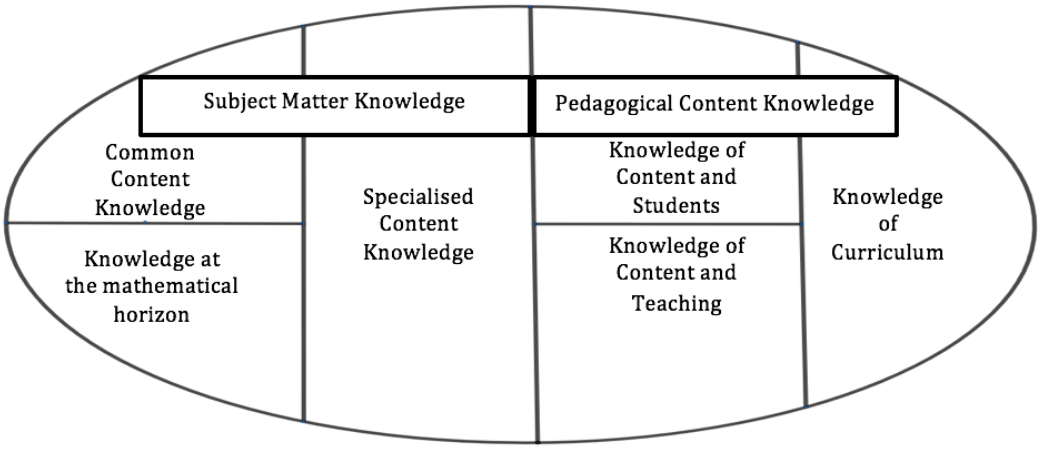

Figure 8: Domains of Mathematical Knowledge for Teaching (Ball et al., 2008)

Ball et al. (2008) distinguishes between the subcategories. Specialised Content Knowledge is defined as the mathematical knowledge not typically needed for purposes other than teaching, which includes the knowledge of unpacking mathematical methods and the ability to assess the mathematical validity of students' suggestions or non-standard solutions. Common Content Knowledge is defined as mathematical knowledge which is familiar to people who know mathematics, and not unique to teachers. This form of knowledge aligns with the objective knowledge defined by Pehkonen and Pietilä (2003) earlier. It comprises of knowledge needed to solve mathematics problems, and use mathematical terms and notation rigorously. Ball et al. (2008) explain that teachers, ultimately, must be able to conceptualise the content which they need to teach students. Askew (2008) finds that a lack of this type of knowledge is associated with less successful teaching and assessment practices. Horizon Knowledge is an awareness of how mathematical topics are related over the span of mathematics included in the curriculum, which included the vision in seeing connections to much later mathematical ideas. In contrast, familiarity with frequent errors and deciding which of several errors students are most likely to make are examples of Knowledge of Content and Students. Knowledge of Content and Teaching combines knowing about

teaching and knowing about mathematics. Ball et al. (2008) explain that many of the mathematical tasks of teaching and assessment require a mathematical knowledge of the design of teaching and the design of creating assessments. Beliefs are thus distinct from knowledge as it carries the connotation of disputability (Thompson, 1992).

2.4.4 HOW TEACHERS MAKE SENSE OF CURRICULUM REQUIREMENTS

To understand how teachers make sense of the curriculum documents and requirements, I will refer to a study by Sullivan, Clarke, Clarke, Farrell and Gerrard (2012), which focuses on the sources of curriculum authority that teachers consult, and the way that teachers plan and use assessment information in that planning. In the study, Sullivan et al. found that teachers use the curriculum documents in different ways, depending on their immediate local circumstances, the social, political and cultural contexts in which they are operating, the material resources available to them, and the pragmatic constraints and opportunities of their work settings, among many factors. Sullivan et al. found that curriculum knowledge and intentions are central to the sort of decisions teachers make when planning instruction and developing assessments. Much attention has been dedicated towards teachers' subject matter knowledge and pedagogical content knowledge (Hill et al., 2007). As Martin Choppin (2009) and Sullivan et al. (2012) note, there is an increasing need within the mathematics community to consider teachers' curriculum knowledge, but there is a gap in the research on teachers' curriculum knowledge. Sullivan et al. (2012) explain that the ways in which teachers come to enact curricular knowledge in their planning and development of assessments both are an individual process influenced by teachers' beliefs and understandings of teaching and learning (Drake and Sherin, 2006), and highly dependent on schooling context. Silver & Stein (1996) reports that the teacher's planning of assessments and instructional tasks is influenced by the teacher's goals, curriculum knowledge, subject matter

knowledge, and knowledge of students. Sullivan et al. (2012) state that studies on teachers' interpretations of curriculum documents on the role of assessment are underwhelming.

2.5 CHALLENGES TEACHERS FACE DESIGNING ASSESSMENTS

The following section will build on the theoretical perspective on the different learning theories to which teachers prescribe. Windschitl (2002) uses a framework of four types of challenges or dilemmas (conceptual, pedagogical, cultural, and political) to put forth a phenomenological perspective on constructivist teaching by describing the range and structure of experiences that make up constructivist teaching. Constructivism in practice, Windschitl explains, involves phenomena distributed across multiple contexts of teaching, which include assessment to promote learning. The dilemmas are aspects of teachers' intellectual and life experiences that prevent theoretical ideals of constructivism from being realised in school settings (Windschitl, 2002).

Four frames of reference are used to describe these dilemmas. Conceptual dilemmas are rooted in teachers' attempts to understand the philosophical, psychological, and epistemological underpinnings of constructivism. Pedagogical dilemmas for teachers arise from the more complex approaches to designing curriculum and fashioning learning experiences which constructivism demands. Cultural dilemmas emerge between teachers and students during radical reorientation of classroom roles and expectations necessary to accommodate the constructivist ethos. Political dilemmas are associated with resistance from various stakeholders in school communities when institutional norms are questioned, and routines of privilege and authority are disturbed.

I have adapted the framework Windschitl developed with the analytical framework of Suurtamm and Koch (2014) on the categorisation of four domains of dilemmas teachers experience in transforming their teaching and assessment practices towards constructivism.

Table 2: The categorisation of four domains of dilemmas teachers experience in transforming their teaching and assessment practices towards constructivism

Definition of dilemma	Representative questions of the teacher and examples of each dilemma
Conceptual dilemmas: Grappling with current theories and thinking in assessment and mathematics teaching and learning; Reconciling current beliefs about pedagogy with the epistemological orientations necessary to support a constructivist learning environment; Considering the 'why' of assessment	Understanding the different versions of constructivism and the different purposes of assessments. Do all activities and assessments result in knowledge construction by students? Is my classroom supposed to be a collection of individuals working toward conceptual change or a community of students whose development is measured by participating in authentic practices?
Pedagogical dilemmas: Developing deeper knowledge of subject matter; managing new kinds of discourse and collaborative work in the classroom; Grappling with the design of assessment tasks; considering the 'how to' of assessment	Do I base my teaching on students' existing ideas rather than on learning objectives? How can I facilitate learning? What types of assessment will capture the learning I want to foster? Finding ways to increase students' involvement in the assessment process
Cultural dilemmas: Becoming conscious of the culture of one's own classroom; questing assumptions about what kinds of activities should be valued; understanding the varied cultural backgrounds of students; being intentional about transforming students' beliefs and practices; focusing on changes in classroom culture with regard to assessment practice; arise when new assessment practices threaten existing cultural practices.	How can we contradict traditional, efficient classroom routines and generate new agreements with students about what is valued and rewarded? How do my own experiences of what is proper and possible in a classroom prevent me from seeing the potential for a different kind of learning environment? How can I accommodate the worldviews of students from diverse backgrounds while at the same time transforming my own classroom culture? Dealing with student expectations with respect to marks Being influenced by the concerns of colleagues, students, parents or administrators about new approaches to assessment
Political dilemmas: Confronting issues of accountability with various stakeholders in the school community; negotiating with key members in authority and support to teach for understanding; dealing with school, district or provincial policies on classroom or high-stakes assessments that may not align with teachers' assessment thinking and practices	Being restricted to following a curriculum that do not align with teacher thinking Should I make use of a curriculum that is not sensitive enough to my students' needs, or should I create my own? Will constructivist approaches adequately prepare my students for high-stakes examinations Reconciling current thinking in classroom assessment with the requirements of test-based accountability assessments

Table 2 discusses the definitions of each dilemma with representative questions and examples. The literature on constructivism in classrooms indicates that the four dimensions of this model reasonably circumscribe the range of challenges faced by teachers. Furthermore, failure to attend to any one of these dimensions can compromise teachers' attempts to implement progressive pedagogies in their classrooms. While highlighting the characteristics of each type of dilemma can be very useful, Windschitl points out that dilemmas may not always fit neatly into one of the four domains because they are inherently complex, therefore overlapping, and interconnections between dilemmas will exist. I will use the adapted framework as a lens to interpret the participating teachers' dilemmas concerning assessment.

2.6 CONCLUSION

The purpose of the literature review was to research how to effect teacher change, which will assist me in gaining insight into the data I collected to understand better how teachers can adapt their classroom-based assessments to promote mathematical proficiency. The literature review allows me to understand the relationship between teaching, learning and assessment. The literature review, which focused on teachers' beliefs, teachers' classroom-based assessment practices and teachers' knowledge, provided me with the tools to develop my theoretical framework which will be discussed in the next chapter. The theoretical framework will focus on the relationships between teachers' beliefs, teachers' classroom-based assessment practices and teachers' knowledge.

CHAPTER 3:

A THEORETICAL FRAMEWORK

3.1 INTRODUCTION

The theoretical framework in figure 9 focusses on the relationship between the three main concepts to understand how secondary school mathematics teachers can design their classroom-based assessments towards mathematical proficiency. The three main concepts of the theoretical framework, which are adapted from Belbase (2012) are (1) teachers' beliefs; (2) teachers' assessment practices of mathematical proficiency (MP); and (3) teachers' knowledge of mathematical proficiency (MP). In this study I promoted teachers' knowledge of mathematical proficiency (MP) as described by Kilpatrick et al., (2001).

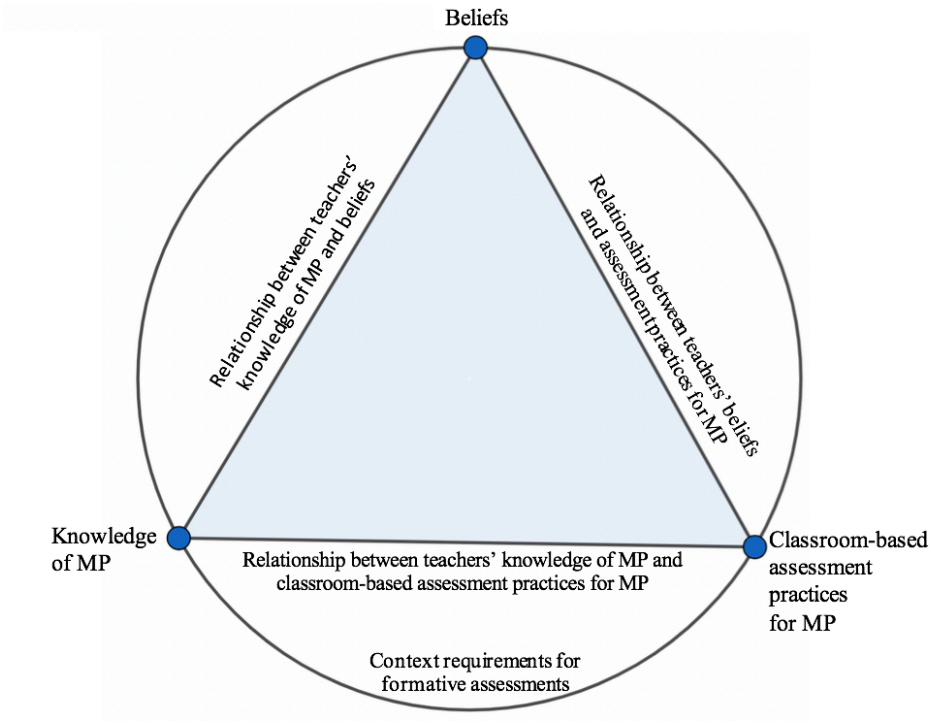

Figure 9: The relationship between teachers' beliefs, knowledge and assessment practices in equilibrium

I interpret the relationship between teaching, learning and assessment from the perspective of developing teachers' assessment as a network: The circle represents the given context in which the participants teach. The three main concepts are located as three nodes on the circumference of the circle. The area of the triangle that is shaped by connecting the three vertices with one another, describes the extend of the teacher change, dependent on the school context. This context is not fixed, as it can expand or shrink as the relationships between the nodes change. The edges in the network describe the relationship between the teachers' knowledge and beliefs; beliefs and assessment practices; and knowledge and assessment practices. My intervention was located on the edge between teachers' knowledge and assessment practices. I engaged the participant teachers on the construct of mathematical proficiency (Kilpatrick et al.,2001) and asked them to adapt their classroom-based assessments towards mathematical proficiency. Since Belbase (2012) emphasised beliefs as a key aspect of this network, I also gathered data about the participants' beliefs about learning, teaching and assessment

I will now discuss each of the three main concepts of the framework (teachers' beliefs, knowledge and assessment practices), visualised as nodes, and the relationships that exists between the concepts, which are visualised as edges.

3.2 A THEORETICAL FRAME TO RESEARCH TEACHERS' BELIEFS.

I used Delandshere & Jones's (1999) three assertions to frame my research of teachers' beliefs: Teachers' assessment practices are shaped by:

(1) beliefs of the purposes and functions of assessment;

(2) beliefs about what they perceive the official curriculum is within the school structure and where they position themselves with regard to the subject matter; and

(3) beliefs of how they understand learning and their expectations of their students.

3.3 A THEORETICAL FRAME TO RESEARCH TEACHERS' CLASSROOM-BASED ASSESSMENT PRACTICES FOR MATHEMATICAL PROFICIENCY

The five strands of mathematical proficiency are used as a frame to research how the participating teachers' current classroom-based assessments are aligned to mathematical proficiency, as well as how the participating teachers adapt their classroom-based assessments towards mathematical proficiency.

3.4 A THEORETICAL FRAME TO RESEARCH KNOWLEDGE

I worked with Bloom's taxonomy which is prescribed in the current South African Mathematics curriculum to distinguish between the levels of cognitive demand. This taxonomy does not take into account different mathematical processes as described by the five strands of mathematical proficiency. The teachers' knowledge and use of the mathematical proficiency strands to design and critically analyse classroom-based assessments: procedural fluency, conceptual understanding, adaptive reasoning and strategic competence, were researched against the cognitive levels of Bloom's taxonomy: knowledge, routine procedural skills, complex procedures, and problem-solving. The participating teachers were familiar with Bloom's taxonomy, as it is prescribed in the current South African Mathematics curriculum. The frame which is illustrated in figure 10 allows me to research how the participating teachers design and evaluate classroom-based assessments across the strands of mathematical proficiency and the cognitive levels of Bloom's taxonomy.

In Figure 10, the five strands of mathematical proficiency are placed on the circumference of a circle. The five nodes of mathematical proficiency form a pentagon that represents

mathematical proficiency. The circle is not fixed. The size of the circle illustrates the cognitive demand of classroom-based assessments. A smaller circle represents a lower order cognitive demand, and a circle with a greater circumference represents a higher cognitive demand.

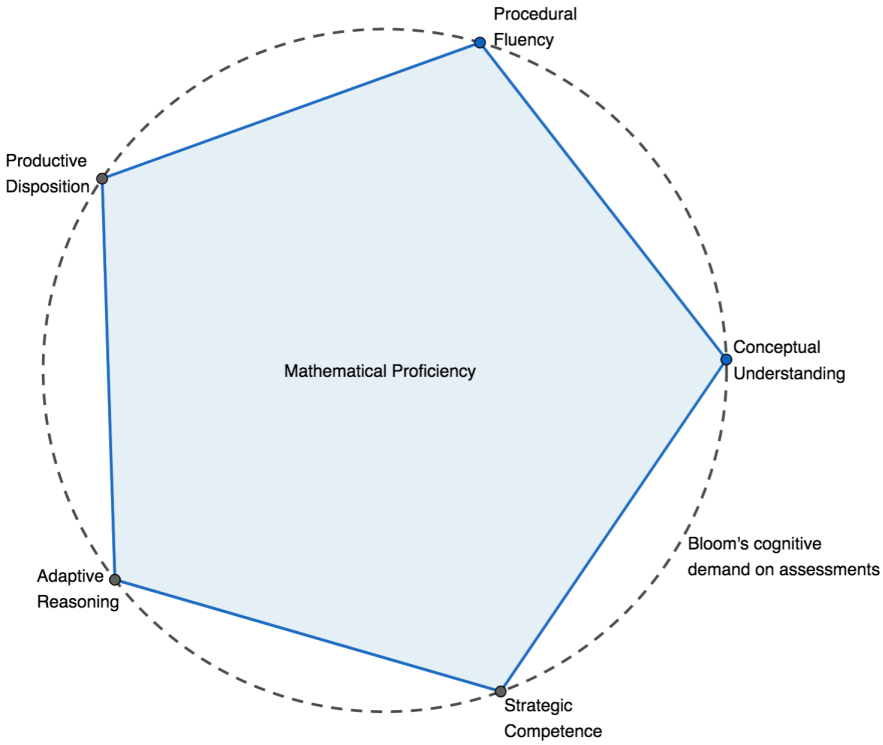

Figure 10: The relationship between designing classroom-based assessments towards mathematical proficiency and the cognitive demand of classroom-based assessments

I decided not to use Lange's assessment pyramid (De Lange, 1999) as part of my theoretical framework to research how the participating teachers' applied the knowledge of mathematical proficiency to the design classroom-based assessment. The research conducted on the assessment pyramid (De Lange, 1999) vastly focused on the design of the difficulty levels of each of the taxonomy levels of high-stakes summative assessments. It is, however, important to note that if teachers design classroom-based assessments mostly in the bottom layer of the pyramid, whether the problems posed in the classroom-based assessments are

considered as easy or difficult, will not have the desired outcome of assessing for mathematical proficiency.

3.5 A THEORETICAL FRAME TO RESEARCH THE RELATIONSHIP BETWEEN TEACHERS' KNOWLEDGE AND ASSESSMENT PRACTICES.

My study of this relationship is based on the use of the five strands of MP as a lens to view current practice and the teachers' ideas of redesigning assessments. The relationship between teachers' knowledge of mathematical proficiency and their assessment practices are essential to understand what happens when mathematics teachers are asked to adapt their classroom-based assessments, as is the instance with the mathematics teaching and learning framework (DBE, 2018), where teachers are asked to rethink and adapt their teaching and assessment practices by striving towards integrating the first four of the mathematical proficiency strands.

3.6 A THEORETICAL FRAME TO RESEARCH THE RELATIONSHIP BETWEEN TEACHERS' BELIEFS AND THEIR ASSESSMENT PRACTICES.

I used Remesal's (2011) four-dimensional bi-polar model and Brown's (2002) four-dimensional model of trends of conceptions of assessment to develop a framework to relate teachers' beliefs and their assessment practices. My framework is illustrated in figure11.

This model places teachers' beliefs about the purposes of assessment on four continuums. Each continuum stretches between two orientations, namely an assessment culture aligned to pedagogy and a testing culture aligned to societal conceptions of assessment.

The four continuums are: (1) assessment conceived as a tool for improvement of learning; (2) assessment conceived as a tool for improvement of teaching; (3) assessment driven by school

and teacher accountability purposes; and (4) assessment driven by student accountability and certification purposes.

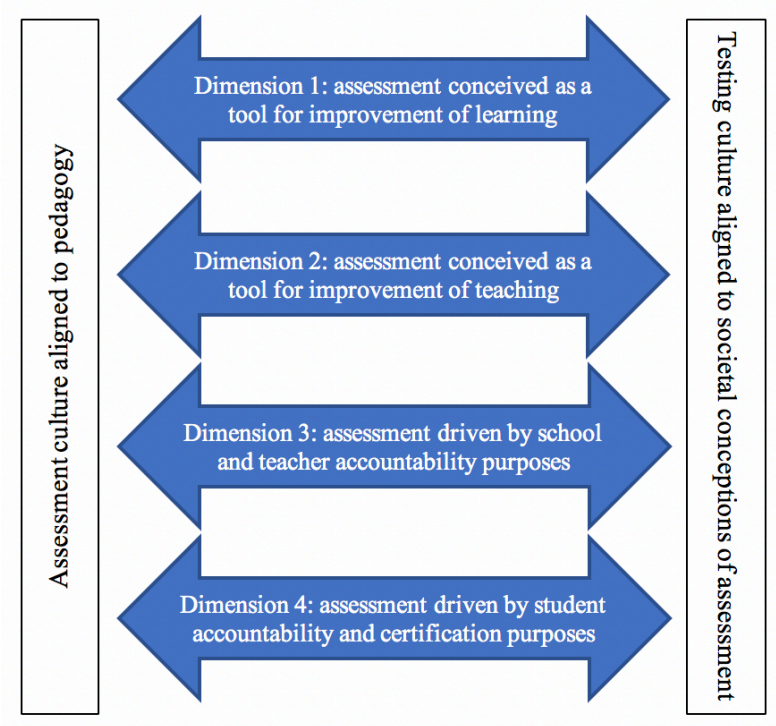

Figure 117: A four-continuum model across societal and pedagogical orientations, to frame the participating teachers' conceptions of assessment.

3.7 A THEORETICAL FRAME TO RESEARCH THE RELATIONSHIP BETWEEN TEACHERS' BELIEFS AND KNOWLEDGE.

As for the relationship between teacher knowledge of MP and classroom-based assessment practices, I framed the participating teachers' beliefs about teaching and learning mathematics against the constructs of Kilpatrick et al.'s (2001) mathematical proficiency strands. I developed codes, which is presented in the methodology chapter, to align the participating teachers' beliefs of teaching and learning mathematics against the mathematical proficiency strands.

3.8 A THEORETICAL FRAME TO DESCRIBE THE LEARNING AND TEACHING CONTEXTS

My study of the relationship between teachers' beliefs, classroom-based assessment practices and knowledge is based on the use of the five strands of MP as a lens to view the relationship between teachers' ideas of redesigning assessments, and their beliefs, positioned in their given learning and teaching contexts. The five strands of MP are used as to frame the learning and teaching contexts of the participating teachers.

3.9 SUMMARY

The frameworks which I developed to research beliefs, practices and knowledge and the relationships between them were developed to operationalise beliefs, knowledge and practices. In the following chapter, I will explain my research methods and analytical tools against these frameworks.

CHAPTER 4:
METHODOLOGY

4.1 INTRODUCTION

In this chapter I will use the theoretical frames I developed in chapter 3 to discuss my research design and methodology. starts with describing the research aim of this study which will be followed by outlining my research strategy.

4.2 AIM OF THE RESEARCH

The overarching aim in undertaking this study was to better understand how guided experience in assessment design allows Secondary School Mathematics teachers to reassess their assessment and teaching practices towards mathematical proficiency. This overarching goal was divided into three subsidiary aims. The first subsidiary aim was for me to explore how Mathematics teachers describe and justify their current classroom-based assessment practices. To achieve this aim, it was important to link the beliefs that teachers have about assessment, teaching and learning with their assessment practices. The second subsidiary aim of this study was to investigate how secondary school Mathematics teachers adapt their assessments towards assessing mathematical proficiency, barriers to change and factors that may facilitate change. To achieve this aim, I asked the teachers to critically analyse the assessments they have designed and used, and then to redesign classroom-based assessments towards mathematical proficiency. The third subsidiary aim was to better understand the challenges teachers face when they incorporate new ideas to their assessment practice.

The overarching research question is “How do secondary Mathematics teachers assess classroom-based assessments towards mathematics proficiency?”

The three subsidiary research questions are:

1. How do teachers describe and justify their current classroom-based assessment practices?
2. How do Secondary School Mathematics teachers adapt their assessments to towards assessing mathematical proficiency?
3. What are the challenges teachers experience incorporating new ideas in the design of classroom-based assessments?

4.3 RESEARCH DESIGN

4.3.1 CASE STUDY

I chose a case-study design because I had a collegial relationship with the participant teachers, which allowed me to gather rich qualitative data. A case study research design was considered to be the most appropriate for this research because it explore events within the parameters of openness, communicativity, naturalism, and interpretativity, prescribed by the interpretive paradigm (Sarantakos, 2005). This study is a qualitative case study designed to better understand how guided experience in assessment design allows Secondary School Mathematics teachers to reassess their assessment and teaching practices towards mathematical proficiency. As Robson (2002) remarks, case studies opt for analytic rather than statistical generalization, that is they develop a theory which can help researchers to understand other similar cases, phenomena or situations. Case studies can establish cause and effect, indeed one of their strengths is that they observe effects in real contexts, recognizing that context is a powerful determinant of both causes and effects (Cohen et al, 2007). The general objective is to develop an understanding of how ideas and abstract principles fit together (Nisbet and Watt, 1984). Case studies can penetrate situations in ways that are not always susceptible to numerical analysis (Cohen, Manion & Morrison, 2007).

As I discussed in the theoretical frame, which I will use as a lens to analyse the data I gathered from the semi-structured interviews and my intervention, I engaged the participant teachers on the construct of mathematical proficiency (Kilpatrick et al.,2001) and asked them to adapt their classroom-based assessments towards mathematical proficiency. The central ideology of this research study was to ensure that if the promise of teachers incorporating new ideas to classroom-based assessments was to be realised, I had to stay clear from a research design that tells the teachers what to do. I decided to work in a genuinely collaborative way with a small group of teachers, suggesting directions to incorporating new ideas to their classroom-based assessments, and supporting them as well as I could, without falling into a trap of prescribing to the teachers and giving them tips. I drew my inspiration from my research design from the research strategy employed by Wiliam and Black in number of their studies. Wiliam, Lee, Harrison and Black (2004) suggest that in doing studies like this, teachers, at first, believed that researchers were operating in a perverted model of discovery learning in which the researchers knew fully well what they wanted the teachers to do, but didn't tell them because they wanted the teachers to discover it for themselves.

My experience working closely with the teachers were that teachers initially thought I had the 'answer' and that I wanted the teachers to discover it. After a while, it became clear to teachers that there was no prescribed model of redesigning classroom-based assessments that promotes mathematical proficiency, and that each teacher would need to find their own way of implementing these new ideas to their assessment design. The key words pertaining to this methodology are participation, collaboration and engagement (Henning, van Rensburg, and Smit, 2004). In the interpretive approach the researcher does not stand above or outside, but is a participant observer (Carr and Kemmis, 1986) who engages in the activities and discerns the meanings of actions as they are expressed within specific social contexts.

4.3.2 PARTICIPANTS

After I received permission from the REC and WCED to conduct research at schools, permission letters to conduct research was sent to the Principals of the two schools that participated in the study (School A and School B) and five other schools. I approached 7 schools in total to participate in the research to include a wide range of teacher participants. However, due to saturation of being researched on experiences, the teacher at five schools chose not to participate. One Principal declined because he felt that it would take too much time for the teachers to participate in research. Another Principal communicated that he does not want his teachers to be part of research, because in his experience researchers come to their school to conduct research and then they leave without hearing anything about the researchers or their research again. The principles at two of schools, School A and School B, gave me permission to conduct research with the teachers at their schools. Hence, the participation of the two schools reflects the collegial cooperation and trust between the teacher at the two schools, and in particular between myself and the participants.

The case study focused on the teachers at the two schools that participated in the study. The first school, named School A, is a lower-quintile government school and the other school, named School B, which is a well-resourced private school, were chosen. The main reason for selecting the two schools were because they were substantially different in terms of the socio-economic status of students and the teaching and learning resources, and because there was an established collaboration between the two schools. Both schools had a similar number of learners in the secondary phase. The two schools were also close in proximity.

The research was conducted at the sites of the respective schools. At the first meeting at both schools, I introduced myself to all the secondary school mathematics teachers. I explained to

the teachers what is expected and what it will entail. I disclosed that the research has a professional development agenda and that participation is totally voluntary. I handed a consent form to each teacher and asked him or her to read, sign and bring the form with to the next meeting if they want to participate in the research. Four teachers at the Government school and five teachers at the Private school gave consent to conduct research. I narrowed the number of the participating teachers at the Private school to form part of the research down to two and the number of teachers at the Government school to three teachers. Background information of each of the participant teachers is discussed in Chapter 5.

Despite the small number of participants, the range of backgrounds in terms of knowledge, beliefs and classroom-based assessment practices provided an adequate boundary for a case study. Merriam (1998) warns if the phenomenon the researcher is interested in studying is not intrinsically bounded it will not be a case. One technique for assessing the boundaries of the topic is to ask how finite the data collection would be, that is, whether there is a limit to the number of people involved who could be interviewed or a finite amount of time for observations. If there is no end, actually or theoretically, to the number of people who could be interviewed or to observations that could be conducted, then the phenomenon is not bounded enough as a case (Merriam, 1998).

4.3.2.1 BACKGROUND OF THE TWO SCHOOLS.

Specific information about each of the schools where the participated teachers' teach, such as type, socio-economic classification, primary teaching language, and number of learners per class, are presented in table 3.

Table 3: Introducing the two schools

Description	School A	School B
Type of School	Government School	Private School
School-fee structure	No-fee paying school, Lower quintile, under-resourced	High-fee paying school Well-resourced
Area in which school is situated	High Crime Rate. Permanent community Police officer at School.	Middle-class neighbourhood, safe suburb.
Number of Students in Secondary School in Gr 8 and Gr 9	121 students	128 students
Number of Mathematics Teachers and classes in Secondary School	6 classes, 4 teachers	8 classes, 8 teachers
Number of Students in Grade 10 studying Mathematics Language of instruction	15 students Total no of Gr10s: 51 English and Afrikaans	53 students Total no of Gr10s: 63 English

I am a teacher at School B that has a strong relationship and working collaboration with the mathematics teachers and students at School A, as is the case with many well-resources private and under-resourced government school collaborations in South Africa. The collaboration between the two schools started in 2015. The first phase of the collaboration consisted of student's being tutored in Mathematics and English on Thursday afternoons. In the second phase of the collaboration, which started in 2016, the Mathematics teachers of the two schools started to work together and collaborated on ideas to advance teaching and learning. It is within this phase that my study is positioned.

4.3.2.2 BACKGROUND OF THE PARTICIPANTS.

The five participating teachers were given pseudonyms to conceal their identity and will be known as Alpha, Lambda, Phi, Epsilon and Omega. The five participating teachers were selected from a total of nine participants in two schools. Specific aspects of each participant, such as gender, position, academic qualification, teaching experience, and teaching load, are presented in table 4 below. The academic qualifications of the participants ranged from no academic qualification in Mathematics or Mathematics teaching, Higher Diploma in Education (HDE), Bachelors of Science degrees (BSc), Bachelors of Education degrees (BEd) and

Masters degree in Mathematics. The age of the participants ranges from 20s to 60s. The teaching experience of the participants ranged from less than three years to more than 30 years. The selected participants were selected from the original nine teachers who volunteered, because they were considered the most information-rich cases as all the types of data were collected from them.

Table 4: The Participants

Teacher	Teaching Experience (years)	Mathematical Qualification	School	Teaching load (hours per week/32)	Gender	Position and subjects
Alpha	25	No Mathematics Qualification HDE: Social Sciences	A	5	Male	Principal, Mathematics teacher
Phi	17	BSc(Ed): Mathematics	A	32	Female	Mathematics and Life Orientation teacher
Lambda	14	HDE: Senior Phase: Mathematics	A	29	Male	Deputy Principal, Head of Mathematics department
Omega	31	BSc: Mathematics; HDE	B	8	Female	Head of Academics, Mathematics and Mathematical literacy teacher
Eta	3	Masters in Mathematics	B	21	Male	Mathematics and Physics teacher

Background information of each of the participating teachers are provided in Chapter 5, which are essential to understand how secondary mathematics teachers can redesign their classroom-based assessments that promotes mathematical proficiency.

4.3.3 AN INTERPRETATIVE STUDY FROM A SOCIO-CONSTRUCTIVIST PERSPECTIVE

This study is located in the interpretative paradigm, and the emphasis is on understanding how guided experience in assessment design allows Secondary School Mathematics teachers to reassess their assessment and teaching practices towards mathematical proficiency. A

qualitative approach towards data collection, which will be discussed under research design, was considered to be the most appropriate.

Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences (Merriam, 2009). The main purpose of qualitative research is to provide an in-depth description and understanding of the human experience and meaning given to those experiences (Lichtman, 2006). A Qualitative research approach is the preferred form of inquiry when the focus of the research is to provided a detailed understanding of a particular issue, and it is useful for describing and answering questions about participants and context (Creswell, 2007; Gay and Airasian, 2003).

This study is defined as an interpretative study from a socio-constructivist perspective (Cobb, 2003). The research design for this study is a descriptive and interpretive case study that is analysed through qualitative methods. According to the ontological perspective of interpretivist paradigm, "reality is socially and discursively constructed by human actors" (Grix, 2004, p. 459). Constructivism proposes that each individual mentally constructs the world of experience through cognitive processes. Individuals differ in the way they make sense of the world and the way they construct meanings from objects through their interaction and engagement with them (Bryman, 2004). It needs to be acknowledged that these multiple realities are shaped by the knowledge of people as participants in a social world, their practice and understandings (Robson, 2011).

I used multiple data collection processes over a period of six months. The following section will provide an overview of the data collection process.

4.4 RESEARCH METHODOLOGY

4.4.1 RESEARCH DESIGN FRAMEWORK FOR THE DATA COLLECTION AND ANALYSIS PROCESS

I was seeking to understand how teachers can redesign their classroom-based assessments towards mathematical proficiency. I realised early in the research process that the impact the study can have will rely on the quality of the data generated and the importance of using multiple data-generation procedures. Multiple data-generation procedures will afford me the opportunity to examine the cases from several points of view, which is important for triangulation. Multiple data collection procedures are essential for providing the information in context which will provide rich data for analysis. Lankshear and Knobel (2005) described data as bits and pieces of information found in the environment that are collected in systemic ways to provide data evidential base from which to make interpretations to advance understanding and knowledge concerning the research problem. Data should not be seen as which is out there to collect, but rather what the researcher 'manufactures' and records (David and Sutton, 2004) which means that the researcher determines what counts as data in relation to the achieving the goal of the study.

Figure 12 depicts the framework for the data collection and data analysis process, showing the different phase. A pilot study was undertaken to analyse the responses and to modify the interview questions. The participant, Iota, which was used in the pilot study was not one of the seven participants of the main study. A number of the questions I prepared in the semi-structured interviews were modified as a result to assist with making the responses more open.

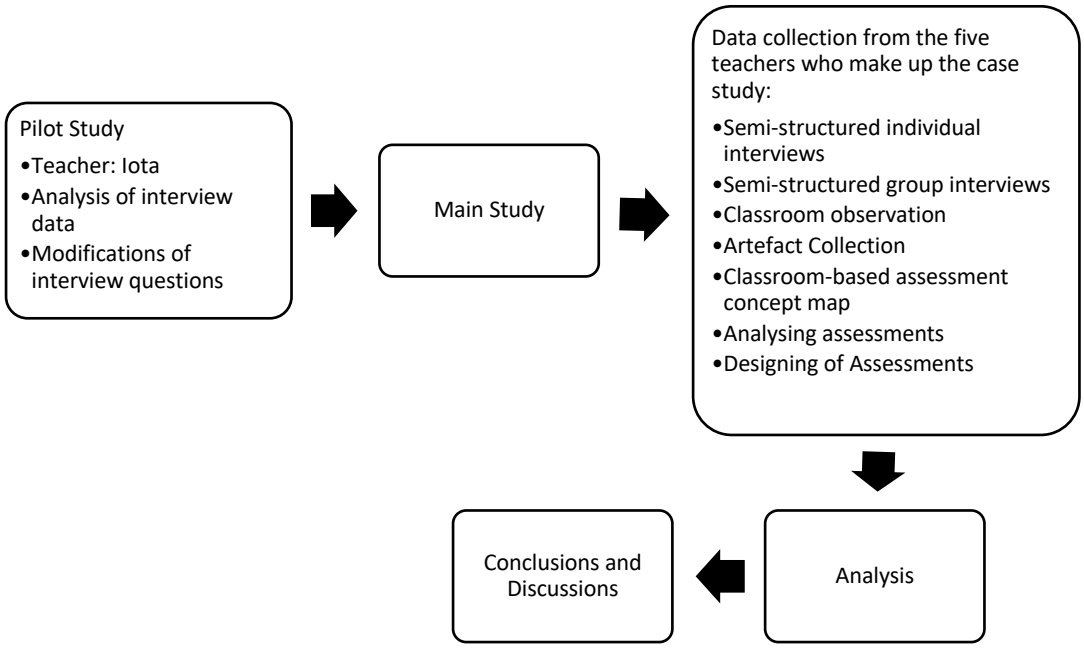

Figure 12: Research Design Framework for data collection and analysis

I used six different methods of collecting data from the participating teachers to understand how they reassess their classroom-based assessments towards mathematical proficiency. I will explain the semi-structured interviews, classroom-observations, artefact collections, concept maps, the analysis of assessments, as well as the redesigning of assessments, to provide clarity on the data collection methods I used.

4.4.2 DATA COLLECTION

In January 2017 the ethical clearance for this research was approved by the Research Ethics Committee (REC). Part of the requirements of the REC were to receive consent from the teachers, principals of schools and the Western Cape Education Department (WCED). I applied to the Western Cape Education Department for permission to conduct research, which was granted for the period between February 2017 to August 2017. The ethical clearance approval letter from the REC and the permission letter to conduct research from the WCED can be found in appendices 1 and 3 respectively.

Table 5: Data gathering methods and dates

Description of data gathering method	Research question	School A	School B
1. Semi--structured Group-Interviews: Prompts about school context, beliefs about teaching and learning mathematics	1, 2	21 Feb 2017 GI-A1	8 March 2017 GI-B1
2. Semi—structured Group Interviews: Prompts about the curriculum; purposes and demands of assessment	1, 2	28 Feb 2017 GI-A2	16 March 2017 GI-B2
3. Semi--structured Individual-Interviews, concept-map and artefact collection: Prompts about classroom-based assessment practices, processes of developing classroom-based assessments, purpose of classroom-based assessment; concept-map about purpose of classroom-based assessment	1, 2	14 March 2017 II-ALP1 II-PHI1 II-LAM1	24 March 2017 II-ETA1 II-OME1
4. Classroom observation	2	14 March 2017	24 March 2017
5. Analysing of classroom-based assessments	2, 3	2 May 2017 GI-A3	5 May 2017 GI-B3
6. Semi-structured Individual Interviews and the designing of classroom-based assessment	2, 3	16 May 2017 II-ALP2 II-PHI2 II-LAM2	2 June 2017 II-ETA2 II-OME2
7. Semi-structured Group Interviews Challenges about redesigning classroom-based assessments and conclusion	3	25 July 2017 GI-A4	28 July 2017 GI-B4

Table 5 is an outline of the data gathering methods which were used to answer the three subsidiary research questions: (1) How do teachers describe and justify their current classroom-based assessment practices? (2) How do Secondary School Mathematics teachers adapt their assessments to towards assessing mathematical proficiency? (3) What are the challenges teachers experience incorporating new ideas in the design of classroom-based assessments?

The next part will describe the data gathering methods which were used in greater detail.

4.4.2.1 SEMI-STRUCTURED INTERVIEWS

Qualitative interviews vary in the degree to which they are structured and offer the interviewer considerable latitude to pursue a range of topics and offer the subject a chance to shape the content of the interview (Bogdan & Biklen, 2007). Semi-structured interviews with open-ended questions were used to enable interview conversations and, in the process, gain understanding of the teachers' assessment practices. My aim was to create shared experiences in which the researcher and participating interviewees come together to create a context of conversational intimacy in which the participants feel comfortable to participate in the study, and to reduce my influence over the interviewing process (Corbin & Morse, 2003).

Semi-structured interviews were conducted with each of the participating teachers individually and as part of a group. The semi-structured interviews were an essential method to gather data in order to meet the aim of the research and to answer all three of the subsidiary research questions.

I made a decision to conduct both individual and group semi-structured interviews. The two semi-structured individual interviews were conducted with one teacher at a time at their school. The duration of each interview was approximately 40 minutes to one hour. The interviews were conducted in English at both Schools. There were three semi-structured group interviews conducted at each of the schools, each one-hour in duration, which was conducted with the all of the case study teachers at each respective school.

4.4.2.2 CLASSROOM OBSERVATIONS

Observations reveal characteristics and elicit data that is nearly impossible with other means or approaches (Bell, 1987). A classroom observation, which focused on the use of classroom-based assessments, was arranged with each of the case-study teachers. The aim of the classroom observations was to see how teachers conduct classroom-based assessments and to give context to their assessment practices. It was also important to get a more comprehensive understanding of their teaching and assessment practices, to understand how the teachers' alignment to learning theories plays out in the classroom. I asked the participating teachers to observe a lesson in which they conducted classroom-based assessments. The observation took place before the participating teachers were introduced to the five strands of mathematical proficiency. I expected to observe formative classroom-based assessments, but the assessments which I observed at both schools were classroom-based assessments used for summative purposes, including grading purposes. The students' negative attitudes towards assessment from the lessons which I observed at School A struck me. I commented in my field notes about my observation of the distance and disconnectedness which existed between assessment, learning and teaching. There was also a moment when a student asked Phi about the possibility of being afforded another opportunity to do the assessment. This comment was made as soon as the student received the assessment. I had to research the multiple assessment opportunities phenomena.

4.4.2.3 ARTEFACT COLLECTION

I asked each of the participating teachers to provide me with an example of a formative classroom-based assessment which they have develop and used. Assessment instruments from the participating teachers were collected during research. By reviewing classroom-based

assessment instruments which teachers in the past or currently make use of, offered distinctive analytic possibilities for this study, especially combined with the other forms of data.

4.4.2.4 CLASSROOM-BASED ASSESSMENT CONCEPT MAP

Each teacher was asked to construct a concept map on classroom-based assessment in the third semi-structured group interview. The aim of the concept mapping allowed me to understand teachers' ideas about classroom-based assessment in the moment and how that understanding changed over time.

Cognitive psychologists seem to agree that the internal representation of knowledge resembles webs or network of ideas that are organized and structured (Hiebert & Carpenter, 1992; Marx & Boyle, 1993). Concept mapping is a tool with which connections between ideas can be represented in a diagram. Key ideas are represented as nodes, and related ideas are connected with lines or arrows called links. These links are described with phrases to help illustrate the ways the ideas are related. (Novak & Gowin, 1984).

Concept mapping provides a way for researchers to decipher teachers' understanding via their representation about a topic. In addition, concept mapping can be can be revisited and revised, allowing new ideas to be incorporated with existing understanding. From the perspective of the researcher, the opportunity to see both how teachers understand ideas in the moment and how that understanding changes over time can inform decisions on modifying professional development courses.

4.4.2.5 TEACHERS' EVALUATIONS OF CLASSROOM-BASED ASSESSMENTS

I selected two of the classroom-based assessments which I collected from the teachers to be critically evaluated. The constructs of mathematical proficiency were introduced to the participating teachers at the beginning of this intervention. I have asked each teacher to critically evaluate a classroom-based assessment in terms of the assessment's alignment to curriculum and the five strands of mathematical proficiency. The Analysis of the assessments was done in a group with the teachers at each school. Each of the teachers were asked to analyse an assessment, which was then discussed in the group. The goals and aims of the curriculum were discussed at length and a considerable amount of time was dedicated to conceptualising the five strands of mathematical proficiency.

4.4.2.6 DESIGNING OF ASSESSMENTS

To understand how teachers design assessments, a 40-minute sessions were conducted with each of the participating teachers. After the teachers critically evaluated a classroom-based assessment, and after the characteristics of the five strands of mathematical proficiency was discussed, each of teachers were asked to redesign problems in a classroom-based assessment which promotes mathematical proficiency. The emphasis of redesigning a classroom-based assessment towards mathematical proficiency was less on the final product but on understanding how teachers can incorporate new ideas in their assessment practices. The theoretical framework is used to frame the relationship between teachers' knowledge of mathematical proficiency and their classroom-based assessments of mathematical proficiency.

4.4.3 ANALYSING THE DATA

Data Analysis is the process of making sense of the data which involves consolidating, reducing, and interpreting what people have said and what the researcher has experienced. These meanings or understandings or insights constitute the findings of the study (Merriam, 1998).

I undertook the data gathering for this study between February and August in. At completion of data collection I began the daunting task of analysis of the data set in its entirety which is a key element of design research methodology used to maintain trustworthiness of the research findings (Cobb, 2000; McClain, 2000). I realised soon after collecting the first data that qualitative data analysis is ongoing in nature. The data analysis proceeded as each form of data was collected. Data analysis requires a constant spiralling forward and backward from concrete chunks of data towards larger and more abstract levels (Creswell, 1998). In case study research, Yin (2003) discusses the need for searching the data for "patterns" which may explain or identify causal links in the data. An example of the patterns which I observed that contributed to the study is the relationship between the teachers' beliefs about assessment and their assessment practices. In the process, the researcher concentrates on the whole data first, then attempts to take it apart and re-constructs it again more meaningfully.

Data reduction. To bring meaning and structure to the volume of data from the five participant teachers, I first had to start by using a data reduction process (Miles & Huberman, 1994). Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming the data that appear in written-up field notes and transcriptions. Even before the data are actually collected, anticipatory data reduction is occurring as the researcher decides which conceptual framework, which cases, which research questions, and which data collection

approaches to choose. As data collection proceeds, further episodes of data reduction occur (writing summaries, coding, teasing out themes, making clusters, writing notes (Miles & Huberman, 1994). After each of the interviews were transcribed, all the data which I gathered from each of the research participants were compiled in a document. In each of the documents, uneasy information was deleted and the data reduced.

Observer comments. After each session, where data collecting to place though interviews, classroom observations, artefact collection, collecting concept maps on assessment and designing assessments with the participants, I penned "observer comments" about the main ideas that was brought to light. The observer comments served as a resource for critical and analytical thinking when I analysed the data at a later date, but most importantly it reflected what I was learning.

Coding. As explained earlier, the first steps of analysing the data was transcribing all the audio-recorded interviews after which data reducing took place. Organising the notes taken from classroom-observations, and collecting the assessment concept maps and classroom-based assessment artefacts followed this. Following the recommendations by Merriam (1998) and Bogdan and Biklen (2007), the data was analysed through an interactive process by moving back and forth between the data collected. The next step in the data analysis activity was to allocate different codes. Codes are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study. Codes are usually attached to "chunks" of varying size – words, phrases, sentences, or whole paragraphs, connected or unconnected to a specific setting. For my purpose, it is not the words themselves but their meaning that matters. Data from the semi-structured interviews with the teachers were

reviewed to identify initial codes for broad categories. Twenty codes were initially identified using open coding techniques, which are illustrated in table 6.

After the initial coding I continued with open coding to uncover emergent properties which aligned with the various categories. The individual and group responses were analysed, compared and categorised. I started with the research questions and used the interview transcripts to identify the emerging patterns and evidence that addressed my research questions. After reading transcripts, I defined initial codes. I connected the twenty codes to the research questions.

Table 6: Coding categories

Coding Categories	Research Question	Code
Learning or assessment culture	1, 2, 3	AC
Testing culture	1, 2, 3	TC
Purpose of classroom-based education	1, 2	PUR
Assessments used to promote or advance teaching	1, 2	PUR-T
Assessments used to promote or advance learning	1, 2	PUR-L
Assessment used to certify	1, 2	PUR-C
Assessment used for accountability purposes	1, 2	PUR-A
Assessment practices of teachers	1, 2	PRAC
Assessments are irrelevant	1, 2	PUR-I
Teaching conditions and learning environment	1, 2, 3	ENV
Beliefs of Assessment	1, 2	BEL-CBA
Beliefs of the Curriculum	1, 2	BEL-CUR
Views and expectations of students	1, 2	V-STU
Feedback of assessment	1, 2	FEED
What a good mathematics student can do	1, 2	V-MATSTU
The importance of teaching and learning mathematics	1, 2	V-MAT
Challenges teachers face concerning assessment	3	CHAL
Pressures and influences which act on teachers	3	PRES
Principles and procedures of designing classroom-based assessments	1, 2	DES-CBA

4.5 MY STANCE

I was very sensitive to the fact, as I explained in the research strategy (4.3), that the effectiveness of the research depends on me being seen as a participant observer as opposed to the bearer of knowledge and truth in redesigning classroom-based assessments toward mathematical proficiency. Because of the terrible legacy of Apartheid in South Africa, I was aware that my white skin colour might have an effect on how the teachers will engage with me, especially when I need to establish the teachers' schooling backgrounds and professional development.

I was both an insider and outsider to the teachers at School A. I was an outsider because of my cultural, language, socio-economic and background differences to the teachers at the government school. I was an insider because of the collaborative and established relationship which I had with the participants, as well as my prior experience working in schools situated in low socio-economic areas. The participating teachers thanked me for conducting research on the topic of classroom-based assessments. The teachers pulled no punches when it came to discussing their views of the curriculum, assessment and teaching. The interactions with me were honest and transparent. I think this was mostly because they saw me as a researcher acting for them and that they do not need to be diplomatic about anything. The sessions became a time for teachers to lower their guard and to reflect what they believe education should look like. Being an outsider provided both limitations and opportunities. There was also something special about being a fellow mathematics teacher who appreciated the challenge and pressures of teaching mathematics to students of varying abilities and interests. The research required me to establish a relationship with the participated teachers which were researched.

4.6 TRUSTWORTHINESS AND CREDIBILITY

If a study is trustworthy it has to be carried out fairly and ethically with findings representing close experiences of respondents (Padgett, 2009) and to make certain the research is trustworthy and reliable in qualitative research it is essential to follow correct ethical procedures (Merriam, 1998).

I followed the processes of ethics (see appendices 1 and 2). I explained to the participants before the study commenced. The participants were informed that they were able to modify any comments they made during the group and individual interviews, and that the recordings of interviews and copies of transcripts were available at their request to help secure the interpretive validity of the research. This also helped to confirm the accuracy of the transcriptions. The multiple data gathering techniques such as observations, semi-structured interviews and artefact collection provided adequate triangulation. I did an initial analysis of each interview before the next one. each interview started with a section clarification at the beginning of each session to ensure trustworthiness.

4.7 ETHICAL IMPLICATIONS OF RESEARCHER – PARTICIPANT RELATIONSHIP

I am a teacher at School B that has a strong collaboration with the mathematics teachers and students at School A, as is the case with many well-resources private and under-resourced government school collaborations in South Africa. When the objects of inquiry are human beings, such as the mathematics teachers in this study, extreme care must be taken to avoid any potential harm to both the researcher and the researched (Boubee-Hill, 1998; Cohen et al, 2000; Fontana & Frey, 1994). Cohen et al (2000) and Kvale (1996) suggest two concerns to watch for in ethical considerations; first, the manner in which the research has been conducted in

relation to the research subject (matters such as informed consent, confidentiality, and persons involved) and secondly, acknowledgement of the contribution of all the people who have been involved in the research and as well as open recognition of individuals whose research influenced this present study.

The guidelines of the University of Stellenbosch Humanities Research Ethics Regulation (Humanities) were adhered to. As stated previously, following the approval of my ethics application by the University of Stellenbosch (see appendix 1), I obtained permission from the Western Cape Education Department (see appendix 3) to conduct research with Mathematics teachers in secondary schools. I wrote to the principals of various secondary schools in Cape Town, informing them of my research intent and asking them permission and approval to conduct research at their school. All the ethical issues relating to participants, including what is expected from participants, were addressed in the covering letter and letter of consent (see appendix 2) where I requested participation. A meeting was scheduled at the two schools, which was selected with all the mathematics teachers. I read and explained the consent form to the teachers for clarification and discussed what is expected from the participants. Consent forms were handed to the teachers. The teachers were asked to sign the consent forms if they are willing to participate in the research to next scheduled meeting. All participants gave their informed consent and were informed that they would remain anonymous and that the data that are to be derived from their feedback would only be used for purposes of reporting and analysis. Ethical considerations that underpinned the study include:

(1) Informed voluntary consent

The participants were verbally informed of the expectations of the research. I copy of the letter is in appendix 2.

(2) Right to privacy

The names of the schools and participating teachers are not mentioned. The teachers and schools were given pseudo names.

(3) Confidentiality

I was the only person who had access to the raw data.

(4) Participant's right to decline

The right of the participants to decline was clearly stated in the letter maintained throughout the study. All of the research participants gave me consent to participate in the study.

4.8 CONCLUSION

This chapter included several sections detailing the research design and research methodology used in this qualitative study. The decision to choose the case-study as a research method was discussed, together with giving brief information of the five participating teachers, information about the two schools, my research strategy, data collection methods, data analysis and ethical concerns. The theoretical framework which was discussed in chapter 3 will be used to frame the data which is presented and analysed in the following chapter.

CHAPTER FIVE:

DATA PRESENTATION AND ANALYSIS OF DATA

5.1 INTRODUCTION

This chapter presents an overview of the data I collected from the five participant teachers redesigning their classroom-based assessments towards mathematical proficiency. I also use my theoretical framework to frame the data which I gathered from the semi-structured group and individual interviews, the teachers' concept maps on the purpose of classroom-based assessments, the artefact collection of previously designed classroom-based assessments, the classroom observation, and the designing of classroom-based assessments towards mathematical proficiency, in a chronological order.

5.2 THE RESEARCH PARTICIPANTS

As I explained in the Methodology chapter, the five participating teachers were selected from a total of nine participants in two schools. I will introduce each of the participant teachers to you and provide you with background information, which will be useful to get a better understanding of each of the teachers' experience and beliefs about education. The five participating teachers were given pseudonyms to conceal their identity, and they will be known as Alpha, Lambda, Phi, Epsilon and Omega. These participating teachers were my fellow companions on the journey to redesign classroom-based assessments that promote mathematical proficiency. The semi-structured interviews happened before the five strands of mathematical proficiency were introduced, but it served as a lens through which I looked.

5.2.1 BACKGROUND INFORMATION OF THE RESEARCH PARTICIPANTS

Before the data I gathered and analysed is presented, I thought it would be a good idea to provide you with a brief description of each of the five participating teachers.

5.2.1.1 ALPHA

The Oxford Dictionary's definition of Alpha, "denoting a person who has a dominant role or position within a particular sphere", provides an accurate description of the first participant. Alpha is the Principal of School A, and he is in his mid-40s with more than 25 years of teaching experience, including five years of mathematics teaching experience in the Senior Phase. Alpha is a qualified Social Sciences teacher, and he does not have a professional or academic qualification in Mathematics. He explained why he is teaching Mathematics: "I am not a Mathematics teacher. We needed someone in the lower grades since last year, because of staffing issues, so I stepped in. I realised that we [as a school] needed to put more emphasis on Mathematics at our school, so I decided to teach one of the Grade 8 classes this year" (Alpha, GI-A1). Alpha was an essential participant in the study because his limited training in mathematics education is not unique to many Mathematics teachers in South Africa. The Department of Basic Education's Mathematics and Science Audit revealed that more than 50% of Mathematics teachers had received no formal subject training (DoE, 2001a).

Alpha's beliefs about teaching Mathematics, despite his limited experience, are aligned strongly with developing the fifth strand, the productive disposition, in the students he teaches. Although he bemoaned that "all we are trying to do is to get our kids [students] to pass, to go through school" (Alpha, GI-A1), he wants to provide the students he teaches with "practical cognitive tools" to use in the 'real world' by bringing "real-life scenarios into the classroom so they can make connections" (Alpha, GI-A1). He believes that "all students have

the ability to achieve" (Alpha, GI-A1), but that their progress much depends on their "mindset" (Alpha, GI-A1), which aligns closely with the productive disposition strand. He said that the students approach their studies with "a wrong mindset of only passing" and that he wants his students to "be able to understand that mathematical skills assist them with problem-solving techniques" and for the students to understand that "the ability to strategically solve problems is important in life" (Alpha, GI-A2), which speaks to developing strategic competence. He also wants the students he teaches to develop conceptual understanding, so that they are "able to think logically" and "understand what was conveyed to them [so that] they are able to retain that information" (Alpha, GI-A2).

Alpha believes that teaching and assessment are connected and talked about the need for "teaching in such a way that our kids understood, in a way they can relate (Alpha, GI-A1)", which speaks to developing conceptual understanding in the students he teaches, and not only procedural fluency. He feels that the approach towards assessment "is very problematic […] because all that we are doing is we are testing kids to pass the test, and after they have passed the test, they forget about it again (Alpha, GI-A1)". I found his comments on assessment and teaching fascinating because he admitted to teaching the students only to "pass the test", the very notion which he lamented earlier in the students he teaches. It was also clear that he believes the students he teaches do not have a developed conceptual understanding and that the classroom-based assessments he uses prioritise procedures above conceptual understanding.

Alpha believes that how he assesses is not very different from how he was assessed when he was at school, and that he learnt how to develop assessments from studying the limited "exam banks and model papers (Alpha, GI-A2)" which are in circulation. He is critical of the support that is available from the Department of Education, explaining that the subject advisors "are not active in the way we want them to be active … Instead of offering

advice, all that they do is they come and inspect, no help or support, they only inspect". Alpha tries to replicate the external assessments, such as the annual national assessments for Grade 9, by "asking questions that are similar to the questions that will be asked for students to be confident (Alpha, GI-A2)". Alpha has received no professional training on how to develop a range of assessments in any of the subjects he teaches, saying, "not even at teachers' college have I been taught alternative assessment techniques, the focus has been on designing tests (Alpha, GI-A2)". He describes an effective classroom-based assessment instrument as a test, which "covers the content at the appropriate level, giving you an idea about where the students are at (Alpha, GI-A2)", and which places the assessments he uses under the "assessment of learning" umbrella. He explains that he has had a "lack of experience and exposure (Alpha, GI-A2)" for developing other forms of assessments, as well as "insufficient resources (Alpha, GI-A2)" which are available. He also referred to the influence which the final assessment has on his teaching and assessment practices, by commenting that "we already know what type of things will be set and asked in the matric exam where we have no control, so that dominates how I assess" (Alpha, GI-A2). This revealed that his beliefs around developing conceptual understanding, strategic competence, and enhancing productive disposition in the students he teaches are easily overshadowed and "dominated" by the demands, types of questions, and format of the external assessments. He was very open and honest that he, primarily, is teaching to the test.

Alpha is, without a doubt, a passionate teacher who values the importance of students learning Mathematics. He identified that the Mathematics teaching in the earlier years of his school has not been up to standard, and decided that he can make a difference. I was interested in understanding why his beliefs, which he shared earlier around the need for developing much more than sound procedural fluency in his students, is not reflected in how he described a practical classroom-based assessment, mainly because he talked extensively

about the connection between teaching and assessment. I believe that he wants the students he teaches to excel in Mathematics, but that being a principal of an at-risk school takes up most of his time, which makes preparing lessons that enhance conceptual understanding and strategic competence, that he wants for the students he teaches, very difficult. Then one considers that he is not trained as a Mathematics teacher, nor has he received any professional training on how to develop assessments, which only adds to the pressure of teaching Mathematics. Who would blame him from lensing his assessments from the high-stakes, external assessments which the students write? Many Mathematics teachers in our country are in a similar position as Alpha, teachers who value the teaching of Mathematics but have not received any formal training or professional development, and for whom there is very little support. Alpha's story is a compelling one; he speaks about the characteristics of the conceptual understanding, strategic competence, and productive disposition strands without any formal knowledge of Kilpatrick's mathematical proficiency. If Alpha can design his classroom-based assessments towards mathematical proficiency, I believe then half[2] of the Mathematics teachers in South Africa, who are in a similar position, will be able to, too.

5.2.1.2 PHI

I chose the name 'Phi' for the second participating teacher, not because I believe she is irrational, but because, like the golden ratio, she is as pure as gold, and full of deep meanings, creativity and flair. Phi is a trained and experienced Mathematics teacher in her 40s. She is teaching at School A, the government school where Alpha is the principal. She has 17 years' experience, and she has a Mathematics qualification. She is originally from Zimbabwe, where

[2] The Department of Basic Education's Mathematics and Science Audit (DoE, 2001a)

she obtained a Bachelor's Degree in Mathematical Sciences Education, majoring in Mathematics Education, as well as an Honour's Degree on Mathematics Education. Phi wants to further her Mathematical qualification, and at the time when the research was conducted, registered for a Master's Degree course in Mathematics Education. Phi's experience with the South African and Zimbabwean Education Department gives us a different take and insight. She joined the school less than a year ago. Besides teaching Mathematics, she teaches Life Orientation. Phi teaches every lesson in the timetable, which means she has no free periods and very little time to plan assessments.

Although Phi, as was the case with the other participating teachers, at the time was unaware of Kilpatrick's five strands of mathematical proficiency, her beliefs about teaching and learnings Mathematics strongly correlates with the five strands of mathematical proficiency. Phi is of the opinion that an essential part of her role as a teacher consists of teaching students to make links between concepts, because making links and connections "is all about comprehension, application and linking topics and concept[s] (Phi, GI-A1)". She wants to develop students who "can make links, apply concepts, and think independently (Phi, GI-A1)", which strongly corresponds with the conceptual understanding strand. More interesting is that her determination to let students discover "that actually we did this, being able to link what they've done to what they are doing (Phi, GI-A1)" also points strongly to the second level, labelled as connections, of mathematical thinking on De Lange's multi-dimensional assessment pyramid (De Lange, 1999).

Phi believes that we need to develop students who are able to "be goal driven" and are "able to comprehend, make links as well as understand concepts and the application" (Phi, GI-A1). Phi is of the opinion that her teaching influences how she assesses: "In your teaching students must comprehend and link topics" (Phi, GI-A2). It became clear that she uses

assessment as an instrument to see if the students she teaches have a full understanding of the concepts by being able to make interrelated links between concepts.

Even though Phi received her teacher training in another country, she explained that she learnt how to develop assessments by looking at the exit assessments. Phi thought back to how she was assessed when she was at school and felt that the students "would never have coped if they were assessed as we [had been] assessed" because "it is much easier for them (Phi, GI-A2)". Phi's comments revealed that she feels that the education standards have been reduced, and that the demands placed on the students are not high. Phi explained that the students "can rewrite the assessments, but it is making very little difference (Phi, GI-A2)", which emphasises her lack of belief in the effectiveness of their school's assessment approach. Phi bemoaned, with similar sentiments to Alpha, the difficulty of accessing assessments and said "there are not sufficient resources available to use (Phi, GI-A2)". Phi explained that she wants to use a wide range of classroom-based assessments, but finds it "difficult to get hold of practical learning resources" as most of the resources she "get are just tests and exams (Phi, GI-A2)". Phi believes that using a large variety of assessments will be beneficial for the majority of the students she is teaching who are not "finding mathematics easy" (Phi, GI-A1).

I believe that Phi is a committed and thoughtful teacher who wants to make a difference in the students' understanding and learning experiences. Phi gave the impression of a strict but fair teacher, which was confirmed when I observed a lesson of hers. She wants to develop herself in order to develop her students, but it became clear that she is not satisfied with the demands and expectations which are put on the student. She believes the students should be more driven and independent about their own studies. She clearly links her teaching and assessment practices, which speaks to her thoughtful and considered approach. I was most excited when I realised that her teaching goals corresponded so closely with the

five strands of mathematical proficiency, and that the backbone of her teaching and assessment goal, enabling students to "make links", is aligned with the second level of De Lange's assessment pyramid. I believe Phi plays an important part in this research for two reasons: the first is that she is an experienced teacher who is deeply committed to the teaching profession and who wants to develop herself; furthermore, she represents an estimated 4000[3] Zimbabwean mathematics and science teachers who are currently teaching in South Africa.

5.2.1.3 LAMBDA

I chose the name "lambda" for the third participating teacher, not because lambda represents an uncharged, unstable elementary particle, but because lambda is often used as the symbol for wavelength. Lambda has been involved in mathematics education for over 17 years, and has experienced the extremes of each of the curriculum waves. He has been teaching at the same school as Epsilon and Phi for 14 years. Most of his teaching experience has been at the senior phase level, focussed on the teaching of mathematics. He graduated with a Higher Diploma in Mathematics Education for the GET phase, which allows him to teach students in the Senior Phase – grades 8 and 9. He is the Deputy Principal of the school, as well as the Head of the Mathematics Department. Lambda's teaching load is a grade 8 and grade 9 mathematics class, and a grade 11 and a grade 12 mathematical literacy class. Lambda described himself as an enthusiastic and passionate teacher who wants to inspire the students he teaches. Lambda talked through his past experiences designing assessments, and explained

[3] De Villiers (2007) argued that South Africa was already home to 10,000 Zimbabwean teachers by 2004, where approximately 4,000 of these were qualified science and mathematics teachers.

how difficult it was to go through the multiple curriculum changes, each with its own "interpretation and expectation of assessments that need to be conducted" (Lambda, GI-A1). He explained that he probably received training in assessment design when he was at teachers' college, but that he has not received any "adequate" professional development on how to implement and develop assessments, other than tests. This was very similar to the experience of Alpha and Phi. Lambda, similarly, explained that he learnt how to develop assessments by studying the previous external assessments.

Lambda's beliefs concerning mathematics education varied significantly from the beliefs of Alpha and Phi. Lambda believes that, because very few, "if any, of our students, will study mathematics after school" (Lambda, GI-A1), the students will be "better suited [to] doing more practical, contextualised mathematics, to solve real-life problems and acquire the skills to help them when they leave school" (Lambda, GI-A1). Although the other participants also talked about the importance of preparing students to solve "real-life problems", Lambda's beliefs are more aligned with mathematical literacy than with the development of "practical cognitive tools" to use in the "real world" by bringing "real-life scenarios into the classroom so they can make connections" (Lambda, GI-A1). He did not refer to making connections between concepts, or between abstract or concrete concepts. He also did not refer to using more practical "real-life" examples to make an abstract concept more accessible. Lambda revealed a goal-orientated, teacher-centred approach towards teaching by commenting that it is essential to establish "what we want our students to be able to do", and secondly, "what will be most helpful for students to know (Lambda, GI-A1)". It was interesting that the role of the student in the decision was not mentioned. Lambda believes that it is essential for students to be able "to do different types of problems, to apply knowledge, to have a range of skills and good application (Lambda, GI-A2)". His beliefs corelated closely with the procedural fluency strand, while the other strands were absent. I

found Lambda's comments often very conflicting, as he would then state at a later stage that he wants to develop students who are able "to solve problems quickly, to understand the concepts, to appreciate mathematical knowledge (Lambda, GI-A2)". This again points to the fact that he wants the students he teaches to develop conceptual understanding and a productive disposition. This was initially confusing to make sense of if one considers all his experience of teaching mathematics. I came to realise that, despite his experience in teaching mathematics, he is less focussed on developing strong mathematics students who will study mathematics at a tertiary level, and more on using mathematics as a way for the students he teaches to find employment. It was most noticeable that he did not link assessment and teaching, even when he was prompted on the relationship between these two aspects.

Lambda will play a significant role in this study. He is seen as the experienced mathematics teacher at the school, but his beliefs of the core business of teaching mathematics differ significantly from his colleagues. I believe that his teaching environment, which includes the students he teaches and their socio-economic conditions, has had an overwhelming influence on his beliefs about teaching mathematics. It is clear that he wants what is best for the students, and from the lesson observation it was clear that he and the students he taught had the most positive relationship of all the teachers who were observed at School A. He believes that what is best for them is to have practical vocational skills, and not an academic skill-set. This speaks directly to the tension he experiences with the current curriculum, which will be elaborated on further later in the thesis.

5.2.1.4 OMEGA

The symbol for omega denotes the last or the ultimate limit of a set. Omega has vast experience as a mathematics teacher, with more than 30 years' teaching experience. She explained that she is at the end stage of her teaching career, and she is considering retirement

in the next few years. She has been teaching at School B for ten years. Omega teaches Mathematics to a grade 8 and 9 class, a grade 10 Advanced Programme mathematics class, and a grade 12 mathematical literacy class. She is also the Head of Academics at School B, which results in her having a reduced teaching load. Omega holds a Bachelor's of Science degree and a Higher Diploma in Education. Omega said that the first time she received professional development on assessments was in her teacher training where she had to "develop an entire matric [exam] paper, and we had to go through which principles we were applying, [and] why we were asking questions" (Omega, GI-B1). Although her training focussed primarily on designing summative assessments, Omega mentioned that she received professional development from the Department of Basic Education when the curriculum and external assessments changed. She commented that the training happened because "outcomes-based education was introduced "(Omega, GI-B1) on how to develop classroom-based assessments. Omega told me that, although she believes she was born to be a teacher, she had to learn how to teach. She left teaching 15 years ago to experience Information Technology in the private sector, and returned to the teaching profession after two years. She explained that she "came back because teaching is value-driven" (Omega, GI-B1) and she believes that she, too, is value-driven. Omega gets satisfaction from teaching mathematics to students. She explained that she does not "know of any other job that gives you that buzz [like] when a student gets something because of your intervention" (Omega, GI-B1). Omega initially went into teaching because of political motives. She explained that being in a classroom allowed her to have open discussions about race and injustice. She explained that it was the only "legal way" that she could "challenge and change minds without being chucked in jail" (Omega, GI-B1). It became clear from the start that, for Omega, teaching consists of more than just teaching the subject matter, and that she and her students are her first priority.

She explained that, although she believes that she "cannot change the country, [she] can change lives" (Omega, GI-B1).

One of Omega's strongest beliefs is centred on developing the productive disposition strand in the students she teaches. Omega feels that mathematics is essential to education for students to develop resilience and logic. She explained that for her "it is about cognitive growth" (Omega, GI-B1) and she does not believe that the cognitive skills which students develop in mathematics can be acquired anywhere else. She explained that mathematics enables students to have "discipline in thought through rigorous training, but then the ability to push yourself and spark" (Omega, GI-B1). She shared that mathematics allows students to trust their intuition, which develops confidence in the students she teaches. She explained that, when confronted with a problem, she wants her students to say, "I have an idea: is it okay; will it work, or will it fail" (Omega, GI-B1). Omega believes that the purpose of education and the purpose of mathematics education are the same. She explained that "education is about growth – that is why we teach mathematics; it is about growth in students, building capacity" (Omega, GI-B1).

Omega's believes that the mathematics students she teaches must be able to engage in problem solving. She explained that "solving of routine problems has its place in establishing general efficacy and skill, but a competent mathematics student should be able to use a variety of skills in a logical way to solve unfamiliar problems" (Omega, GI-B2). Omega was the first participating teacher who has talked about the importance of problem-solving. She emphasised that she wants to develop students who can "generalise patterns and […] solve problems on a range of cognitive levels" (Omega, GI-B2). She believes in key mathematical values that must be reflected in teaching and assessments, such as "mathematical thinking opportunities" to "develop problem-solving ability" (Omega, GI-B2). She criticised the current educational system's emphasis "on solving problems in a set time under immense

pressure" (Omega, GI-B2). She feels that in "real life", one does "not necessarily provide the best solution to a problem under somewhat unrealistic time expectations" (Omega, GI-B2). Omega's beliefs of assessment link with the second and third thinking levels of De Lange's Assessment Pyramid. The integration for problem-solving, as well as mathematical thinking and reasoning, generalisation and insight encapsulate her beliefs. Omega explains the reason why she emphasises problem-solving is because she wants her students to be "tenacious", and they must be "comfortable with grappling and be able to stick at it" (Omega, GI-B2). She believes that a competent mathematics student can read mathematics as a language. She explains that these students "can see the structure of the expression and equation" (Omega, GI-B1). She further explains that she believes that "what underlies this is the ability to draw linkages between various ideas and concepts, and have a comprehension of concepts" (Omega, GI-B1). Omega's beliefs correlate closely with Kilpatrick's strands of mathematical proficiency. She talked about the essence of Kilpatrick's conceptual understanding, strategic competence, and adaptive reasoning strands when she described the student she wants to develop. The productive disposition strand forms a prominent feature in her beliefs. It was interesting to note how she described mathematics as a tool to develop confidence in students. This contrasted with the views of Alpha, who described his students' fear of mathematics.

My view of Omega is that she is a flexible and creative teacher who can balance her students' insecurities in mathematics with the teaching and learning goals which she sets for her students. My lesson observation confirmed my views. Although the students were not all enthusiastic about the problems which were presented in the lesson, they were more comfortable with trying a strategy to solve a problem, and dealing with a failed approach. Here, it was not a case of students only being allowed to "reach the minimum requirements", but to use problem-solving as a personal growth tool where one explores multiple problem-

solving techniques, and to learn how to trust one's intuition. Omega plays an essential part in this research not only because she brings experience with her, but because her beliefs are vastly different from the other participating teachers.

5.2.1.5 ETA

The Greek letter "eta", among other aspects in various fields, is used to represent a kind of electrically neutral meson having zero spin. I have chosen the pseudonym Eta for this research participant mainly because of his neutrality. It became clear that Eta's pedagogical knowledge and experience of curriculums are limited, which resulted in his responses being less coded and more straightforward and transparent. He has a mathematics degree without a teaching degree, and very little teaching experience or pedagogical knowledge. Eta is a mathematics teacher at School B in his late 20s. Eta's only teaching experience has been at School B, where he has been teaching for three years. He holds a Master's Degree in Mathematics from a university in England but does not have a professional teaching qualification. Eta explained that he was not sure what he wanted to do when he accompanied his wife when they moved to South Africa, and he gave teaching a try. He noted that the first year was challenging getting to grips with all the demands of teaching, but that it did not take long before he could not see himself doing anything else. Eta commented that what he enjoys most about teaching is helping students finding their "aha" moment, the moment when abstract concepts make sense. Eta explained that the reason why he became a mathematics teacher is that he was always good at mathematics, and he felt he has something to offer. He explained that, because he enjoys mathematics, he sees a lot of value in it for himself: "I got a lot out of it in my life, both in terms of opportunities and pure enjoyment" (Eta, GI-B1). For Eta, it is the "human desire to share when you had a good experience – you want to share the enjoyable experience" (Eta, GI-B1).

Eta learned how to develop assessments from working in a team in a department and learning from colleagues, by designing different types of "assessments for different purposes" (Eta, GI-B2) and learning from mistakes he made along the way. Eta was the first participant teacher who spoke about different assessments to achieve different purposes. Eta believes that how he was assessed when he was in school has had very little effect on how he designs classroom-based assessment practices. He recalled that a surprisingly large component of the assessments he wrote at school was multiple choice, and he remembered that as a student he felt those components were "shallow" and "didn't challenge" (Eta, GI-B2) him.

Even though Eta's experience and training are very different from the other participating teachers, he also beliefs that the external high-stakes assessment has a direct impact on his teaching. Eta explains that the way that the subject is assessed massively influences how he teaches the content because when he teaches, he is "keeping in mind how it will be assessed" (Eta, GI-B2). The external assessment has had a positive effect on his teaching, as it has prompted Eta to teach every section in a way so that his students will be "confident answering whatever may come their way" (Eta, GI-B2). For me, it is more understandable that, with Eta's limited curriculum and pedagogical knowledge and experience, out of all the participating teachers, his assessments would mirror the final, most important assessment. It is Eta's belief that, if a teacher were tasked with teaching the curriculum without knowing how it would be assessed, the content would be taught in a very different way. Eta has a different approach to teaching grades where there is not an external assessment (the case with teaching grade 12s). He explained that when he teaches the grade 9 students, his "approach is very different because there is not external pressure" (Eta, GI-B2), which results in him going deeper into the content, and often exploring mathematics concepts outside the scope of the curriculum. He feels that he has the freedom to develop creative lessons and assessments in a way in which he thinks would be best for the students.

Eta's beliefs about the role of the students, despite his limited teaching experience, have distinguished him from the other research participants. He sees the students as part of the whole teaching and learning process and he believes that it is essential that he develops a good relationship with each of his students, saying: "I set a very high expectation for all the students, higher than most people would do for the particular group. I am determined that they meet the expectations to excel" (Eta, GI-B1). Eta's relationship with his students allows him to set high expectations for his students and to demand their best. He believes that because the students "construct their own meaning, they are absolutely at the centre". Eta wants the students he teaches to have the "tenacity and desire to solve the problem" (Eta, GI-B1). Eta believes that there must be an element of developed intuition in his students, and explained that, "when they see an unfamiliar problem, they need to have an idea where to start" (Eta, GI-B1). Although Eta believes that every student can build the capacity to excel in mathematics, this clearly comes with strong conditions. For Eta, students must have existing and partially developed intuition, compared to Omega, who believes that students' intuition must be developed through "mathematical thinking opportunities". The difference between the beliefs of Eta and Omega concerning the students' intuition rests on the degree of the intuition which the student must have to be able to engage in problem-solving activities. He also commented that students' "procedural soundness" (Eta, GI-B2) must not be underestimated. He believes that a competent mathematics student will need to have all of these pieces strongly developed. Eta's beliefs about teaching and assessment overlap largely with Kilpatrick's five proficiency strands. An aspect which is different from the other participant teachers is that, to be a competent mathematics student, there are various skills which must be mastered, which must all be well developed. Similar to Omega, Eta believes that it is essential for students to have the confidence and tools to solve problems. Eta's beliefs, despite his limited teaching experience and pedagogical training, about what a

proficient student must be able to do strongly correlates with the procedural fluency, conceptual understanding, strategic competence, and productive disposition strands.

5.2.2 EVALUATING THE PARTICIPATING TEACHERS' BELIEFS ABOUT TEACHING AND LEARNING MATHEMATICS IN TERMS OF THE PROFICIENCY STRANDS

This first part of the chapter introduced each of the participating teachers by giving background information, as well as a window into their teaching worlds and beliefs about teaching mathematics. The importance of this section should not be underrated because these participating teachers will tell their own story to you in the next few chapters on their journey towards designing classroom-based assessments towards mathematical proficiency. It is empirical to capture the voice and experiences of each of the teachers to better understand their beliefs about all the various elements affecting how they view and design classroom-based assessments. It will be essential to keep the backgrounds and aspects of identity of the teachers in mind throughout the journey to understand each of the participating teacher's worldviews.

It was interesting to observe the beliefs of the teachers at both of the schools and to compare the participating teachers' beliefs about mathematics teaching and learning with their experience teaching mathematics and the training they have received. Table 7 reveals that, although the participating teachers had no knowledge of Kilpatrick's five strands of mathematical proficiency by the time the semi-structured interviews were gathered, their beliefs of what students should be able to do corresponded to many of the proficiency strands.

Table 7: Linking teachers' beliefs about teaching and learning mathematics to the proficiency strands.

	Beliefs about teaching and learning mathematics	Proficiency strands
Alpha	The progress of the students greatly depends on their "mindset" – "a wrong mindset of only passing"	Productive disposition
	Students must "be able to understand that mathematical skills assist them with problem-solving techniques" – "the ability to strategically solve problems is important in life"	Strategic competence
	"Teaching in such a way that our kids understood, in a way they can relate"	Conceptual understanding
Phi	It "is all about comprehension, application and linking topics and concept[s]". Students must be able to "make links, apply concepts, and can think independently"	Conceptual understanding
Lambda	Students must be able "to do different types of problems, to apply knowledge, to have a range of skills and good application"	Procedural fluency
	Importance "to solve problems quickly, to understand the concepts, to appreciate mathematical knowledge"	Conceptual understanding; Productive disposition
Omega	"discipline in thought, through rigorous training but then the ability to push yourself and spark" ; "it is about growth in students, building capacity" ; "tenacious" students who must be "comfortable with grappling and be able to stick at it"	Productive disposition
	"solving of routine problems has its place in establishing general efficacy and skill, but a competent mathematics student should be able to use a variety of skills in a logical way to solve unfamiliar problems"	Procedural fluency; Strategic competence
	"the ability to draw linkages between various ideas and concepts, and have a comprehension of concepts"	Conceptual understanding
Eta	Students must be "confident answering whatever may come their way" ; students "construct their own meaning, they are absolutely at the centre"	Conceptual understanding
	Students must have "procedural soundness"	Procedural fluency

Although none of the participating teachers' beliefs about teaching and learning mathematics covered all of the proficiency strands, I was surprised by the range of the proficiency strands which could be linked to their beliefs of teaching and learning mathematics. It was also interesting that the experience or training of the participating teachers was not a predictor of

the range of proficiency strands which linked to their beliefs. Alpha had no mathematics training and very little experience teaching mathematics, yet his beliefs aligned with three of the proficiency strands. Then again, the beliefs of Phi, who is a trained and experienced mathematics teacher, focussed extensively on the conceptual understanding strand to the expense of the other strands. The beliefs of Omega, who was the most experienced participant, concerning teaching and learning mathematics linked up to four of the five proficiency strands. The only proficiency strand which did not link to the teachers' beliefs about teaching and learning mathematics was the adaptive reasoning strand. Conceptual understanding was the modal proficiency strand which could be linked to the beliefs of the participating teachers.

Linking the proficiency strands to the participating teachers' beliefs of teaching and learning mathematics was important for two reasons. The first is that it revealed that their beliefs of teaching and learning mathematics closely linked to many of the proficiency strands, which indicated to me that their belief system would accommodate Kilpatrick's five mathematical strands when it was introduced to them. This is crucial because it would be expected from the participating teachers at a later date to design assessments which promote the mathematical proficiency strands. The second reason is that, by linking the proficiency strands, together with the background information of the participating teachers, pointed to the diverse beliefs of the five participating teachers. The diverseness of the five participating teachers concerning their beliefs, experience, training, and working conditions provides us with insight into how varied mathematics teachers in South Africa are. It is clear from the five participating teachers that training and experience does not correspond as well as I initially thought with the range of beliefs which has a direct impact on the teaching practices of teachers.

Stiggins states: “Classroom assessment requires a great deal of time and effort; teachers may spend as much as 40% of their time directly involved in assessment-related activities. Yet teachers are never trained nor prepared for this demanding task” (1998). Even though this quotation was used in a publication more than 30 years ago, it is as relevant today as it was then. It is also clear from investigating the training and development which the teachers received that very little has changed over the last 30 years when it comes to training and preparing teachers to implement new forms of assessment, especially those aimed at assessment for learning. Not one of the teachers felt they had received adequate training and professional development on designing assessments. All the teachers expressed confidence in designing traditional formative and summative assessments forms of assessment, such as tests and exams. A common thread from the participating teachers centred on designing assessments which replicate the externally set examinations. The challenge of providing adequate professional development is not unique to the South African education system. Just as teachers struggle to find time and resources to better support each of their students’ learning in their mathematics class, administrators around the world have struggled to provide timely professional learning for these students’ teachers (Hudson, 2017). It became clear from the participating teachers that professional development which focusses on developing formative classroom-based assessments is not readily available. No professional development programmes offered by the South African Council for Educators (SACE) or by the Department of Basic Education (DBE) could be found on their respective websites. Although a number of short courses are offered by the universities and higher educational institutes for secondary school mathematics teachers, the majority of the courses focus on pedagogical and content knowledge. Teachers’ professional development must be centred on the link between teacher skill and knowledge, and student learning (Welch, 2012). After extensive research, I could find only found two short courses offered in 2016 which focussed

on assessment principles and strategies for secondary school mathematics teachers and seven courses on general assessment accreditation. One of the courses for secondary school mathematics teachers focusses on how to assess students to improve instructions, diagnose difficulty, determine remediation needs, and identify errors in thinking using assessment criteria. If we value formative classroom-based assessment, then it is clear that there is an enormous need for professional development programmes to focus also on the main approaches to assessment, which includes the designing of classroom-based assessments.

Now that we have a better understanding of the working conditions, background, and beliefs of the participating teachers concerning teaching and learning mathematics, we can delve deeper into aspects of their belief systems to understand better how the beliefs correlates with their teaching practices. In the next section, the beliefs of the teachers concerning the purpose of classroom-based assessment will be explored to answer the first research question: how secondary school mathematics teachers describe and justify their current classroom-based assessment practices.

5.2.3 THE PARTICIPATING TEACHERS' CLASSROOM-BASED ASSESSMENT PRACTICES

To be able to understand the possible complexities and challenges that could arise later in the process of redesigning assessments, it was important to become familiar with the participating teachers' current assessment practices. The goal was to gain an understanding of each of the participating teachers' experiences, which is essential to present my findings on the challenges that the participating teachers experience incorporating new ideas into their classroom-based assessments. I had the opportunity to interview each of the teachers, as well as to observe classroom-based assessments in the lessons of each of the teachers. The teachers generously provided me with examples of classroom-based assessments which they

have used, and, in some cases, also designed. A brief description of each teacher's classroom-based assessment practices follows.

The current South African curriculum encourages teachers to use Baseline, Diagnostic, Formative, and Summative assessments. The South African curriculum states that all formal assessments must be marked and formally recorded by the teacher for promotion purposes. The current South African curriculum stipulates that formal assessment comprises of School-based Assessment (SBA), which comprises of tests, examinations, projects, assignments and investigations, and end-of-the-year examination.

5.2.3.1 A TERMINOLOGY CONUNDRUM: FORMAL AND FORMATIVE ASSESSMENTS

Each of the participating teachers often used the terms formal and formative assessment interchangeably during the semi-structured interviews. To equate formative assessments to formal assessments is of course problematic, as formal assessment should be used for promotion purposes, but formative assessments are used to aid the teaching and learning process. Formative assessment should not be used for promotion purposes. The formal assessments are thus summative assessments, as these are carried out after the completion of a mathematics topic or a cluster of related topics, and are concerned with the product of learning. I believe that the reason the participating teachers confused formal assessments with formative assessments is due to the term 'formal assessment' which they used in a different way to how the current curriculum defines it. It became clear that the participating teachers used the term "formal assessment" to indicate an assessment that is structured, and, hence, not "informal". Alpha and Lambda referred to formal assessments as formative assessments "to be written under test conditions", which refers to assessment of learning. Eta and Omega again used formal assessments to mean a structured formative assessment for learning. The

teachers were able to distinguish between the ideas of formative and summative assessments, but the distinction between formal and formative assessments were blurry at the best of times. It is, however, essential to note that I do not believe that the confusion between formal and formative assessment is simply about using the incorrect word. The participating teachers argued about the need for the marks of the formative assessments to be accurate and valid. Formative assessments, in this sense, fulfils the purpose of formal assessments. This culture of high marks representing proficiency is drawn into classroom-based assessments. This confirms that mark allocation of the formative classroom-based assessments is thus divorced from the qualitative indicators of developing mathematical proficiency. To further illustrate this, I will discuss the classroom-based assessment practices of each of the participating teachers.

5.2.3.2 THE CLASSROOM-BASED ASSESSMENT PRACTICES OF EACH OF THE PARTICIPATING TEACHERS.

By analysing the key points and main themes of the teachers' use and design of classroom-based assessments, four main types of designers and users of classroom-based assessments became apparent: the optimistic innovator, the "road less travelled" explorer, the cautious explorer, and the traditionalist.

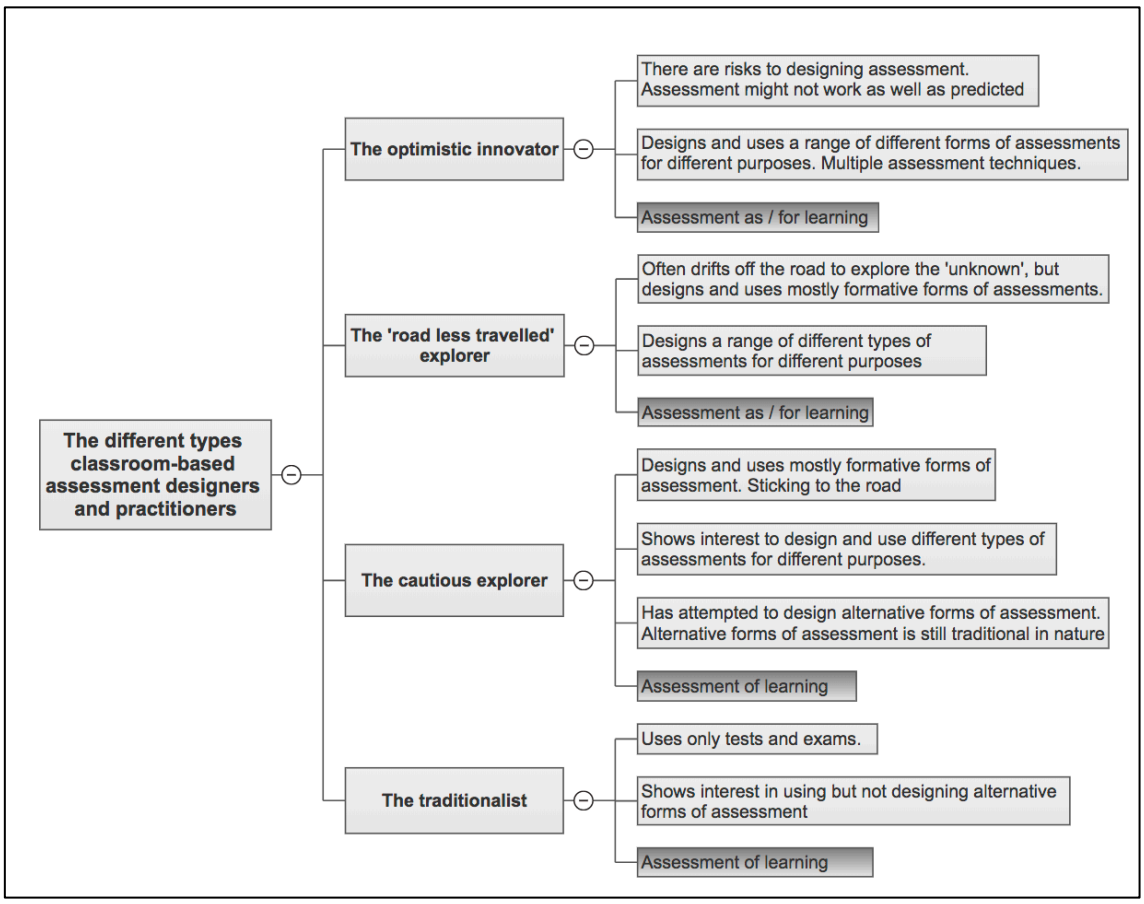

Figure 13: Four types of designers of classroom-based assessments

Figure 13 above illustrates the characteristics of each type of classroom-based assessment designers which were observed. The main distinctions between the four types of designers lie in the purpose of the assessments they design. The more conservative and traditional classroom-based assessment designers use formative classroom-based assessment for a

summative purpose of collecting marks from students. Here, the assessments form the function of "assessment of learning". The cautious explorer designs and then use the rigid formative classroom-based assessments to inform teaching and learning. The main distinction between the "cautious" explorer and the "road less travelled" explorer lies in the role of the student in the learning process. For the "cautious" designer, the purpose of the designed assessments is to inform the student of what the student can or cannot do, whereas the "road less travelled" designer sees the purpose of the designed assessments as an opportunity to inform, as well as an opportunity for the student to learn. Finally, the "optimistic innovator" has a more holistic and flexible view of the classroom-based assessment, where the purpose of the assessment is to enable students to be in charge of their own learning and to provide opportunities for students' skills to be extended. The main difference between the "optimistic innovator" and the "road less travelled explorer" lies in the risks involved in designing assessment. In this way, the "optimistic innovator" is less conservative of the alternative forms of assessments which are designed, and realises that some assessments might not work as well as they were intended to, but that this is acceptable, as learning is flexible.

Below, I provide brief background information of the data which I collected about the classroom-based assessment practices of each of the participating teachers.

ALPHA

Alpha is what I would describe as a "traditionalist" assessment designer and practitioner. He described his classroom assessment practice as "conventional", stating that he mainly makes use of formal class tests as classroom-based assessments. For Alpha, the types of assessments he uses are essential for "reflection on prior knowledge" (II-ALP1). During the observation of the participant's assessment practices, Alpha employed two types of assessments: formal class tests and small informal tests or quizzes. Alpha shows interest in using formative

"assessments for learning" assessments, but it seems that the jump is just too big, as he could not provide me with an example nor could he describe to me an investigation or project which he has used. Although it is encouraging that, despite Alpha's lack of mathematics training and experience teaching mathematics, he shows interest in using a wider range of assessments, I did not observe evidence of any form of informal or alternative classroom-based assessments. Alpha assess his students "on a monthly basis", and he feels that "once a month is more than adequate" to assess students.

Alpha noted that "if students have not met the minimum pass mark, second opportunities are afforded, then marked, and students receive the feedback" (II-ALP1). He describes the feedback as "the mark the student obtained" (II-ALP1). He explains that he is worried about the feedback which the students are receiving, as he is concerned that simply "illustrating to students how to solve the questions, which is only done after multiple opportunities are given" (II-ALP1) does not have the impact he wishes, because very little intervention takes place between him and the students after the first assessment, and before rewriting the assessment.

For Alpha, assessments do not seem to provide much of learning opportunity to the students. Alpha explained that he is not always sure before administering an assessment whether students will do well or not, especially if he structures questions in a different way. It is his experience that he can only know after the assessment has been written and "based on the scores of students, after affording multiple opportunities" (II-ALP1) if an assessment was at the right cognitive level, which confirms that he uses formative forms of assessments for summative purposes. He further commented that "if everyone passes the first time, then it is probably too easy", but that this "very seldom happens" (II-ALP1).

PHI

Phi's excitement and enthusiasm about using classroom-based assessment was refreshing, and I classified her as "the road less travelled" explorer assessment designer. She designed and used a variety of assessments for different purposes, which can be categorised as "assessment for learning" forms of assessments. She enthusiastically listed a variety of classroom-based assessment which she uses with her senior phase mathematics classes. She spoke about individual classwork activities, group work, and group activities which "assist students in learning new concepts" (II-PHI1). She was asked to provide an example of an assessment which she has used, and she explained an activity where students build platonic polyhedral, an activity which the students really enjoyed, saying: "They got so excited when they were able to make sense of the formula of getting faces and edges" (II-PHI1). She also explained that she uses informal assessment techniques to assess her students: "I often make use of cards in class. I ask students questions, and they show me their written solutions. They sometimes make their own cards with problems, but I battle with resources" (II-PHI1).

Phi was asked to describe which resources she is referring to, and she listed "materials, like cardboard, pens, and scissors" (II-PHI1). Phi further explained that it is important for the students to "feel that they are doing real-world mathematics" (II-PHI1). She noted that "we are doing mystery mathematics – by looking at fake murder in their communities and at home, they are discovering who committed the murder by solving a series of problems" (II-PHI1).

Phi beliefs classroom-based assessments should be used on a "day-by-day basis" (II-PHI1), but that "it will take up most of your teaching time" (II-PHI1) if the assessments are not planned and administered properly. For Phi, feedback is more essential than the assessment itself. When Phi was asked to describe the feedback that was given to the students, she mentioned: "discussions, marking their work, giving a group activity on

concepts that I see were not grasped well or not answered well" (II-PHI1). For her, it is important that "action" takes places after an assessment, stating that "some of the students want to rewrite the assessments without making any progress on their previous understanding" (II-PHI1). Phi observes student participation and work during lessons to know how her students are doing. She is of the opinion that she knows if students will achieve, by "looking at their work and [the students'] participation" (II-PHI1). She explained that it is important to know "at what level the students are working" (II-PHI1), as this needs to guide the teacher in designing assessments.

LAMBDA

Lambda, similarly to Alpha, is classified as a "traditionalist" assessment designer and practitioner. The classroom-based assessments that Lambda uses to assess his senior phase students are in the form of written tests, worksheets, and exercises from the textbook. He uses classroom-based assessments on a regular basis, at least once per term.

Lambda explained that he, as the head of the mathematics department, is charged with moderating the assessments his colleagues develop. He explained that his moderation function is mainly to ensure that the teachers in the mathematics department do the prescribed assessments and adhere to the assessment requirements. Lambda, as was the case with Alpha, explained that the feedback the students receive from him is in the form of marks per question, and a final mark for the assessment. Lambda commented that when students do not succeed in an assessment, do they give up in frustration. He then explained that students know before they write an assessment that they will be afforded the opportunity to rewrite an assessment if they underperform in the assessment. Although Lambda believes that this initiative helped immensely with students' confidence because "they feel good when they get it right the second time around" (II-LAM1), he noted that this does not work effectively for

all students: “It happens that students do not do well in the first round, because they know that they can rewrite it” (II-LAM1).

Lambda explained how he knows, before implementing a classroom-based assessment, if students will over- or under-perform in a classroom-based assessment, by gauging “if the test or assessment is focussing on the same skills as what I taught in class” (II-LAM1). He explains that, although he recognises that there is a danger of “teaching to the test”, if the questions are very different, then, of course, “the students do not do so well” (II-LAM1). He further explained that he knows if an assessment is too easy or too difficult by looking at the students’ marks, which further points to using assessments in the form of “assessment of learning”.

ETA

I classified Eta as a “cautious explorer” assessment designer and practitioner. Although he showed evidence of many of the creative tasks which he has used with his senior phase students, the tasks were classified as learning materials and not assessments, because the students’ responses were not collected, nor was feedback given to individual students. He mostly uses formative assessments in the form of “assessment of learning”, but what distinguishes the formative assessment he uses from those used by Alpha and Lambda is the feedback which the students receive: “Sometimes the students mark their work themselves, with guidance from me. Sometimes I mark the work myself and return it to the students a few days later” (II-ETA1). He provides his students with “written feedback on individual work” (II-ETA1). He also explained that “feedback is given to the whole group, often in the form of worked solutions and identifying common errors and confusion” (II-ETA1).

For Eta, the process of designing assessments is an essential learning opportunity for him. Although he believes that assessments should be reused, “I usually refine or adjust them

to reflect past experience in their use" (II-ETA1). He is of the belief that this iterative process of rethinking and redesigning results in higher quality instruments. He explained that he, together with his colleagues, develop completely new instruments a few times a year, by "incorporating things learned from the strengths and weaknesses of previously used instruments" (II-ETA1).

Eta explained that he uses regular small quizzes to assess mostly knowledge and application of routine procedures and some basic problem-solving. He further explained that other skills are assessed in longer tasks at the end of each semester: "These longer tasks assess a broad range of mathematical skills across a variety of cognitive levels" (II-ETA1). Eta commented that he did not have a fixed assessment schedule and explained: "I think a fixed schedule of classroom-based assessments could lead to them becoming a reluctantly anticipated chore" (II-ETA1). He noted that he assesses regularly enough to be able to assess student progress, at least once every two weeks.

Although Eta explained that he has become better at knowing how students will do in an assessment, he said: "I do not always get this right; in fact, I am quite frequently surprised when students find a particular task much easier or more difficult than I had thought they would" (II-ETA1). Eta further explained that it depends on which skills are being assessed: "Past assessments are often a valuable guide as to difficulty levels. I often get ideas for alternative formats from blogs and articles I read" (II-ETA1).

OMEGA

Omega was classified as the "optimistic innovator" assessment designer and practitioner. She explains that she collects data from all the "learning activities" (II-OME1) which she uses in lessons. A range of classroom-based assessments has been observed in Omega's lessons. She started the lesson with a five-minute "Plickers" activity on what was learned in the previous

lesson, and concluded both lessons with a three-minute "Kahoot" activity to "see how well [students] understand new concepts taught" (II-OME1). According to Omega, the forms of classroom-based assessment she uses in order from most to least are: (1) direct inquiry, which comprises of teacher questioning students; (2) marking of continuous practice, i.e. module questions; (3) proficiency tests where no mark is given; (4) online revision tests; (5) problem-solving exercises both in groups and individually; (6) class tests and revision tests which are often repeated; and (7) online quizzes such as "Plickers" and "Kahoot".

Omega believes that classroom-based assessment should be used frequently, "albeit not militantly" (II-OME1). She noted that

> "there is evidence that an assessment-driven approach does not necessarily contribute to more effective learning, but I believe the key is in variety and approaching assessment as pedagogy in itself. Since learning thrives on instant feedback, assessment should be integrated as a form of learning without the 'high stakes' element that often leads to anxiety and fear. So somewhat contradictory to my initial response, assessment can be used daily although not in a strictly formal manner" (II-OME1).

Omega noted that feedback is always given "after completion of an assessment" (II-OME1). She explained that "for formal assessments [tests], the memoranda are made available online for students' revision purposes. Once the student scripts are marked, they returned to the students, and I work through the entire paper with the students in order to allow them to complete their corrections on the paper" (II-OME1).

5.2.3.3 THE PARTICIPATING TEACHERS' CLASSROOM-BASED ASSESSMENT PRACTICES, AND THEIR BELIEFS ABOUT TEACHING AND LEARNING MATHEMATICS

Interviewing the teachers on their classroom-based assessment practices and having the opportunity to observe how they go about conducting their classroom-based assessments, gave me great insights into the practical dimension of conducting assessments. This was

important for me to experience and interrogate, as there is the danger of basing my own ideas and interpretation of their classroom-based practices from their beliefs about assessment, to separate the proverbial “talk-the-talk” from “walk-the-walk”.

The teachers employed very different classroom-based assessment practices. Designing alternative forms of classroom-based assessments, other than tests and examinations, was found to be uncommon. Most of the teachers were satisfied to re-use the same assessments year after year. When the teachers were asked how many alternative forms of classroom-based assessments they designed in the previous academic year, the total of new alternative forms of classroom-based assessments only added up to two. The use of alternative classroom-based assessment was also very low compared to the use of tests and examinations. It thus became clear that teachers were hesitant to use and design classroom-based assessments. I often asked myself during the interviews and observations, how could this be? What happened to their beliefs about mathematics learning and teaching, which I presented in 5.2.2? It was as if the participating teachers’ beliefs about mathematics teaching and learning, and their classroom-based assessments practices were out of sync.

It was difficult for me at first to understand why the participating teachers’ beliefs and assessment practices are not closely correlated. I was reminded that that teachers’ mathematical beliefs originated from their learning experiences in schools which eventually was reproduced in their classroom teaching and assessment practices (Handal, 2003). Handal further commented that teachers’ beliefs could be seen as a filter or a lens through which they make their decisions, rather than just relying on their pedagogical knowledge and curriculum guidelines. Teachers’ beliefs, then, are developed by acting on school conventions, including the learning experience the teacher experienced as a student, and the influences of the environment where the teachers teach (Pehkonen, 1994).

But this still does not explain the discrepancy. As referred to in the theoretical perspective chapters, teachers' beliefs are often inconsistent with their teaching practices. Reasons for this are various constraints, including time and resources, working conditions, and student behaviour (Phillip, 2007). It is also essential to keep in mind that teachers' belief systems are not simply "fixed" through a process of replacing certain beliefs with more desirable beliefs. Rather, teachers' beliefs must be challenged in such a way that desirable beliefs are seen by teachers as the most sensible beliefs which to cohere (Leatham, 2006). Research, yet again, suggests that beliefs drive classroom actions.

5.2.4 CONCLUSION

The background information gave us a better understanding of the experiences, assessment practices, and beliefs about teaching and learning mathematics of each of the participating teachers. The participating teachers' beliefs about teaching and learning mathematics did not link up with their classroom-based assessment practices. In the next section, I attempted to understand how the participating teachers justified and described their classroom-based assessment practices.

5.3 HOW DO SECONDARY SCHOOL MATHEMATICS TEACHERS DESCRIBE AND JUSTIFY THEIR CURRENT CLASSROOM-BASED ASSESSMENT PRACTICES.

5.3.1 INTRODUCTION

In the previous part of the chapter (5.2), the teachers were introduced, which has given us a better idea about the beliefs of each of the participating teachers concerning general aspects of mathematics teaching, learning, and assessment. The participating teachers' beliefs of teaching and learning mathematics were mapped against Kilpatrick's five proficiency strands. The background information further gave us a better understanding of each of the

participating teachers' experience, exposure, and confidence designing classroom-based assessments, as well as their classroom-based assessment practices. I found that the participating teachers' initial beliefs about teaching and learning mathematics did not link up with their classroom-based assessment practices. It was time to establish how the participating teachers describe and justify their current classroom-based assessment practices.

I believe that there is potential to link teachers' conceptions about assessment to their assessment practices. Remesal (2010) stated that an important amount of current research has been conducted around teachers' assessment practices, and even more specifically around grading practices, rather than on the beliefs that may ground these practices. Many of these studies (Harlen, 2005; Liu, 2008; Duncan et al., 2009; Leighton, Gokiert, Cor & Hefferman, 2010; Remesal, 2010) concluded that teachers' conceptions are one of the key factors which influence classroom decisions. A study by Griffiths, Gore, and Ladwig (2006) found that beliefs affect teaching and assessment practices to a greater degree than teaching experience and socioeconomic school context. My theoretical stance for focussing on the beliefs of each of the participating teachers is to support my argument that these beliefs greatly influence teachers' assessment practices, and that if teachers were expected to amend their assessment teaching and practices, such as the case with the implementation of the mathematics teaching and learning framework for South Africa (DBE, 2018), it is paramount to have a better understanding of their beliefs systems concerning assessment. These beliefs about assessment will affect how teachers interpret information about new approaches to assessment (Barnes, 2015). As long as teachers' beliefs are left aside, some superficial changes might take place, but the likelihood of profound long-lasting changes in classroom practices is rather small (Remesal, 2010).

As explained in the theoretical perspectives chapter, for the purpose of this study, the terms "belief" and "conception" are clearly differentiated. A person's conception can be described

as an organised system of beliefs that this person holds, whereas a person's belief refers to the basic statements about different aspects of reality that any person might take for being true at different times in the person's life, although these truths do not have to be an objective truth at all (Goodenough, 1990; Remesal, 2010). Beliefs do not remain unchangeable throughout life, are subject to influences from the social context of which the person participates in (Remesal, 2010), and are never held in total independence of other beliefs (Thompson, 1992). Conceptions act as a framework through which a teacher views, interprets, and interacts with his/her teaching environment (Marton, 1981; Brown, 2002).

5.3.2 TEACHERS' CONCEPTIONS OF ASSESSMENTS

Data was gathered from semi-structured individual and group interviews to understand how secondary school mathematics teachers justify and describe their assessment practices. It was important to establish the participating teachers' beliefs concerning classroom-based assessment before exploring teachers' current assessment practices. Semi-structured individual interviews were conducted with each of the participants to delve deeper into their conceptions of assessment. I had to get a better understanding of the participating teachers' beliefs of classroom-based assessments in mathematics education. Each of the teachers were asked what he/she thought the intended purpose of classroom-based assessments was and for whom he/she thought classroom-based assessments were most useful.

This study will attempt to understand the participating teachers' conceptions about assessment by using two conceptual frameworks. Firstly, I will use the three assertions of assessment by Delandshere & Jones (1999) which they used to identify and describe teachers' conceptions of assessment. The three assertions are: (a) teachers' beliefs about assessment are shaped by its defined functions and purposes; (b) teachers' beliefs about assessment are shaped by what they perceive as the official curriculum within the school

structure and where they position themselves regarding the subject matter; and (c) teachers' beliefs about assessment are shaped by how they understand learning and their students.

Secondly, I analysed the teachers' conceptions of assessment with the use of a model which consists of four continuums across two orientations, which was adapted from Remesal's (2011) four-dimensional bipolar model and Brown's (2002) four-dimensional model of trends of conceptions of assessment. The four continuums are: (1) assessment conceived as a tool for improvement of learning; (2) assessment conceived as a tool for improvement of teaching; (3) assessment driven by school and teacher accountability purposes; and (4) assessment driven by student accountability and certification purposes.

5.3.3 THREE ASSERTIONS OF ASSESSMENT

5.3.3.1 ASSERTION 1: TEACHERS' CONCEPTIONS ABOUT ASSESSMENT ARE SHAPED BY ITS DEFINED FUNCTIONS AND PURPOSES.

The participating teachers were asked what they thought the purpose of assessment is. From analysing their responses in the semi-structured interviews, I was able to described their use of assessment in terms of four main purposes: (1) to advance learning; (2) to advance teaching; (3) to monitor learning and certify students; and (4) to act as an accountability measure. Each of the participating teachers conveyed what he/she thought the function and purpose of assessment are.

(i) THE PURPOSE OF ASSESSMENT IS TO ADVANCE LEARNING AND TEACHING

Phi shared more extensively compared to the other participating teachers about the purpose of classroom-based assessments to advance learning. Phi believes that the "importance of classroom-based assessments should never be underestimated; it is when real learning takes

place" (PHI, GI-A2). She described a brilliant classroom-based assessment instrument as an instrument that will make students engaged, think critically, and which caters for weak students, and that classroom-based assessments should include class work, group activities, and small, informal tests. She believes that simply asking questions as you teach and let students write on "show-boards" are effective forms of classroom-based assessments, combined with very formal assessments, like formal tests. She explained that for some assessments the purpose of some assessments would be to "encourage real learning" (Phi, GI-A2), and for other assessments the purpose would be to gather information about how the students are progressing, which indicates that she does not conflate the purposes of assessment.

Similarly, Eta believes that classroom-based assessments should assess a broad variety of skills and competencies, depending on the particular assessment. He believes that classroom-based assessments can also be used to assess skills which are difficult or impossible to assess with formal examination-type assessments, such as problem-solving, mathematical modelling, and mathematical communication. He believes that effective classroom-based assessments should always be useful to the teacher and the student. The students' application of routine procedure must also be assessed, but other skills should be considered, too. He elaborated that confidence with routine procedures must be considered alongside problem-solving skills, in-depth mathematical understanding, and logical, mathematical thinking. It is clear that Eta believes that a purpose of assessment can be to strengthen students' routine procedures and problem-solving. Here, the purpose of assessment tilts more to advance learning and teaching, as opposed to monitoring.

Omega views assessment as just as important as instruction, and that learning cannot be completed with the absence thereof. Omega's beliefs correspond with the views of Even

(2005), in that the degree of integration of assessment with teaching, as well as the methods used for assessment, are related to the purpose of the assessment (Even, 2005).

Although all of the participating teachers had the view that the most important function and purpose of assessment is to advance teaching and learning, they often conflated these two purposes of assessment with the purpose of monitoring students' learning. Alpha often contradicted himself, by sharing views which equated "assessment for monitoring" and "assessment to advance learning".

On the one hand, he held the belief that assessment in mathematics must "include various informal assessment activities" (Alpha, GI-A2), which was interpreted as learning activities to advance learning. Alpha asked himself in the interview what he thought was more important: "if students are able to remember or if they understand?" (Alpha, GI-A2) He responded that "it is definitely more important that they [students] understand than just remembering, therefore this is what classroom assessments should focus on" (Alpha, GI-A2). On the other hand, he explained that the purpose of assessment is to "determine how much learning has taken place", as well as to determine if the "educator has been successful in teaching" (Alpha, GI-A2). These sentiments speak more to assessment serving the purpose to monitor teaching and learning, and less to advance learning and teaching. Although Alpha explained that the purpose and function of assessment is to advancing learning, it is clear that he is referring rather to the monitor learning. Alpha did not mention that a function of assessment is to provide descriptive feedback of how the student is progressing, rather "how much" was quantitively measuring the students' learning of applying their skills to assessments which consists of "questions and answers, spot testing, giving students short verbal questions to answer", as well as "assessing prior learning knowledge" (Alpha, GI-A2). Even (2005) explained that contemporary classroom-based assessments to advance students' learning and inform teachers to make teaching decisions must shift from the concentration on

summative assessment towards an emphasis on formative assessment. The use of assessment data to make teaching decisions, including adapting the pace of teaching, selecting resources, and challenging students' thinking, is aimed at advancing students' learning.

(ii) THE PURPOSE OF ASSESSMENT IS TO MONITOR STUDENTS' LEARNING AND FOR ACCOUNTABILITY PURPOSES

A belief of the purpose of assessments, which was expressed by three teachers, was around the purpose of assessment to monitor learning, which thus will inform teaching and learning. Eta is of the belief that classroom-based assessments are intended primarily to evaluate students' progress and to inform further teaching and learning. Similarly, Omega viewed the purposes of assessment as first to provide feedback to the student and teacher about what the student can or cannot do, which in turn directs the teaching of the teacher and learning of the student. She explains that assessment "fulfils the role of providing feedback to a student with regards to his/her progress and also aids in directing a student's learning by focussing their attention on the important aspects of the course material" (Omega, GI-B2). Lambda describes a classroom-based assessment as "less formal assessments that you can do with students. It happens in the classroom and is developed by the teacher to monitor progress in specific areas, sometimes in smaller content areas" (Lambda, GI-A2). For him, the intended purpose of all his classroom-based assessments is "if students are able to apply the content and knowledge. It must give everyone a clear idea about how the student is progressing" (Lambda, GI-A2).

There was also the belief that a purpose of assessment is to monitor student learning in order to motivate and force students to study. Lambda referred to the "wake-up call" (Lambda, GI-A2) assessments "must give students when they are doing badly to put more into their studies" (Lambda, GI-A2). Lambda was asked if he feels that this strategy is

successful to motivate students to work more effectively if they under-achieve. He responded that this is very seldom the case and revealed that this "does not work for most students; most the time it is a battle to prevent students from turning their backs on their academics". According to him, the students "don't play their part" (Lambda, GI-A2). He went on to explain that "one would think that once you failed an assessment, it will motivate you, encourage you to learn the work, to do better in the next assessment, but this is not the case for the majority of students" (Lambda, GI-A2). He described a brilliant classroom-based assessment instrument as "an assessment that accurately reports on a student's understanding of the content and provides ample opportunity for a student to engage, develop, and ultimately master the skills and required knowledge" (Lambda, GI-A2). He feels that he needs to be more "mindful [of] making teaching and assessment relevant to students" (Lambda, GI-A2).

The teachers' beliefs of the purpose of classroom assessments supports the findings of Shepard (2008) that the teachers often confuse the purpose of classroom-based assessments, as the purpose of developing and conducting classroom-based assessments is to help students learn and to improve teaching rather than to rank students or to be used as an administrative tool. Shepard explained that in classrooms where participation in learning is motivated by its use and value, students and teachers understand that they are working together to find out what makes sense and what does not. To serve this, classroom-based assessment requires that expectations and intermediate steps for improvement be made visible for students. Shepard noted that a classroom-based assessment should formative in nature, aimed more at helping students take the next steps in learning than at judging the endpoints of achievement, and should be used only for the purpose it was designed to achieve. Classroom-based assessments should operate independently from large-scale external assessments. The purpose of

classroom-based assessment is not primarily to certify student proficiency levels at a fixed point with precision, but rather to generate hypotheses and guide intervention.

Other beliefs of the purposes of assessments included placing students into ability groups and preparing students for high-stakes externally set assessments. Omega believes that the main purpose of assessment is often to stratify students in logical and abstract thinking ability. Here, the "stratifying" was less to group students into homogeneous ability classes, but to group students in the same class in lessons into "confidence groups" in order to "differentiate assessment and instruction" (Omega, GI-B2). I will focus more on what the teachers shared about preparing students for high-stakes externally set assessments in the next section when I can interpret it by the four-continuum model of conceptions.

5.3.3.2 ASSERTION 2: TEACHERS' BELIEFS ABOUT ASSESSMENT ARE SHAPED BY WHAT THEY PERCEIVE AS THE OFFICIAL CURRICULUM WITHIN THE SCHOOL STRUCTURE AND WHERE THEY POSITION THEMSELVES TO THE SUBJECT MATTER

During the first semi-structured group interview at School A, I got the impression from the teachers that they had mixed views of the current South African mathematics curriculum. Whenever the teachers made comments about specific aspects of the curriculum during the first few interviews, I made a note to refer back to it when it was time to discuss the curriculum. I will start by analysing the participating teachers' views and experiences of the curriculum. Although the participating teachers made extensive reference to the effect of the current South African curriculum on students, I decided to separate their beliefs of students and learning from their views of the curriculum, as the teachers' views of the students they teach form part of the third dimension. I then will focus on the teachers' beliefs of the goals and aims of the curriculum.

5.3.3.2.1 THE TEACHERS' VIEWS AND EXPERIENCES OF THE CURRICULUM

Although the teachers from the two schools in the study were teaching in vastly different conditions, the teachers of both schools had very mixed, mostly negative, feelings on the current curriculum. I was surprised at the extent of their negative feelings towards curriculum. I grouped the data gathered from the individual and group interviews in three main themes: (1) the curriculum is messy, overloaded, and disjointed; (2) time and administrative demands of the curriculum; (3) accountability and authority. Below, I discuss each of the themes to encapsulate the teachers' feelings and experiences of the curriculum.

(i) A MESSY, OVERLOADED, AND DISJOINTED CURRICULUM

Every one of the participating teachers talked extensively to the overloaded curriculum. During the interviews, this was by far the biggest talking point which sparked emotions.

> Alpha gave a personal account of the effect of the overloaded curriculum:
>
> "I use my youngest daughter as an example: she never used to go to bed earlier than 23:00, every single day of the week. When she was in Grade 8, she would come home, she would rest for half an hour, and she will be busy with schoolwork every day. She never enjoyed school, and I blame this on the curriculum, because she never enjoyed what you would except a normal child to enjoy" (Alpha, GI-A2).

He commented several times that the entire curriculum is overloaded and that the curriculum demands are unreasonable both for students and teachers.

Phi feels that "the syllabus is too broad" (Phi, GI-A2). She went on to explain that "we just touch base, explore the basics on some concepts and we do not go deeper. I think it is better for it [the syllabus] to be narrow, and then you go deep" (Phi, GI-A2). Phi stated that the "wide and shallow syllabus" has a very negative effect, in that, "in the end, learners get confused" (Phi, GI-A2). She compared the South African syllabus to the Cambridge system which the Zimbabwean Education Department follows. She described the Zimbabwean

syllabus as "rigorous but manageable" because "it's narrow and deep" (Phi, GI-A2). She explained that in the Zimbabwean system "you would go deep into a concept, but here [CAPS] you just touch base and then learners get confused and get lost" (Phi, GI-A2).

Eta described the curriculum as "messy and disjointed". For him, the curriculum feels strange, when he considers the mathematics which is emphasised:

> "There are things that don't link together. There are obvious extensions that haven't been done. There are areas where you think that this is a weird place to stop, like with calculus, we have done so little calculus you think what the use you have done any, as it doesn't really lead anywhere, but then we spend a large chunk on probability and financial mathematics. It feels odd and bitty" (Eta, GI-B2).

Omega is of the view that the curriculum is too rigid and far too full of detailed prescribed content, rather than intent. She feels that teachers are told what to teach but they are not told about the purpose or the intent. Omega does not think that "mathematics teachers have a clear idea about why we are doing this [section] and why we are doing that. I feel there is very little intention. It is more a case of just jumping through the following one thousand hoops if you want to make it" (Omega, GI-B2).

(ii) DEMANDS CONCERNING TIME AND ADMINISTRATION

The teachers did not censor themselves when it came to sharing their feelings about the curriculum. I was shocked by the level of the teachers' negative feelings about the curriculum. The teachers at School A felt substantially more strongly about what they perceive as the negative effects of the curriculum – time constraints, administration, and high workload – compared to the teachers at School B.

According to Alpha, the majority of teachers he has spoken to have very negative views about CAPS. He explained that "in the majority of our schools throughout the country, you can walk into any school […] please invite me when you hear from a teacher that CAPS is fine" (Alpha, GI-A2). He shared that he and his management need to spend an "enormous

amount of time" (Alpha, GI-A2) with the teachers at their school so that the teachers can embrace CAPS and feel positive about it. He added that teachers "battle, they are not coping" with the demands and that they are not "devoted" to and "invested" (Alpha, GI-A2) in the current South African curriculum. Alpha believed that teachers would need to be given adequate time to design and to think about assessments: "CAPS robs you of that, to think creatively. What you do is just grab hold of an assessment, because you are supposed to have an assessment due next week so that you are not falling behind, so the space for your creativity is missing" (Alpha, GI-A2).

Alpha's comments point to time-constraints and pressures which the teachers face. Most of the teachers referred to how difficult it is to teach all the concepts, because of the content-heavy curriculum. Lambda explained that lessons are filled with covering the required and stipulated content, which means there is no space for creativity. Phi explained that the curriculum "tells you in week one you should do this, week two this […] not taking into consideration the fact that my learners didn't comprehend last week's work, so I am still teaching last week's work, and this week I am supposed to start a new concept – it doesn't cater for that" (Phi, GI-A2).

The second theme was the high workload and administration which accompany CAPS. Phi was the most vocal about sharing her frustration with the high workload and amount of administration she has to do. She explained that

> "in Zimbabwe, we had very little admin to do. We had more time to focus on lessons. We could focus on the syllabus. The maths department of each school drafts a school syllabus on what they could cover each term. There were much fewer topics, but we explored the topics much deeper. Not like here, where it is so wide and shallow" (Phi, GI-A2).

Alpha further explained that teachers spend abominable amounts of time filling in forms, preparing for inspections, and doing lesson plans, and not enough time on the preparation of lessons.

(iii) ACCOUNTABILITY AND AUTHORITY

The third theme that arose was about the current South African curriculum (CAPS) monitoring teachers and students. The matter of accountability also emerged as a third purpose for conduction of classroom-based assessments in section 5.3.1. Alpha is of the view that CAPS exists "to keep us as teachers in check" and to ensure that "teachers do what they are told to do" (Alpha, GI-A2). Lambda felt that CAPS reduces teachers' "authority" by micro-managing teachers and "stipulating" (Lambda, GI-A2) what should be taught in every lesson. For Alpha, the curriculum is a "teaching bible" that "instructs you [on] what to do and what not to do" (Alpha, GI-A2). Eta and Omega shared that the teachers in the mathematics department, and across disciplines, meet regularly to "rethink and re-imagine how they taught" (Eta, GI-B2). At School B, the school decided that bi-weekly tests needed to be written. While Omega bemoaned the pressure she faces to be "on-top of my game in teaching mathematics" (Omega, GI-B2), Phi shared her frustration with being "mandated to implement an initiative" (Phi, GI-A2) that she does not believe will make a significant impact.

Lambda was the first teacher to refer to the lies the curriculum tells students. Alpha explained that there are two main lies that the curriculum tells the students: the first is that everyone must be academic and go to university; and the second lie is that you will succeed in life if you do well in school. For Lambda, it is a constant battle to motivate students for them to understand that it is not only important to get a Grade 12 certificate, but also to get good marks:

> "It is difficult, because you know at best some of them will get the lowest form of a pass and that there is not even a chance they will be allowed to study further. Their future prospects are bleak. Some of the students come from households where one or both parents didn't attend school. Then there are those students who did get a good, decent matric but do not have work. What is the motivation for them?" (Lambda, GI-A2).

Phi added that the students are benchmarking far from what is required in secondary school, because of various reasons. She exclaimed that only a handful of learners are on track and might go to university, but that 95% will get a minimum pass with which they cannot do anything. These students have been to school for at least twelve years, and after grade 12 they have nothing to show.

In the 2017 Africa survey, the Institute of Race Relations (IRR, 2017) found that only 43,3% of South African of working age are employed. The study also found that the biggest predictor of successful employment depends on the person's level of education. The percentage of South Africans who are employed with tertiary education is 75,6%, compared to a dismal 50,3% of people who are employed with matric as their highest level of education. The study further found that of the 9,3 million unemployed people in South Africa, there are 6 million people between the ages of 18 and 35, which is almost 65% of all unemployed people, who are seeking employment. By considering the data, we have a better understanding of the stances of Phi, Alpha, and Lambda concerning the curriculum and the illusion it creates that meeting the minimum requirements will be enough. This again raised further questions of why the teachers advocate the minimum requirements if it these are not sufficient to secure tertiary studies or to guarantee employment after school. Alpha responded that the students' satisfaction with meeting the minimum requirements is a complex and endemic problem.

5.3.3.2.2 THE TEACHERS' BELIEFS OF THE INTENDED GOALS AND AIMS OF THE SOUTH AFRICAN CURRICULUM

The analysis of the participating teachers' understanding of the intended goals and aims of the current South African curriculum will position them to the subject matter. The teachers were asked what they thought the intended goals and aims are of mathematics teaching and

learning in CAPS. It became evident that none of the teachers had the faintest clue what the specific goals and aims were of CAPS. The teachers' views of the curriculum were defined largely by textbook resources, what is expected from learners to perform well in the grade 9 and grade 12 final assessments, and by studying past externally set assessments.

According to Alpha, the intended goal of the mathematics curriculum is to ensure that teachers teach the "appropriate mathematical content" and to "specify" how teaching is to take place, but felt that "what was intended is far from what is happening" (Alpha, GI-A2). Phi believes the intended goals of the curriculum are to keep track of what the teachers are doing in class, because of the pacesetters.

For Lambda, the intended goal of the curriculum is to channel students into the relevant career options and to prepare the students for tertiary studies. Lambda believes the curriculum prepares students for a career in a mathematical field. He added that the curriculum determines if students are able to study mathematics at a tertiary level. Lambda frequently shared that he believes that mathematics must provide the student with the tools to solve problems they will encounter after school. This, for Lambda, was the most important goal of the curriculum, yet he explained that the intended aim of curriculum is to ensure that students understand and apply the mathematical concepts, but that he believes the Department of Education wanted a total "top-down system" in which they could control what is happening in every classroom (Lambda, GI-A2).

Eta shared that there is a huge difference between intention and the actual outcome. He is of the opinion that one of the intentions of the curriculum is that every student should do mathematics, a goal which he thinks is creating enormous issues: "This leads to lowering of standards where you create a situation where you need to address the numeracy goal, problem-solving skills and to produce mathematicians, to prepare students for tertiary study. It is trying to cater for all and this is creating immense conflict" (Eta, GI-B2). For Eta, a

specific aim of the curriculum must be to develop those difficult skills, like reducing a problem to a previously solved problem.

According to Omega, the specific goals and aims of the curriculum are "muddled". She described a big difference between what the Education Department says the goals are and what they actually are: "We are not intentional about where we are going in mathematics. I think if we were intentional we would develop those flexible students" (Omega, GI-B2). She does not believe that it is the role of school education to prepare students for first-year mathematics fully: "Our role is much bigger than that" (Omega, GI-B2). I was surprised that, even for Omega, who is an experienced teacher, the specific goals and aims of the curriculum were "muddled". By looking back at her responses in the first two sections of the chapter, she should have been able to articulate the goals and aims of the curriculum.

Each teacher was given a copy of the specific goals and specific skills of the curriculum. I then asked each teacher to respond to the specific goals and specific skills of CAPS relating to mathematics. Phi's response captures sentiments shared by the other participants. Phi responded that she is very surprised that we do not follow the specific goals and skills of CAPS. She is of the opinion that very few teachers teach to these goals and skills: "This is what the government tells us to do, but this is not in the assessments, so why should we assess this way. I understand that one cannot really assess the specific aims of curriculum, that it actually falls under the productive disposition strand which you talked about" (Phi, GI-A2) She went on to state that things like points 2, 3, 4, and 5 of the specific skills should be the focus of teaching, more specifically; that "this is what we should assess and focus on, but we don't. We don't do any of this. This is a big disjoint – it is a lie" (Phi, GI-A2).

5.3.3.2.3 CONCLUSION

The teachers had very negative feelings about the curriculum and Assessment Policy Statement in individual and group interviews. The feeling of a messy, disjointed, and overloaded curriculum resonated with all the teachers. The teachers began talking about the wide and shallow curriculum where, according to two teachers (Eta and Omega), the most obvious extensions were missing. There was a big contrast in the responses from the teachers in the two different schools when it came to the demands of the curriculum. For the teachers in School A, students are battling to meet the demands of the curriculum. The teachers at school B wanted greater authority as professionals, and for students to be pushed more and held to a higher standard. The challenge and complexities of language and the students' socio-economic conditions were discussed and debated by the teachers at School A. The controversial statement by these teachers that "the curriculum treats all students as if they are the same" was a way for the teachers make me aware that the students have been behind the curve, in most subjects but most notably in mathematics and English, since the beginning and that they have been treated unfairly. The same teachers expressed their dissatisfaction and frustration with the mathematics curriculum's time constraints, and although the high administration demands were mentioned, it was considered as a minor cause of frustration by the teachers. They talked about the lies, such as that students need to be academic and get their grade 12 school-leaving certificate to succeed, which is what the curriculum tells students. Many of the teachers felt that school mathematics does not prepare and equip students for "the real world".

The teachers were asked what they thought the intended goals and aims of the curriculum were and to discuss the specific goals and skills of the curriculum. None of the teachers was cognisant of the goals, aims, or specific skills, and expressed being surprised by

the curriculum's goals, aims and specific skills. The five strands of mathematical proficiency were introduced to teachers for the first time towards the end of the second semi-structured group interview.

In reviewing the literature in Chapter 3, I included Shepard's (2010) learning culture. I want to home in on two of the principles of curriculum theories. Firstly, the transmission model of learning, which was based on rote memorisation of isolated facts, removed learning from contexts which could provide both meaning and application. Shepard warned of the dangers when watering down curricula and emphasising minimum competencies where schools have lowered expectations and limited opportunities to learn. Shepard noted that if students are presented with more challenging and complex problems and given the support to solve them, students will develop deeper understandings of the concepts and at the same time become more proficient at problem-solving and reasoning, which will help them solve unknown, unseen problems in the future.

Secondly, Shepard (2010) explained that, when classroom practices assist students in developing higher-order thinking skills and good habits of thinking, they will know how to tackle problems, ask and persist in trying, use prior knowledge, strive for in-depth understanding, and communicate their ideas. Shepard noted that the goal is not to motivate students to work hard on challenging problems but to ensure that they develop identities of capable students.

I found, similar to the findings of Sullivan, Clarke, Clarke, Farrell and Gerrard (2012), that teachers use and apply the curriculum documents in different ways, depending on their immediate local circumstances, the social, political and cultural contexts in which they are operating, the material resources available to them, and the pragmatic constraints and opportunities of their work settings, among many factors. Choppin (2009) and Sullivan et al. (2012) noted that there is an increasing need within the mathematics community to consider

teachers' curriculum knowledge, but that there is a gap in the research on the teachers' curriculum knowledge. Sullivan et al. (2012) noted that the ways in which teachers come to enact curricular knowledge in their planning and development of assessments are both an individual process influenced by teachers' beliefs and understandings of teaching and learning (Drake and Sherin, 2006), and highly dependent on schooling context. Silver & Stein (1996) reported that the teacher's planning of assessments and instructional tasks is influenced by the teacher's goals, curriculum knowledge, subject matter knowledge, and knowledge of students. Sullivan et al. (2012) describes influences on teachers' knowledge and practice, and especially on the ways in which teachers interpret and implement curriculum documents. The knowledge of the subject, combined with an in-depth curriculum, informs planning and the designing of classroom activities, including classroom-based assessments. How teachers come to enact curricular knowledge in their planning and designing of assessments is both an individual process influenced by teachers' beliefs of teaching and learning (Drake and Sherin, 2006; Chan and Wong, 2014), and highly dependent on school contexts. The power struggle between the teachers' knowledge and beliefs with the constraints and opportunities has a direct impact on knowledge development, planning, and the designing of assessments which dramatically influences students' learning.

5.3.3.3 ASSERTION 3: TEACHERS' BELIEFS ABOUT ASSESSMENT ARE SHAPED BY HOW THEY UNDERSTAND LEARNING AND THEIR STUDENTS

It became clear from analysing the semi-structured interviews that there was evidence that some of the participating teachers viewed students' learning as resulting from a fixed level of ability, and that the students' ability to perform is restricted by their socio-economic backgrounds. The participating teachers at School A referred to "our type of students" nine times in the first group interview. When I asked one of the teachers to explain what was

meant by "our type of students", Alpha interjected. The following is an extract where Alpha addressed the participating teachers during the first semi-structured interview at School A:

> "I want to caution you, colleagues, it is no disrespect intended, when we talk about our students or when we say our type of students, what we were actually implying is that they are of a lesser lower calibre [sic]. If we want to help our students, we must first see all people as equal in this forum or in any forum, because indirectly we are stigmatising. Be careful of creating a situation for them and us. What I am saying is, we must stop saying "this student" or "these students of ours" or "our type of students" because they are just students. Colleagues, just on the point of caution, be conscious about it. Often you don't hear it, and it is normal, and you become used to saying that and the kids hear you saying that, then the kids tell the teachers they are stigmatising us [sic]" (Alpha, GI-A2).

This view of students, and hence the conception that learning results from a fixed level of ability, seemed to be validated by presumptions based on teachers' knowledge of students' social origins. The participating teachers at School A shared their experiences of teaching students who have been pushed through every year, but who are still lacking the same skills they lacked three years ago. Lambda exclaimed that the "system treats all the students the same, regardless of their background" (Lambda, GI-A2). Lambda also felt that the curriculum's "one size fits all" demands are unfair for most of the students: "It is as if the curriculum pressurises students to fall off the wagon, to get lost along the way" (Lambda, GI-A2). The teachers freely shared their views about the unequal education system that exists where the curriculum assumes equality and fair playing grounds for all.

Although it was encouraging to see that the participating teachers cared about the well-being of their students, the teachers' conception that learning results from a fixed level of ability, and is limited by the socio-economic background of the student, appeared to prevent the teachers from considering assessment as an investigative tool which they could use to learn about students' learning, and to inform their teaching. According to Alpha, one of the biggest reasons why students battle to meet the demands of the curriculum is that the

students' socio-economic conditions have a direct impact on their performance. He explained:

> "it is not that they want to study in the afternoons – there is no space for them to learn and work at home[…] Remember that they come from homes where you might not even have your own bed, not even to mention having the luxury of a study-space[….] Curriculum developers didn't take into account that the majority of students come from difficult circumstances, that they have been behind the curve since the beginning" (Alpha, GI, A2).

The teachers explained how frustrating it is that the students have approached their learning with a "meeting-the-minimum-requirement mentality". Lambda explained that the students are fully aware of the minimum requirements which they need to meet, and they know that they are only required to pass. When I asked the participating teachers why so many of the students were content with meeting the minimum requirements, it was Alpha who claimed that "the students most likely pick up this notion from the teachers" (Alpha, GI-A2). The teachers' perceptions of students' socioeconomic conditions defined the learning expectations they had for them. I was reminded that when teachers assess students' levels of mathematical proficiency, they rely on: (1) their personal knowledge of mathematics and the curriculum; (2) their beliefs about the learning of mathematics based on their own mathematics history; (3) their expectations on how mathematical knowledge can be communicated; and (4) their expectations of their students (Morgan and Watson, 2002). Ponton (2005) found that when teachers believed in the abilities of the students, the students believed in themselves, and as a result performed better than students where the teachers doubt students' abilities. Clearly, the teachers had relatively low expectations of their students.

Apart from the students having a "meeting-the-minimum-requirement mentality", the participating teachers at both schools also talked about the students fearing failure and having negative feelings towards assessment. What distinguished Alpha, Phi and Lambda, from Eta and Omega was their beliefs surrounding the purposes of their classroom-based assessments.

Neither Alpha, Phi, nor Lambda considered assessment as a process that informs their teaching to the benefit of the student. Rather, these teachers considered assessment as a summative judgement of what the students know and what they can do or cannot do. Alpha shared his deep concern for what he labelled as a "fear of failure that exists among the students" (Alpha, GI-A2). He explained that "many students have a fear of getting something wrong. So they will not say or try anything. Saying nothing for some of them is better than trying something and getting it wrong" (Alpha, GI-A2).

Alpha's sentiments were echoed by Phi and Lambda. The relationship between how they taught and how students learn was not strong nor considered. It was expected that Alpha and Lambda would have had these conceptions if one considers their beliefs about teaching and learning mathematics. They were both classified as "traditionalist" designers and users of classroom-based assessment. I was surprised by Phi's views on this, especially because she was classified as a "road less travelled" designer and user of classroom-based assessments who designed and used classroom-based assessments for different purposes. It was clear that her views and conceptions of the ability of the students she teaches had a significant effect on her conceptions of assessment.

The conversations of Alpha, Lambda and Phi revealed general concepts of ability and motivation, with few references to how these applied specifically to mathematics learning. For these three teachers, their main focus was on their students' well-being, their motivation, and participation, and their sense of success. They placed emphasis on the students' socio-economic background, which they perceive as impacting the students' abilities, on their fear of failure to meet the minimum requirements. These factors were considered almost separately of their learning, which speaks to the tensions and contradictions in the beliefs that these teachers held with regard to learning and their students. On the one hand, the teachers' major concern was the welfare, confidence and success of their students. On the other hand,

they believed that some of their students were not developing or could not develop fully the expected levels of understanding. The teachers placed emphasis on making mathematics fun ("assessment brings negative attitudes in students if you only give written formal tasks, but positive when students use different fun activities" [Phi]); on effort, participation and procedural aspects of learning ("they are all able to master the skill if they apply their minds […] work hard [but the students] just give up" [Alpha]) ; and of student students' performance ("to prepare students for tests and exams" [Lambda]), as indicators of learning. These considerations were often made at the exclusion of content considerations. This is in stark contrast to the conceptions of Eta and Omega, who talked about the importance of assessment for students to "develop grit" (Omega). Both Eta and Omega believe it is the student who should learn to take pride in achievements and develop "grit" from failures. Eta beliefs that it is important for students to understand that "failure is part of life; what is more important is what you do when you are down" (Eta, GI-B2). He believes mathematics studies is instrumental in developing these characteristics. For Omega, "assessment informs students on their progress and understanding of the different problems set in assessments. Should assessments not be balanced and unnecessarily difficult, it may be very demotivating and detrimental to a student's perception and attitude towards mathematics" (Omega, GI-B2). She further commented that if an assessment is focussed and differentiated and offers a student the opportunity to demonstrate success, it could be conducive to effective learning and motivate a student to improve and excel.

There also seems to be a view among the participating teachers that learning is a mysterious process that they cannot always influence, which is consistent with the findings of Eishenhart, Shrum, Harding & Cuthbert (1998) and Delandshere & Jones (1999). Additionally, the teachers often struggle to help those students with impaired language skills. Alpha felt that some students do not struggle with mathematics, but with the language of

mathematics. He explained that many of the students do not have a solid home language; therefore they do not put meaning to words and do not comprehend the problems. Phi further commented that learners' challenges with language "restrict" how she assesses because the students do not understand the instructions. The teachers from School B hardly mentioned language as a hurdle, which speaks to the fact that these two groups of teachers were from two extremes.

Mathematics education begins in language; moreover, it advances and stumbles because of language, and its outcomes are often assessed in language (Durkin, 1991). In a study on the influence of second-language teaching and learning on mathematics performance in South Africa, Gerber (2005) explains that mastering mathematics is often considered to be a two-step process: firstly, the student has to understand the mathematical concepts as verbally explained by the teacher; secondly, the student has to be able to communicate these concepts in written format and make connections between the concepts, either by reading or writing mathematics. Gerber explains that, in the first step, the teacher clarifies concepts by essentially using two distinct verbal languages: a commonly spoken, everyday language and a subject-specific, scientific language. It is of crucial importance that a student is proficient in both languages, since underlying mathematical concepts are often first conveyed and clarified using spoken examples. He further explains that, in the second step, the mode of communication also helps the student in acquiring an in-depth understanding of abstract concepts since it gives yet another explanation of mathematical concepts. Gerber states that mastering mathematics relies heavily on two aspects of language: (1) effective verbal communication of abstract concepts; and (2) the students' ability to understand and communicate the concepts when translated into written mathematics. In the South African context, linguistic diversity is a complex issue. In the Western Cape, English is only spoken

at home by 17,1% of the youth, compared to just 5,4% in the rest of South Africa. The teachers' concerns about the students' difficulty in applying their language skills to mathematics, by looking at findings from other studies, is thus justified.

Even though the language barrier of the students must be acknowledged, the assessment practices of the participating teachers was limited to evaluative judgements about what students could and could not do, which resulted in little information for understanding how and why students learn. Such understanding is necessary and essential if one is to promote the curriculum reforms, such as the Mathematics Teaching and Learning Framework: Teaching for Conceptual Understanding. The ideas of Alpha, Phi, and Lambda about learning mathematics seemed uncertain, and mostly were anchored in general notions of motivation ("force students to study" – Lambda) and social expectation ("developing sound working habits" – Phi), but with very little insight into how these factors play out in the context of mathematics.

5.3.4 ANALYSING THE TEACHERS' CONCEPTIONS OF ASSESSMENT BY USING A FOUR CONTINUUM MODEL OF TEACHERS' CONCEPTIONS OF ASSESSMENT

It became clear from listening to, and analysing the transcripts, of the semi-structured interviews of each of the participating teachers that their experiences and views of assessment were incongruous. For example, even though each of the participating teachers referred, directly or indirectly, to the accountability purpose which assessment provides, their understanding and beliefs around the specific aspects of the accountability purposes of assessments were incompatible and divergent. I believe that the reasons why the teachers' conceptions about assessment differed so much centres on two conceptions of assessment, which I originally described and labelled as "learning orientated" versus "marks orientated and control". I was desperate to get a better understanding of the general beliefs that the

teachers built over time concerning assessment. School culture (Peterson and Deal, 1998), which refers to the underground system of norms, values, beliefs, traditions, and rituals that people have built up over time, seemed to be the appropriate context in which to search for a better understanding of these two phenomena.

A study by Remesal (2011) on primary and secondary teachers' conceptions of assessment refers to these two opposing poles, which I originally described as "learning orientated" and "marks orientated and control", as "the pedagogical-regulation pole" and "the societal-accreditation pole". As I referred to in the theoretical framework, assessment fulfils at least two basic functions: a pedagogical function and a societal function (Coll, Barberà & Onrubia, 2000; Stiggins, 2005; Remesal, 2011). The pedagogical function sees assessment as a device capable of promoting reflection and change in education by monitoring both learning and teaching. The societal function of assessment sees assessment as a tool for accreditation and certification of different audiences in society, such as the Department of Basic Education and families. It serves for teacher professional accountability, as well as the accountability of student achievement (Remesal, 2011).

For the purpose of this study, I have adapted the four-dimensional bipolar model of Remesal (2011) with changes made in two areas. Firstly, I broadened the scope of the pedagogical-regulation pole and societal-accreditation pole to include the contributions on conceptions of assessment which were made by Wolf, Bixby, Glenn, and Gardner (1991) who distinguished between the opposite orientations in the continuums as the "assessment culture" and the "testing culture". The two opposing orientations, therefore, were labelled as the "pedagogical assessment culture" and the "societal testing culture". Secondly, the dimensions of Brown's (2002) four-dimensional model of four key trends in New Zeeland teachers' conceptions of assessment were aligned to Remesal's (2011) model to be more precise about the specific dimensions. One of Brown's dimensions sees assessment as a tool

for improvement of learning and teaching. I, however, similar to Remesal's model, distinguished between assessment for learning and assessment for teaching.

I analysed the teachers' conceptions of assessment by using a model adapted from Remesal's (2011) four-dimensional bipolar model and Brown's (2002) four-dimensional model of trends of conceptions of assessment. The model, as illustrated in figure 14, included two opposing orientations: "pedagogical conceptions of assessment aligned to an assessment culture" and "societal conceptions of assessment which leads to a testing culture". The four continuums are: (1) assessment conceived as a tool for improvement of learning; (2) assessment conceived as a tool for improvement of teaching; (3) assessment driven by school and teacher accountability purposes; and (4) assessment driven by student accountability and certification purposes. I used the codes (see table 6) to locate and analyse the participants' beliefs in each of the four continuums.

Although it is important to note that all four of the beliefs systems, which are represented as continuums, emerged from analysing the semi-structured interviews of the teachers, my purpose was not to verify the models of Remesal and Brown, such as the studies by Datnow and Hubbart (2016), but to use the adaptive model of conception of assessment to interpret and analyse the participating teachers' conceptions of assessment. The emphasis was on interpreting the participating teachers' conceptions of assessment by locating these conceptions in one of the two orientations.

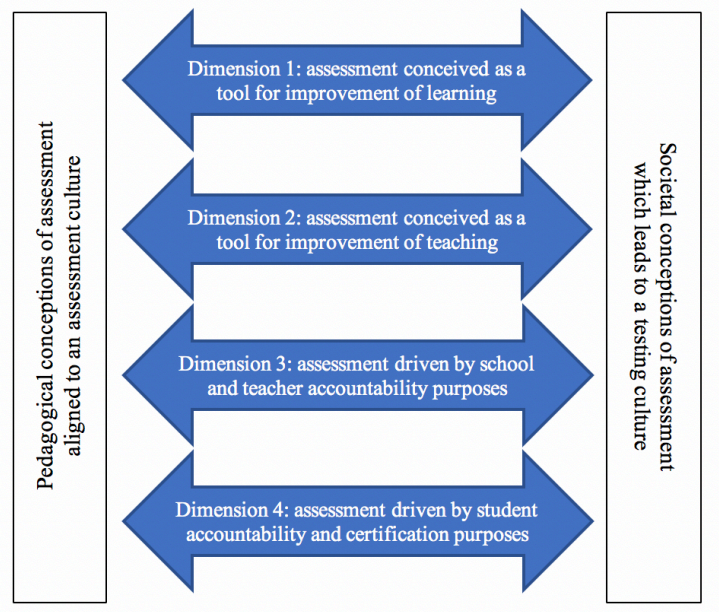

Figure 14: A four-continuum model across societal and pedagogical orientations, to frame the participating teachers' conceptions of assessment.

I presented instances of beliefs expressed by the participating teachers in each of the four continuums. I firstly located the teachers' beliefs in one of the four different continuums (assessment conceived as a tool for improvement of learning and/or teaching; assessment driven by school and teacher accountability purposes; assessment driven by student accountability and certification purposes). I then located each of these beliefs in each of the continuums as a pure pedagogical-assessment culture conception or a pure societal-testing culture conception. Table 8 illustrates examples of the teachers' conceptions of assessment categorised in each of the four continuums across the two orientations.

In interpreting the data gathered from the semi-structured interviews by lensing it through the four-continuum across two orientations model of conceptions of assessment, it is clear that extreme pedagogical and societal conceptions of assessment were held by the teachers.

Table 8: Examples of teachers' conceptions of assessment in four continuums across societal and pedagogical orientations

	Pedagogical–assessment Culture Conception	Societal–testing Culture Conception
A tool for improvement of learning	"for students to learn new content" (Phi); "the importance of classroom-based assessments should never be underestimated; it is when real learning takes place" (Phi); "structured to be beneficial for the student by providing feedback and showing students their mistakes" (Lambda); "aid students in locating areas of misunderstanding and inform remediation to learn from the mistakes they are making" (Omega); "provides ample opportunities and situations for a student to engage and learn" (Lambda); "for students to be exposed to different problems and solve different problems by using and developing a variety of strategies" (Omega)	"forces students to study" (Lambda); "motivates students to learn and then apply" (Lambda); "wake-up call … to students when they are doing badly to put more [work] into their studies" (Lambda); "affords students multiple opportunities to rewrite assessments based on the results they obtain" (Alpha); "is this for marks? If it does not count towards a term mark or SBA mark, the students do not take it seriously" (Eta); "students fear assessment" (Lambda); "causes students unnecessary anxiety" (Lambda)
A tool for improvement of teaching	"assessment is important for teachers in getting to know what the students have grasped" (Phi); "vital aspect to make changes to my teaching" (Eta) "informs me of how students are progressing" (Lambda); "to know if I should re-teach a content area, if I am pitching it at the right level" (Lambda); "determine if … students are on track and if I am meeting their study needs" (Eta); to evaluate students' progress, which informs further teaching and learning (Eta)	"the teacher as an "enforcer of assessment" (Lambda); "we don't always have appropriate feedback opportunities after assessment, which minimises the opportunity the student has to learn from the assessment and for me to make changes to my teaching" (Omega); "often has little impact – assessment is done after content has been taught" (Lambda); "takes away lesson times, puts pressure on teaching" (Phi)
School and teacher accountability	"important to evaluate teachers and how well school is doing in specific facets of learning" (Omega); "for teachers, parents, and students to work together" (Eta); "for the teacher to provide feedback to his/her students and parents about the progress and shortcomings of the learning that has taken place" (Phi)	"to determine if the educator has been successful in teaching" (Alpha); "shows which school has a 100% pass rate, which shows that the staff are committed to the students" (Lambda); "complying to the administrative demands" (Alpha); "reduced to checking all the right boxes" (Alpha)
Student accountability and certification	"establish mastery and ability in particular skills" (Eta); "to see how each child is doing in reaching the goals they've set for themselves; to see if students keep on making progress by comparing their performance to previous years" (Omega); "to describe student's learning" (Phi) "stratify students in logical and abstract thinking groups" (Omega)	"we need to submit marks every term" (Lambda); "determines if students meet minimum requirements" (Lambda); "informs parents of student's progress" (Omega); "streams and groups students into ability groups" (Alpha)

It was also interesting that some of the participating teachers' conceptions of assessment were found to be on opposing sides within the same continuum. This dichotomy can be illustrated by looking closely at two of Lambda's beliefs of the effects of assessments on the accountability of teaching. He believes that assessment allows him to hold his teaching accountable to know if he "should re-teach a content area, and if he is "pitching it at the right level" (II-ALP1).

5.3.4.1 PEDAGOGICAL CONCEPTIONS OF ASSESSMENTS ALIGNED TO AN ASSESSMENT CULTURE

The participating teachers' conceptions of assessment could, in all of the continuums, be categorised as pedagogical conceptions of assessments in which there is a strong sense of conceptions relating to a learning culture, as opposed to a testing culture. I will now draw conclusions of the participating teachers' conceptions in all four of the continuums.

The participating teachers' conceptions of assessments in terms of improving learning, in the first continuums, revealed three sub-conceptions: (1) assessment can serve a didactical purpose; (2) assessment can create learning situations to enhance students' strategic competence; and (3) assessment can create learning situations for students to learn from their mistakes.

The first conception is that assessment can serve a didactical purpose and be used in situations for students to learn new content, or to enrich and expand their existing understanding or skill-set. An example of a comment made by a participating teacher to illustrate this is that classroom assessment is essential, as it "is when real learning takes place" (Phi, GI-A2) and, more explicitly, classroom assessment is "for students to learn new content" (Phi, GI-A2). It is important to note at this point that, although Lambda, Eta, and Omega held this conception, which can be identified as a pedagogical conception, these

participating teachers later held contradictory conceptions about assessment as serving a didactical purpose, which can be identified as societal conceptions of assessment. For example, Lambda commented that assessment "provides ample opportunities and situations for a student to engage and learn" (Lambda, GI-A2), but later stressed that assessment serves a "wake-up call" (Lambda, GI-A2), to students to force them to study. This dichotomy is a good example of the "assessment culture" and the "testing culture" of assessment. Phi held the most prominent conception of assessment as creating a learning environment for students to grasp new concepts.

The second continuum is that assessment can create situations or conditions to develop areas beyond procedural fluency and conceptual understanding of "getting the right answer"; this includes situations for students to develop new strategies, which of course enhances strategic competence. Omega and Eta held this conception. An example of this conception is that assessment provides opportunities "for students to be exposed to different problems and solve different problems by using and developing a variety of strategies" (Omega, II-OME1).

The third continuum is that assessment can create situations for students to learn from their mistakes, and thus students are seen as being immersed in the purpose of assessments. Students can play a role in designing of assessments, especially in defining the assessment criteria. All of the participating teachers held this conception of assessment. What differentiated their conceptions was all about what the teacher and student do with these identified mistakes. Omega commented that assessments "aid students in locating areas of misunderstanding and inform remediation to learn from the mistakes they are making" (II-OME1), which differs significantly from Lambda, who was more concerned about assessments "showing students their mistakes" (II-LAM1) as opposed to provide remediation. I found it disconcerting that, although the participating teachers held strong conceptions of assessment being used for the improvement of learning, none of the teachers

developed or used “spot the error” or “error analysis” assessments, which served this purpose with their students.

The participating teachers’ pedagogical conception of assessment in the second continuum, assessment as a tool for the improvement of teaching, created a challenge much bigger than what I initially had anticipated. The participating teachers made comments about the importance of assessment to know what the students have grasped (Phi), how students are progressing (Lambda), and to determine if students are on track (Eta), all to inform their teaching. Here, the teachers’ evaluation of the extent of the students’ progress has a direct impact on their teaching practices. Alpha commented that he often asks his students whether they know how to apply the mathematical concepts or if they fully understand these concepts, which speaks to his desire to teach for conceptual understanding. The challenge which I faced in understanding the participating teachers’ conceptions around assessment informing and improving teaching, is that all of the participating teachers used and described classroom-based assessments which are administered after the content has been taught, and are mostly summative in purpose. It might be the case that these assessments will inform their future teaching, if they are teaching the content again the following year. This, however, does mean that the participating teachers’ assessment practices simply do not allow for immediate changes to be made to their teaching after an assessment has been conducted, such as methodological changes, readjustments, and short-term interventions.

The participating teachers’ pedagogical conception of assessment in the third continuum, assessment to hold the school and teacher accountable, were interesting in two aspects. The first is that the accountability here is around the effectiveness and quality of the learning, which are the result of the quality of the teaching, and secondly, involving the parents and students in providing comprehensive and accurate feedback about the quality of the students’ learning. For Omega, Eta, and Alpha it was clear that there is not adequate

cooperation between the students' parents, the students, and the school. Here it is not about grading the teacher, but for the teacher to initiate effective communication involving the student and the students' parents about the students' learning. The type of feedback from these three teachers to the parents are mostly in the form of a mark, and a small description of what the mark consists of. For Eta and Omega, the cooperation between the student and the students' parents is much more significant. Omega stressed that she refuses to meet with parents without the presence of the student, as "it is all about the student".

Lastly, the participating teachers' pedagogical conception of assessment in the fourth continuum, assessment for students' accountability and certification, often overlapped with their conceptions in the teacher and school accountability continuum. The variety of participating teachers' comments relating to assessment, such as to "establish mastery" (Eta, II-ETA1), "describe student's learning" (Phi, II-PHI1), "stratify students in logical and abstract thinking groups" (Omega, GI-B2), and "to see how each child is doing in reaching the goals they've set for themselves" (Phi, II-PHI1), points to the classification and description of the students' holistic progress. Yet, when the teachers were asked to discuss the feedback they give to students, and the feedback the students and parents receive, the description of feedback was not to be found. Rather, their comments pointed to quantitative feedback, such as the marks a student obtained in an assessment or the mark a student achieved in a specific section. There was, yet again, a dichotomy between the participating teachers' conceptions of assessment, and what is actually happening in the classroom. Their conceptions of the feedback that they believe they should be providing to their students, and the feedback they are actually providing were divorced from another. To be fair, one could argue that the feedback they provide does, to a quantitative extent, "establish mastery" (Eta), but the conceptions of assessments, such as to "describe student's learning" (Phi), "stratify students in logical and abstract thinking groups" (Omega), and "to see how each child are

doing in reaching the goals they've set for themselves" (Phi), were indeed missing in action. The quantitative description of students' learning by means of numeric and categorical grading is clearly preferred over the qualitative and comprehensive description of students' learning.

The feedback which assessments provide to teachers and students, once again, differentiated among the teachers. Omega, who declared that she teaches in an environment with much greater freedom and autonomy, commented that she is not satisfied with the feedback she is giving to her students, as it "minimises the opportunity the student has to learn from the assessment and for me to make changes to my teaching" (II-OME1).

5.3.4.2 SOCIETAL CONCEPTIONS OF ASSESSMENT WHICH LEADS TO A TESTING CULTURE

The participating teachers' conceptions of assessment could also be categorised and classified as societal conceptions of assessment, which relate to a "testing culture", in all of the four continuums, as it was the case with the pedagogical conception of assessment that was discussed in the previous section. I will now draw conclusions on the participating teachers' conceptions in all four of the continuums of conceptions of assessment that were categorised as societal, testing culture conceptions of assessment.

In the first continuum, the participating teachers' societal conceptions of assessments, which are used as a tool for the improvement of learning, revealed two major conclusions. Firstly, although the students are made aware of their level of achievement and progress, their awareness of the degree of the progress they have made is the end-result of learning. The reason for this, of course, is that the assessments which the teachers used are classified as "assessment of learning", whereas "assessment for learning" enables teachers and students to seek and interpret evidence of their learning to decide where the students are positioned in

their learning, where they need to go in relation to their goals, and how best to achieve the goals.

Secondly, the teachers' conceptions of assessment being used for student motivational purposes revealed significant challenges. Lambda and Alpha held very strong conceptions of assessment being useful to force students to study and motivate students to engage in the learning process. Another conception of assessment being used for student motivational purposes after the student knows the outcome of their performance sees the assessment as an instrument to serve as a "wake-up call" (Lambda) to motivate students to study harder for future assessments. Learning is thus conceptualised by these two teachers as an event created by teachers for students to master an outcome, as opposed to seeing students as part of the learning process and involving them to play an active role in their learning and achievement of their goals. This conception of assessment extrinsically motivates students to increase their work ethic and study habits. It was not surprising, then, when Lambda bemoaned students' experience of assessments, such as "students fear assessment" and that assessment "causes students unnecessary anxiety" (Lambda, GI-A2). Lambda, however, was not the only teacher who expressed this. Eta, for example, stated that students often enquire whether assessments count for marks. He explained that "if it does not count towards a term mark or SBA mark, the students do not take it seriously" (Eta, II-ETA1). This further illustrates that, although the participating teachers held conceptions of assessment to be used as a tool to advance learning, that when homing in on these conceptions on a deeper level, their conceptions actually point to a societal, testing culture conception, as opposed to a pedagogical, assessment culture of assessment.

The participating teachers' societal conception in the second continuum, assessment as a tool for the improvement of teaching, revealed many different aspects. I want to focus on two of the aspects which emerged: (1) assessments slowing down the pace of teaching, as

well as negative effects on teachers and their teaching; and (2) the dilemma faced by teachers who held the conception of assessments as being used to improve teaching.

All of the participating teachers held conceptions, to a varying degree, that assessment can influence teaching negatively, such as slowing down the pace of what is taught by the teacher and learnt by the student. Comments of this nature, such as assessment "takes away lesson times, puts pressure on teaching" (Phi, GI-A2), were made by all of the participating teachers. It transpired that the teachers did not actually refer so much to assessment taking much time from teaching, but more that they felt the current south African curriculum's demands do not "allow space" (Eta, GI-B2) for formative assessments, classified as "assessment for learning". Alpha's conceptions of assessment are significantly influenced by his beliefs of the current curriculum. When the teachers of School A were asked to describe why they felt that assessment negatively affects their teaching, Alpha noted the current curriculum and exclaimed that "CAPS robs teachers of time to be creative". Lambda added that lessons are filled with covering the required and stipulated content, which means that there is no space for creativity and meaningful assessment. Phi explained that the curriculum "tells you in week one you should do this, week two this […] not taking into consideration the fact that my learners didn't comprehend last week's work, so I am still teaching last week's work, and this week I am supposed to start a new concept [….] It doesn't cater for that" (Phi, GI-A2). The negative feelings which teachers had towards the current curriculum is not surprising if one considers the teachers' beliefs of assessment, which I described in section 5.3.3.3, and which refer to the second continuum (Delandshere & Jones, 1999) of understanding teachers' conceptions of assessments. Assessments thus are seen by the participating teachers as evaluative activities which are mutually exclusive from learning. The participating teachers used assessment only after the prescribed content or mathematical

concepts had been taught. This again confirms that the assessments of the participating teachers are not "assessment for learning", but indeed summative "assessments of learning". The absence of "assessment for learning" allows me to have a better understanding of the dilemma faced by teachers who held the conception of assessments being used to improve teaching. Comments such as "we don't always have appropriate feedback opportunities after assessment, which minimises the opportunity the student has to learn from the assessment and for me to make changes to my teaching" (Omega, GI-B2), and assessment "often has little impact, as it is done after content has been taught" (Lambda, GI-A2), best describe this aspect. The separation of teaching and assessment further illustrates that the participating teachers held a "testing culture" conception of assessments, as opposed to a pedagogical, learning culture conception of assessment.

The participating teachers' societal conception of assessment in the third continuum, sees the purpose of assessment to hold the school and teacher accountable. The pedagogical conceptions of assessment see accountability as an effective form of learning, which, firstly, is the result of the quality of the teaching, and, secondly, involves the parents and students in providing comprehensive and accurate feedback about the quality of the students' learning. The societal conception of assessment concerning the accountability of the teacher and school, is evaluative of the teacher and the school. The main difference here is that a judgement is made on the quality of the teacher's teaching and the quantitative description of the students' progress, as opposed to the quality of the learning opportunities which the teacher creates. Although standalone comments, such as assessment is important "to determine if the educator has been successful in teaching" (Alpha, GI-A2), might not immediately signal evidence of a "testing culture", these comments signal societal conceptions of assessments, if one takes into account other comments, such as the importance of assessment to "comply to the administrative demands" (Alpha, GI-A2), as well as how

teachers, through assessment, are "reduced to checking all the right boxes" (Alpha, GI-A2). Here "successful in teaching" is an evaluation and judgement, rather than a qualitative description of students' learning. To further illustrate this "societal conception" of assessment, Lambda commented that assessments are important, because the results "show which school has a 100% pass rate, which shows that the staff are committed to the students" (Lambda, II-LAM1). Phi commented on the lack of cooperation between parents, students, and the teachers. The societal conception of assessment detaches the roles and interactions of the teachers and the students, and often creates tension between teachers and students.

Lastly, as was the case with the participating teachers' pedagogical conception of assessment in the fourth continuum, their societal conceptions of assessment in the last continuum (which relates to assessment for students' accountability and certification), often overlapped with their conceptions of assessment located in the teacher and school accountability continuum. Here, quantitative grading is prioritised over descriptive and qualitative learning processes. Comments such as "we need to submit marks every term" (Lambda, II-LAM1); assessment "streams and groups students into ability groups" (Alpha, II-ALP1); assessment "determines if students meet minimum requirements" (Lambda, GI-A2); and assessment "informs parents of students' progress" (Omega, II-OME1), illustrate this emphasis of numerical and quantitative grading. Lambda's comment on students meeting minimum requirements corresponds to the conceptions of the students they teach, which formed part of the third assertion of assessment, and was discussed in section 5.3.3.3. There were comments made by the participating teachers that they lower the demands of assessments to ensure that the "right percentage of students meet the minimum demands" (Lambda, II-LAM1). It is clear from these comments that assessment is used as a system which categorises abilities, and to fulfil an administrative task, as opposed to a pedagogical learning process. Furthermore, the notion of the participating teachers affording "students

multiple opportunities to rewrite assessments based on the results they obtain" (Alpha, GI-A2) to better their marks speaks to the preference of a "testing culture" where the mark is of paramount importance. Here, very little attention is paid to the overall qualitative description of the learning progress of the students.

5.3.4.3 CONCLUSION

The relationship of the teachers' conceptions of assessment and their actual assessment practices, and the extent to which the participating teachers' teaching environment and experience affects and constructs their conceptions of assessment, are important considerations for this study. In section 5.3, the three assertions of assessment identified by Delandshere & Jones (1999) were used to identify and describe teachers' conceptions of assessment. The three assertions of assessment are: (a) teachers' conceptions about assessment are shaped by its defined functions and purposes; (b) teachers' conceptions about assessment are shaped by what they perceive as the official curriculum within the school structure and where they position themselves in relation to the subject matter; and (c) teachers' conceptions about assessment are shaped by how they understand learning and their students.

The participating teachers were asked what they thought the purpose of assessment is. From analysing their responses in the semi-structured interviews, I was able to describe their use of assessment in terms of four main purposes: (1) to advance learning; (2) to advance teaching; (3) to monitor learning and certify students; and (4) to act as an accountability measure. These four purposes of assessment formed four continuums of conceptions of assessment. The participating teachers' conceptions of assessment were analysed by using a model of four continuums across two orientations, which was adapted from Remesal's (2011) four-dimensional bipolar model of conceptions and Brown's (2002) four-dimensional model

of trends of conceptions of assessment. The aim was to interpret the participating teachers' conceptions of assessment by locating these conceptions in four continuums across societal and pedagogical orientations. I presented instances of beliefs expressed by the participating teachers in each of the four continuums and then located the teachers' beliefs in one of the four different continuums. I then located each of these beliefs in each of the continuums as a pure pedagogical, assessment culture conception, or as a pure societal, testing culture conception. I believe that all four continuums are interwoven to form a conception of assessment, and cannot be seen as separate from one another, which is essential when considering school factors in a holistic manner, including school culture. For a participating teacher to be considered as having a particular conception of assessment, there must be evidence of beliefs in each of the continuums in the appropriate orientation. It is thus important to note that teachers' beliefs of assessment in all four continuums describe their conceptions of assessment as a pedagogical conception of assessment, where the teacher upholds an assessment culture of assessment, or a societal conception of assessment where there is a testing culture of assessment.

(i) MIXED CONCEPTIONS OF ASSESSMENT

It was encouraging to learn of the participating teachers' conceptions of assessment pertaining to assessment being used as a tool for improving learning to serve a didactical purpose, enhance students' strategic competence, and create learning situations for students to learn from their mistakes. What became clear, though, was that didactical or "learning assessment" was only effective if it was done on a regular basis in concurrence with teaching, to provide the teacher with the opportunity to make methodological changes, readjustments to teaching and learning situations for students to develop learning strategies, as well as short-term interventions. Even though the participating teachers' conceptions of assessment, as

described and classified in the three assertions of assessment in section 5.3, talked to the relationship between teaching and assessment, these teachers mainly used assessment after the prescribed content or mathematical concepts had been taught as a quantitative evaluation and numerical categorisation. This confirmed that the assessments which the participating teachers are using are not "assessment for learning", but indeed summative "assessments of learning". Therefore, the use of assessment to improve teaching and learning is dependent on the type of assessment the teacher uses, as well as the extent of the feedback which the assessment will provide both to the teachers and the students. It became apparent that, although the participating teachers held pedagogical conceptions of assessment as improving learning and teaching, these conceptions were easily overwhelmed by their societal conceptions of assessment. By comparing the participating teachers' use and design of assessment, which was discussed in section 5.2.3, to the participating teachers' pedagogical and societal conceptions of assessment, it is clear that the societal, testing culture conceptions of assessment manifested more strongly in their assessment practices than the pedagogical, learning culture conceptions of assessment. This was indeed the case with all of the participating teachers, and is illustrated most clearly by considering Alpha's conceptions of assessment, and his assessment practices.

This study categorised Alpha as a "traditionalist" assessment designer and practitioner. I remind you that he described his classroom assessment practice as conventional, and that he mainly makes use of formal class tests as classroom-based assessments. Although Alpha stressed that assessments do not provide many learning opportunities to the students, he bemoaned the approach towards assessment as "very problematic to me because all that we are doing is testing kids to pass the test, and after they have passed the test they forget about it again" (Alpha, II-ALP1). It is clear that Alpha held stronger societal conceptions of assessments, compared to pedagogical conceptions of

assessment, across all of the four continuums, which was the main reason why his assessment practices portray a testing culture of assessment, rather than an assessment culture of assessment. The best way to illustrate this is to look at one of his most prominent conceptions of assessment. Alpha commented that assessment is essential as it "affords students multiple opportunities to rewrite assessments based on the results they obtain". Note here that he is not referring to the descriptive and qualitative evaluation of learning, but the numerical quantitative categorisation of the student. Although he expressed sentiments which could have been located in the pedagogical assessment culture orientation, I found that, as with the other participating teachers, non-flexible core conceptions of societal conceptions of assessment totally overshadow pedagogical assessments of assessments, which directly affects assessment practices. Although the teaching environment at School A is substantially more challenging than at School B, I am not convinced that his assessment practices are directly dominated by his learning and teaching environment. Remember that Alpha was generally satisfied with his teaching conditions. Although some of his comments referred to "teaching to the test" and students' mindset of being satisfied with meeting the minimum requirements, Alpha held high expectations of the students he teaches. He, for example, held the belief that all students have the capacity to do well. I am not convinced that Alpha's assessment practices would be significantly different if he taught in a school with better resources and with students from higher socio-economic backgrounds. His teaching environment, therefore, has an impact on his assessment practices, but not as significantly as I initially thought it had. This corresponds with other authors, such as Brown (2004), who found that teachers' conceptions are not affected by the context they develop in or by previous experience, and even went further to claim that the number of years of professional experience of teachers and the socio-economic status of their schools do not notably influence the conceptions that teachers hold about assessment. I found very little evidence of

the school environment affecting the pedagogical conceptions of the participating teachers; rather, I observed some instances where the school culture and learning environment had an impact on the participating teachers' societal, testing culture conceptions of assessment. Although I initially found the relationship between teachers' conceptions of assessments and their assessment practices inconsistent and variable, what has emerged, however, was that the teachers' societal conceptions of assessment and their assessment practices were, undeniably, closely aligned. The participating teachers who held strong societal, testing culture conceptions, such as Alpha and Lambda, not surprisingly, also used and developed more traditional classroom-based assessments. The participating teachers' societal conceptions of assessment relating to a testing culture weighted stronger than and therefore outbalanced their pedagogical conceptions relating to establishing a learning and assessment culture, especially if one considers their conceptions of assessments and their assessment practices. I found this to be true in all of the participating teachers.

(ii) ASSESSMENT AS AN IRRELEVANT ACTIVITY

The last aspect on which I want to focus in this conclusion is a conception which emerged across all the continuums of the societal, testing culture conception of assessment. I found that the participating teachers held a conception of assessment as an irrelevant activity for teachers and students. The conception of assessment as irrelevant was a conception which was strongly held by all five of the teachers. Once again, participating teachers were linked to this conception only if they held beliefs of assessment, in each of the four continuums, which could be described as seeing assessment as an irrelevant activity for either teacher or student, or for both teacher and student. From analysing the teachers' beliefs which they shared, it became clear that the participating teachers' conceptions of assessment as an irrelevant activity consisted of three aspects: (1) assessments are irrelevant because they are bad for

students; (2) assessments are irrelevant because they provide inaccurate feedback; and (3) assessment is irrelevant for teaching.

When I realised that another conception of assessment emerged from grouping teachers' beliefs of assessment in one of the two different domains across the four continuums, I incorrectly predicted that the participating teachers' beliefs would point to the high-stakes examinations in grade 12 as being irrelevant to them or the students they are teaching in the secondary phase in grade eight and nine. The conception of assessment being irrelevant is multi-facetted, and can best be illustrated by considering Lambda's conceptions of assessment. Lambda readily shared his beliefs of assessment which could be located in each of the four continuums. When Lambda spoke about assessments being useful for advancing learning, he spoke about the negative effects which assessments have on students. He commented that "students fear assessment" (Lambda, GI-A2) and "[assessment] causes students unnecessary anxiety" (Lambda, GI-A2). There was a belief that assessment is not necessarily connected to students' real abilities, but rather just to their test-taking abilities. Comments made by the some of the other participating teachers also pointed to assessment providing information out of context and that assessment is an unfair measure which does not accurately describe student ability. It is clear that Lambda believes that assessments are irrelevant because they are bad for students. Moreover, Lambda commented that, because students fear assessments so much, he feels that assessments are "not always a good indicator of what the students can and cannot do" (Lambda, LAM1). Therefore, the feedback the assessment provides to the students and the teacher is unreliable and insignificant. For Lambda, assessment is irrelevant because it provides inaccurate feedback. Here, the students are not involved in the designing of the assessments. There is a "one size fits all" assessment instrument being used, which does not consider a comprehensive view of the students' learning and progress made. Assessment is rather seen as an instrument used by the teacher to

quantitatively test and categorise students' performances. He further commented that classroom-based assessment "often has little impact; assessment is done after content has been taught" (Lambda, II-LAM1), which again speaks to relying on summative forms of assessment to serve as a tool to advance learning and teaching. This speaks to the third aspect: assessments are irrelevant because they are irrelevant and distinct from teaching. I asked the participating teachers during the semi-structured individual interviews to explain the extent to which their teaching and assessment practices complement each other.

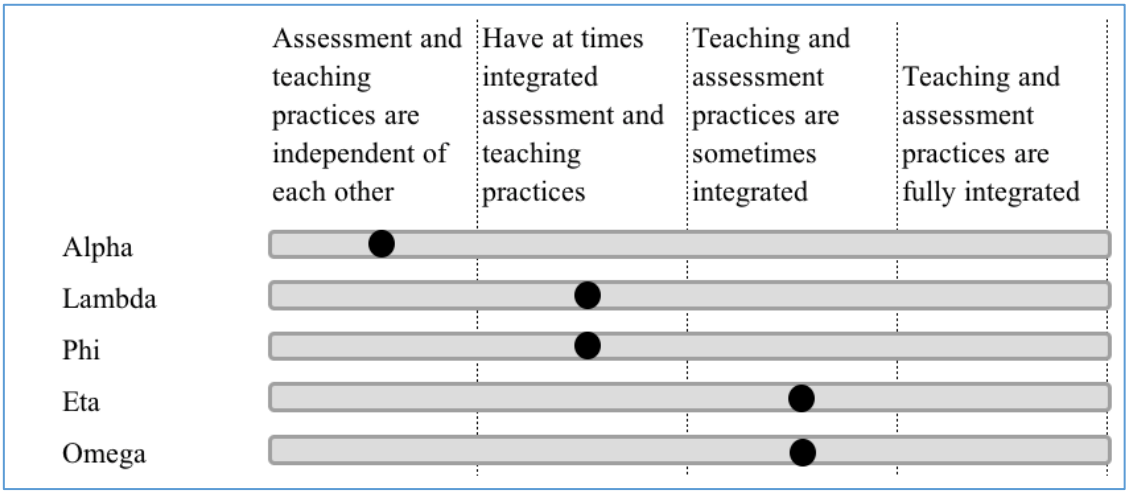

Figure 15: The relationship between teaching and assessment practices

Figure 15 confirms that assessment and teaching practices for Alpha, Lambda, and Phi are mostly independent from each other, despite all three of these teachers holding beliefs of assessment which are positioned in the pedagogical orientation. These assessments do not of course support and align to frameworks, such as the Mathematics Teaching and Learning Framework for South Africa (2018), which promotes conceptual understanding. Comments such as assessment ensures and determines "if students meet minimum requirements" (Lambda) were often made by Lambda and Alpha. Here, assessments only inform the teacher if the students can perform at a level which the participating teachers deem as satisfactory

and required. For the students who are exceeding these "minimum requirements", these assessments are irrelevant in terms of the feedback they provide. Here, I go back to Alpha's beliefs of assessment, where the teachers are "reduced to checking all the right boxes" (Alpha) and "complying to the administrative demands" (Alpha). It was also Alpha who stated that the head of the department mainly designs assessments. Further beliefs of assessment having negative consequences on teaching, such as time constraints, were discussed in the second assertion of assessment in section 5.3. For the participating teachers, such as Alpha and Lambda, having a societal conception of assessment and testing culture of assessment, assessment is not connected to learning and therefore not aligned to teaching.

In conclusion, the participating teachers' beliefs of assessment were analysed and interpreted by using a model of four continuums across two orientations. The participating teachers' conceptions of assessments, which are formed by their beliefs of assessments across four continuums across two orientations, revealed fascinating insights into the complexity of using classroom-based assessments. A dichotomy was found between using formative and summative assessment for classroom-based assessment practices. The former is also referred to as "assessment for learning", and the latter as "assessment of learning". This dichotomy is not new and has been established in previous research (Black and Wiliam, 2008; Remesal, 2011). Although the participating teachers held conflicting pedagogical and societal conceptions of assessments, what ultimately differentiated them in terms of their conceptions of assessments was if they conceptualised and practised an assessment culture of assessment or a testing culture of assessment. It was found that the participating teachers' societal conceptions of assessment were better represented in their assessment practices compared to their mixed pedagogical conceptions of assessment.

Resent research in the field of assessment exposes the difficulties in changing assessment practices in order to monitor learning and teaching in a positive way, so that

assessment of learning turns into assessment for learning (Harlen, 2005; Stiggins et al., 2005; Marshall & Drummond, 2006; Remesal, 2011). In the next section, I will try to understand more clearly how the participating teachers can adapt their assessment practices.

5.4 HOW CAN SECONDARY-SCHOOL MATHEMATICS TEACHERS ADAPT THEIR CURRENT CLASSROOM-BASED ASSESSMENT PRACTICES?

This chapter focusses on my attempt to understand more clearly how secondary-school mathematics teachers can adapt their classroom-based assessments. Firstly, the participating teachers were asked in 5.4.1 to evaluate critically how the classroom-based assessments, which they developed or used, aligned to Kilpatrick's five strands of mathematical proficiency. Secondly, the participating teachers were asked in 5.4.2 to design classroom-based assessments towards assessing for mathematical proficiency. The Mathematics Teaching and Learning Framework for South Africa (DBE, 2018) was published after the data was generated from the semi-structured group interviews with the participating teachers. I analysed the teachers' data, which was gathered from the teachers' designing classroom-based assessment towards mathematical proficiency, by lensing it through: (1) the framework's model of mathematics teaching and learning; (2) the framework's implications of assessment; and (3) by considering the teachers' conceptions of assessment in chapter 5.3, which described how they justified their assessment practices and then linked their assessment practices..

5.4.1 EVALUATING CLASSROOM-BASED ASSESSMENTS

5.4.1.1 INTRODUCTION

The participating teachers at both schools were asked in two separate semi-structured group interviews to analyse critically and compare their classroom-based assessments to Kilpatrick's five strands of mathematical proficiency, and towards achieving the specific goals and skills of the current South African curriculum. The participating teachers at both schools were asked in separate group interviews to provide me with examples of classroom-based assessments that they have recently developed or used with their secondary-phase students, and then to discuss openly the nature, specific goals, and intended purpose of the assessments. I chose two similar assessments, from the examples which were provided to me, for the participating teachers to evaluate. I then used these two assessments, which have been used but not developed by Alpha, as class tests, with the teachers at both schools for the analysis. Examples of the assessments can be found in Appendices 4 and 5.

During the semi-structured group interviews, the terms "assessment for learning" and "assessment of learning", as well as the five strands of mathematical proficiency were explained to the participating teachers. The characteristics of each of the five strands were discussed by using a chapter in Jonathan Katz's book*, Developing Mathematical Thinking: A Guide to Rethinking the Mathematics Classroom* (Katz, 2014). The analysis of the teachers' classroom-based assessments followed the discussions. Although the analysis of assessments was done in a group interview, each of the teachers was asked to analyse an assessment critically. In the first group interview, Alpha, Phi, and Lambda were asked to analyse classroom-based assessments which they have done, and in the second interview, Eta and Omega were asked to analyse the same assessments. From analysing the teachers' evaluation of the two assessments, I homed in on the participating teachers' comments and beliefs of the purpose of the assessments, and the alignment of the assessments with the five strands of

mathematical proficiency and the goals and specific skills of the current South African curriculum.

Each of the participating teachers was asked to comment on what he/she thought the purpose of the assessments was. The teachers' beliefs of the purpose of the assessments were then categorised either as a belief aligned to pedagogical conceptions of assessment, or beliefs aligned to societal conceptions of assessment. The former speaks to an assessment culture of assessment, and the latter as a testing culture of assessment.

5.4.1.2 SOCIETAL CONCEPTIONS OF THE PURPOSE OF THE ASSESSMENTS

Alpha, Phi, and Lambda made comments about the purpose of the two assessments which were provided to them, which could firmly be categorised as societal conceptions of assessments.

Alpha was of the opinion that both of the assessments assess different skills and the required content. He explained that he mainly uses assessments like the ones they are analysing because he thinks they cover all the "right stuff and the right content" (Alpha, GI-A3). Alpha's comments confirmed that he holds strong societal conceptions of assessments, which are more closely aligned to a testing culture than an assessment culture. His comments point to his preference of using assessments which can be classified as "assessment of learning". For Alpha, the purpose of assessments is to provide the teacher with a quantitative categorisation of which students have met the "minimum requirements". He explained that the two assessments "inform the teacher how much the students know – for students to make sure that they have the basics, that they understand the basics" (Alpha, GI-A3).

Alpha believes that the two assessments are "adequate assessments which will tick all the right boxes" (Alpha, GI-A3). It is thus easy to locate his belief of the purpose of the two

assessments, by using the four-continuums model of conceptions, in the teacher accountability continuum in the societal conception orientation.

Alpha's responses to the purpose of the assessments displayed mixed beliefs of using a variety of assessments. On the one hand, Alpha noted that, although he mainly uses assessments which take the form of the two assessments, these are not the only types of classroom-based assessments which should be used: "If other alternative methods can help students understand and conceptualise mathematics, we should make use of them" (Alpha, GI-A3).

One the other hand, although he understands the need to use other forms of assessment, Alpha explained that he would be reluctant to make changes to how he assesses his student:

> "We can change this type of assessment, but how is this going to prepare them [for] when they face a set structure of things that haven't changed in the past 20 years. We have control over these assessments, but if we change it [sic] the fear is that they will not be prepared for the final set exams" (Alpha, GI-A3).

Alpha commented that the reason why he is weary of using alternative forms of assessments is because he teaches students of an "extreme range of abilities" (Alpha, GI-A3). These sentiments were also shared by Lambda, who explained: "So many of the students barely know the basics, and then you have individual students who want to do well. It is difficult to manage this" (Lambda, GI-A3).

The real challenge, of course, is that Lambda and Alpha displayed (in chapter 5.3) evidence of holding strong beliefs of assessments which ensure that students meet the "minimum requirements". The outcome then, they explained, was that assessments become an irrelevant activity for students who are exceeding the minimum requirements. There were no indications from Lambda and Alpha that they would use the assessments qualitatively to describe the progress the students have made. For Lambda, the function of classroom-based assessments is that they must assess a body of knowledge, and assessments must assess

learning, and not to learn activity. He believes that students must learn from the mistakes they made in the assessment to do better in the next assessment: "I disagree with the terms 'assessment for learning' or 'assessment as learning' as a purpose for this type of an assessment. These assessments test learning and are not learning activities. This is not what assessments of this type of test; [they] serve a different purpose" (Lambda, GI-A3).

Alpha was asked to confirm that he believes the purpose of these forms of classroom-based assessments is to ensure that the students pass. He responded:

> "Yes. The students are not driven, you know. They only want to pass. Very few students want to extend themselves. We need to focus on students passing; that is what is expected of us. When we need to submit reports to the WCED, they are interested in how many students passed" (Alpha, GI-A3)

I was surprised when Phi confirmed this belief, and further commented that the emphasis of this assessment is mainly on students passing: "we need to ensure that they all pass. Our assessments must cater for the weaker learners because the majority of our learners are weak and find mathematics a struggle" (Phi, GI-A3). This is indeed surprising if one considers that Phi was classified in chapter 5.1 as "the road-less-travelled explorer" assessment designer. She designed and used a variety of assessments for different purposes, which can be categorised as "assessment for learning" forms of assessments. Here, it seems that Phi's conceptions of the students' abilities and "assessment requirements" have a much greater impact on her assessment practices than what I initially anticipated.

5.4.1.3 PEDAGOGICAL CONCEPTIONS OF THE PURPOSE OF THE ASSESSMENTS

Omega classified these assessments as "assessment of learning". She commented that the type of questions is identical, which she feels is unfortunate, "as they have a limited take on

the concepts and [are] restrictive about the feedback [these questions allow]" (Omega, GI-B3).

Eta explained that these assessments could be altered to become "assessments for learning". He commented that, for an assessment like this to work, it is crucial for "students to be part of the process of learning, and not spectators" (GI-B3). Eta noted that it is important first to understand what the assessment was intended for before it could be analysed. For Eta, the purpose of the assessment is paramount:

> "If the purpose was to let students develop procedural soundness in this particular session, then I think it will do; as a teacher, you will be able to see what type of mistakes students are making. Having said this, I don't think any of these assessments test if students fully comprehend concepts, but [they] will give the teacher an idea of misconceptions. (Eta, GI-B3)

Eta mentioned that assessments like this are most suited to monitor the progress made by the student and the best time to make use of them is to support teaching, and not at the end as a formative assessment: "I don't think that you [as a teacher] will be any wiser if this is done at the end of a section, but it can 'guide learning' over a period of time" (Eta, GI-B3).

5.4.1.4 MIXED CONCEPTIONS OF THE PURPOSE OF THE ASSESSMENTS

The comments made by Phi and Lambda exposed mixed conceptions of the purpose of the assessments. Lambda commented that the assessments the teachers were given to analyse serve the intended purpose of indicating if students have mastered the application of the content. He feels that assessments like these provide both students and the teacher a realistic indication of where each student is at in his/her learning. Lambda's comments on the purpose of the assessments, for instance, that these types of assessments "do not really provide enrichment for the top-achieving students" and that "these assessments are effective to ensure that students learn how to apply the concepts" (Lambda, GI-A3) are examples of his

pedagogical conceptions of assessments in some of the continuums, but are also a strong indication that, although he has mixed conceptions of assessment, his societal conceptions weigh more in the decisions he makes around assessment.

I also locate Phi as having mixed conceptions of the purpose of the assessments. Phi explained that assessments like the ones given to the teachers to analyse do not extend the students who mastered the basic concepts because these assessments have a different purpose. She commented that these are "assessments of learning". She went on to explain that, although students cannot learn anything from doing this assessment, this assessment gives her an idea of what the students can or cannot do. She commented, on the negative aspects of over-using classroom-based assessments like this, that:

> "these assessments have [their] uses, but you can also get stuck on doing only these types of questions with learners. Alternative forms of assessment must be used. This assessment only takes place after learning took place, to test learning. You can use an assessment that helps with learning. It depends on what you want from it. The learners fear this – they don't like this, but it remains the easiest form of assessment to develop" (Phi, GI-A3)

5.4.1.5 EVALUATING AN ASSESSMENT'S DEMANDS VERSUS ITS PURPOSE

When I asked the participating teachers to evaluate the two assessments in terms of the purpose of the assessment, the participating teachers initially confused what was meant by the purpose of the assessment with the demand of the assessment. In fact, the participating teachers were often asked to respond to the purpose of the assessment, as opposed to the demand of the assessment. When I was eventually satisfied with the responses which I received concerning the purpose of the assessments, the participating teachers were asked to comment on the demands of the assessment.

Alpha explained that, if students display procedural fluency with the content, they will do very well and will get close to full marks. He, similarly to Lambda, does not feel that the assessment extends the students, but added that the students who "know their work do

enjoy these type of assessments" (Alpha, GI-A3). Omega noted that this assessment does not challenge the stronger students, and, as a result, they will get bored.

Alpha, Phi, and Lambda talked about the focus of the assessment. They homed in on the type of questions which were asked and debated the level of difficulty of the questions: "There are a couple questions that test the same skill. I guess if they cannot do the one question, then they will not be able to do the next question. There are questions that are more difficult than other questions" (Alpha, GI-A3).

For Omega, the tests contained too many lower-level questions. She felt that the type of questions that were used would not provide feedback to the teacher or student about possible misperceptions and gaps in understanding. She felt assessments like this are best to monitor and track students' progress to solidify the application of concepts, but that these types of assessments must complement other types of assessments: "Students might grow negative feelings towards assessment if they were all like this; it serves as a 'shut-up and sit activity', it is so generic [sic]" (Omega, GI-B3).

Lambda made an interesting comment about the level of difficulty of the questions in assessments. He queried that, if the majority of learners struggle with a knowledge question, should that question still be classified as a knowledge question. Alpha's response highlights key elements:

> "Students learn in a specific and particular way, and it is very difficult for them when it is presented in another way, in a different manner. In general, just change the words around and then they are totally blown away; they do not know what to do. They learn specific types of questions. They are not critical thinkers. They are not able to manipulate the information when things are presented differently on their own. I agree – I find it difficult to know if students are able to do the questions successfully. It is difficult to know if it is too easy or too hard beforehand" (Alpha, GI-A3)

Alpha was asked about a comment he made previously when he said if you change some of the questions too much the students could not do them. He responded that he thinks students can do this type of assessments, like Test B, without really understanding the content and

skills: “I know that it is possible for them to just carry out these skills without knowing what they are doing, that they are just doing the steps without really knowing what is happening and why it is possible to do and apply concepts” (Alpha, GI-A3). Alpha revealed that his students had done questions similar to this before and stressed that it is important to “be mindful; if you change the questions too much and make [them] too difficult, then they get frustrated and cannot do it. They leave it blank. It is almost a replica of the problems we worked through in class” (Alpha, GI-A3).

5.4.1.6 EVALUATING ASSESSMENTS AGAINST ASSESSING FOR MATHEMATICAL PROFICIENCY

The participating teachers were asked in the semi-structured group interviews to evaluate the two assessments against Kilpatrick’s five strands of mathematical proficiency. When Alpha was asked if these types of assessment are aligned to the five strands of mathematical proficiency, or if they promote the aims of the current South African curriculum, he responded that these forms of assessment do very little to promote these goals:

> I think the points made in the curriculum [are] great and I think the mathematical proficiency strands are amazing. We need to think about how to achieve that. I have never thought about it. But you see, they are asking us to do something very different but they are not testing in this way. We are clearly not doing this. Clearly, we should, but we aren’t. (Alpha, GI-A3)

Alpha realised that there might be value in redesigning his assessments to promote mathematical proficiency and the aims of the current South African curriculum. Alpha was also of the view that the assessment “mainly focusses on procedural fluency”. He concurred that the assessment, which was analysed, as well as the assessments which he designs and uses, focus on “conceptual understanding, strategic competence and [are] adaptive to a much lesser degree” (Alpha).

Phi, similarly, believed that both Test A and Test B assess "conceptual understanding and procedural fluency". She noted that the questions in the assessments are closed, short-answer questions:

> The thing is, you can learn for this and not really understand this. I see this with my students. But when you change the question, even the slightest, they cannot do it [sic]. This is the type of assessment I use to get an idea of their understanding, but I know there is little value in it only to make use of this. Why can't kids do the questions when we change them a bit – maybe they don't know what they are doing [sic]? (Phi, GI-A3)

Phi also commented that she does not believe that the particular assessment focusses on the specific skills which are prescribed in the current South African curriculum. She feels that assessments should complement one another, not operate in isolation, and have different functions. She believes that there is a place to use assessments like these, but that this is "a prime example of assessment of learning".

Phi noted that the assessment mainly focusses on procedural fluency, and that there is one question of strategic competence. She feels that the assessment does not ask conceptual understanding questions, but added that the students need to understand the skills and concepts to be able to do this type of assessment. She also does not think that the assessment focusses on adaptive reasoning. For Lambda, the assessments focus on procedural fluency and conceptual understanding: "It tests if students know the work and if they can do the work". He explained that the students struggle "to understand what is meant with questions, but if they are exposed to all the different types of questions, they know how to answer it" (Lambda, GI-A3).

5.4.2 DESIGNING ASSESSMENTS TOWARDS MATHEMATICAL PROFICIENCY

5.4.2.1 INTRODUCTION

The next part of the chapter focusses on how secondary-school teachers can design classroom-based assessment towards mathematical proficiency. After the participating teachers evaluated how the two given assessments measured up to the five strands of mathematical proficiency, each of the participating teachers were asked in a 40-minute individual interview to design a classroom-based assessment that promotes the five strands of mathematical proficiency. I anticipated that some of the participating teachers might find it challenging to design totally new assessments. Therefore, I decided to assist the participating teachers with the designing of a classroom-based assessment by giving them copies of the two assessments, which we evaluated in the previous section. Each of the participating teachers were asked to design an assessment which promotes at least four of the proficiency strands on any topic aimed at secondary-school students. I decided not to dictate whether the assessments should be "assessments for learning" or "assessments of learning". Each of the participating teachers was encouraged to design questions which they thought would be classified as assessing conceptual understanding, procedural fluency, adaptive reasoning, and strategic competence. I interpreted and analysed the data gathered by using the Mathematics Teaching and Learning Framework for South Africa (DBE, 2018), especially the model for learning and teaching mathematics, and implications for assessment.

5.4.2.2 ALPHA: DESIGNING CLASSROOM-BASED ASSESSMENTS TOWARDS MATHEMATICAL PROFICIENCY

Alpha initially found it very difficult to redesign assessments and to think of different ways of asking questions. In the first redesigning assessment session, he spoke about how difficult it is to develop an assessment that is different from what he is used to:

> "I must be honest with you, I wouldn't know how to ask it differently. The way I ask questions is the only way I know how to – the way I'm used to. It is probably because that is the way I was taught at school. I can try and think about it, but right now, I have no clue how to ask it differently" (Alpha, II-ALP2).

I was not shocked by the challenge Alpha experienced in incorporating new ideas into designing assessments, especially when considering that he was classified in the early days of the study as a "traditionalist" assessment designer and practitioner who mainly made use of formal class tests. I was, however, startled at the extent of the challenge he faced to connect the purpose of the assessment with appropriate assessment items in designing assessments. His inability to think of assessment items to be used for a specific purpose distinguished him from the other participating teachers. After spending half an hour with Alpha, it felt as if I had not made any progress. We were still far from designing classroom-based assessments towards mathematical proficiency. He asked more questions on the characteristics of and differences between each of Kilpatrick's strands, as well as my views on the intended purpose of classroom-based assessment. In desperation, I asked Alpha for a follow-up session the following week. What I did not realised at the time was that, for Alpha, this part of the journey was vital. He was given the time to incorporate new ideas into his assessment practices, but some of these ideas were in direct conflict with his societal conceptions of assessment. His conceptions of assessment had been shaped by the three assertions of assessment, namely: (a) its defined functions and purposes; (b) what he perceives as the official curriculum within the school structure and where he positions himself in relation to the subject matter; and (c) how he understands learning and his students. It was remarkable to see how his beliefs in turn shaped his understanding of the purpose of assessment, the curriculum, his students, and what a proficient mathematics student can do:

> "I'm really trying to make sense of this all. I'm trying to balance my understanding of the use of assessment with the assessments which I have used, with the assessment I want to redesign. You don't realise it – all the different aspects going on behind the scenes when you create an assessment" (Alpha, II-ALP2).

At this stage, we can interpret what Alpha experienced by using the Mathematics Teaching and Learning Framework's (DBE, 2018) model for teaching and learning mathematics. The model of mathematics teaching and learning presented in the framework is constituted by four key dimensions – conceptual understanding, procedural fluency, mathematical reasoning, and strategic competence – which are the first four of Kilpatrick's mathematical proficiency strands. In the model, however, each of the dimensions is underpinned by a learning-centred classroom. This is essential to understand the challenges which Alpha experienced in incorporating new ideas into his assessment, as well as the transformation of his beliefs.

We can better understand this by: (1) considering Alpha's beliefs of mathematics teaching and learning; (2) examining his conceptions of assessment defined by its functions and purposes, by what he perceives as the official curriculum within the school structure and where he positions himself in relation to the subject matter, and how he understands learning and his students; and (3) locating his beliefs of assessment in each of the four continuums in the societal, testing culture of assessment. Alpha's beliefs of mathematics teaching and learning and his conceptions of assessment do not promote a learning-centred classroom. Although he held some pedagogical conceptions of assessment which could speak to an assessment culture, his societal conceptions of assessment ultimately dictated his assessment practices. Although he could see how incorporating new ideas into his assessments could benefit the students, the real clash was between his pedagogical and societal conceptions of assessments, considering the four continuums associated with the conceptions. Of course, one must consider his lack of experience, mathematical knowledge, and training as significant contributors, but these contributors should not be seen in isolation. His conceptions formed by how he sees the purpose of assessments, how he sees his students, where he positions himself in relation to the subject matter, as well as the quantitative categorisation of students,

as opposed to qualitative description of performance, had a broad effect on his ability to incorporate new ideas into his assessment design.

Alpha demonstrated that beliefs concerning teaching and learning mathematics, as well as concerning assessment, are fluid and adaptable, and that when beliefs are transformed, these beliefs transform conceptions of assessment. Alpha was able to think critically about his assessment practices in the follow-up sessions after he had been given time to reflect on how he sees assessments and learning. When he was asked again if he can think of ways in which the assessments could be redesigned to focus also on conceptual understanding, strategic competence, and adaptive reasoning, he was more confident in sharing his ideas:

> "Maybe if I asked them to make up their own question that assesses a certain skill […] but I know what will happen – they will make up a question exactly like the ones here and then just change the numbers. With the strategic competence, maybe include questions which require more than one step to obtain the solution, like multi-step problems. I am really not sure how to change it, but I just realised, thinking, you know, of all of this, that why I assess like this is because of how I teach and the type of problems I do with the students" (Alpha, II-ALP2)

By considering and reflecting on how he sees the purpose of assessments, how he sees his students, and where he positions himself in relation to the subject matter, Alpha was able to redesign questions, but he was also able to think of the expected responses from the students. He made the link between assessment and instruction: "You probably need to think the whole time about how you are going to conduct assessment while teaching, something I might need to do more" (Alpha, II-ALP1).

His comment spoke directly to assessment being used as a tool to advance teaching and learning in the pedagogical, assessment culture orientation. Alpha explained that he realised that the vast majority of the assessment which he has designed falls in the category of "assessment of learning" as opposed to "assessment for learning". He was asked how he thinks an assessment can be altered so that it is an "assessment of learning", and responded:

"Maybe if I ask in a geometry question: why is the exterior angle of a triangle equal to the sum of the 2 interior angles or in this assessment: why is $(x^2)^3 = x^6$ and not equal to the mistake they always make, x^5. Asking more why questions" (Alpha). Alpha further commented that questions like this would test conceptual understanding; more specifically, they would "test whether [the students] really understand the concept" (Alpha). After the assessment was redesigned to focus more on the intertwined strands of mathematical proficiency, Alpha reflected on the redesigned assessment and commented oon his reservations of incorporating new ideas into his assessments and how the students will perform:

> "I am scared and cautious, but also sceptical about using assessments like this. But I can see the value in this. Earlier I referred to the fact that we teach students to write the test, but then after the test, they forgot everything. They don't remember it. Using assessments like this might do the trick, it might assist with this, but I am worried about how they will do. They will do badly if they are given an assessment like this. Substantial change will need to be made with regard to teaching to use these assessments" (Alpha, II-ALP1).

His pedagogical conceptions of assessments were still overwhelmed by his societal conceptions of assessment. His testing culture of assessment and how he sees the students he teaches fed Alpha's societal culture of assessment.

5.4.2.3 PHI: DESIGNING CLASSROOM-BASED ASSESSMENTS TOWARDS MATHEMATICAL PROFICIENCY

Phi, like the other participants, was asked to design a classroom-based assessment that promotes the strands of mathematical proficiency. Phi eagerly shared her thoughts on how some of the questions can be changed not only to focus on procedural fluency but also on the other strands.

She explained that a set of questions which focussed on substitution could be redesigned as a contextualised problem.

Original question:

c) Calculate the value of the following if $a = 2$, $b = -1$ *and* $c = 3$:

a) $a + b$ (1)

b) $2a - c$ (2)

c) $2a - b + c$ (3)

Phi's adapted question:

> The follow-up question could have been a scenario, more contextualised, to see if they understand that $2a$ means two times a or double the value of a. I would give a scenario where they can understand it more, to bring it home to what they can understand. Just to give them numbers doesn't help. (Phi, II-PHI2)

The model for teaching and learning mathematics (DBE, 2018) describes that "applying maths in context" is a vital aspect of a learning-centred classroom. When Phi was asked to give an example of the scenario she mentioned, she responded:

> Imagine there are three friends, a, b and c. Friend a has R2, friend b doesn't have any money, he actually is R1 in debt, and friend c has R3. Okay, now the friends want to see how much money they have together. If they all put their money together, how much will they have? If friend a doubles his money, how much will he have? […] I know it becomes difficult with negative numbers, but then we can ask them in a way where they will understand that if you subtract a negative number, it is the same as adding the number" (Phi, II-PHI2).

Phi revealed in the above example an interesting understanding of the variables. In the question, she contextualised that the variable a has a numerical value. She related the different friends to each of the variables. She asked, "If friend a doubles his money, how much will he have", which is confusing because, according to her, a represents one of the friends. If she doubles a, she actually doubles the person, and not necessarily the money. I was disappointed that I only picked up her error when I did the data analysis, as I was curious how she would have dealt with a^2 in the context of people and money.

For Phi, it was important for students to make connections, especially across Algebra and Geometry: "In addition [to] the question $3(x + 1) = 18$, what about if you give a geometry question where each angle of an equilateral triangle is $x + 1$, and the area is 18. Find x?" (Phi, II-PHI2). The model for mathematics teaching and learning (DBE, 2018) also sees "connecting topics and concepts" as descriptors of a "learning-centred classroom".

Phi believes that there should be straightforward procedural fluency questions which assess knowledge in all classroom-based assessment, but that there must then be questions which assess understanding, reasoning, and strategic competence, "questions which check whether students can make links[…] To create assessments of this sort will be in line with the strands of mathematical proficiency; it is the variety of problems which is the key" (Phi, II-PHI2).

Phi was asked to think of ways to redesign the assessment to focus on conceptual understanding, strategic competence, and adaptive reasoning. She explained that she would conceptualise some of the questions with real-life application, and that she would ask the students to make connections, like finding at least two ways of doing a particular question. She believes that asking these questions will not only assess conceptual understanding but also enhance the students' conceptual understanding and strategic competence during the assessment. She believes that these types of assessments would initially be much more difficult for students, but, in the long run, be very rewarding for students' understanding and application of the work.

Phi commented that she is nervous about how assessments like this must be marked. She explained that, although she can think about different ways to ask questions, she would not know how to mark "show that", "justify", or "explain" questions. She also spoke about the challenge of marking because of large numbers of students in classes. She indicated that she finds it difficult to "get her head around" how to assess adaptive reasoning. She also felt

that most of her students would not do so well, because the assessment is too radically different to what they are used to and too challenging in her opinion.

I was not surprised that Phi was much more confident, compared to Alpha, in incorporating new ideas into her assessments and designing an assessment which promotes mathematical proficiency, considering that she was classified as "the road-less-travelled explorer" assessment designer who designed and used a variety of assessments for different purposes, assessments which can be categorised as "assessment for learning" forms of assessments. It was interesting to note that a number of the questions she designed and talked through are strongly aligned to the descriptors and qualities of a "learning-centred classroom". There was, of course, the misinterpretation of a contextualised problem. Although she found it challenging to design questions which assess students' adaptive reasoning, she could design questions which focus on procedural fluency, strategic competence, and conceptual understanding.

5.4.2.4 LAMBDA: DESIGNING CLASSROOM-BASED ASSESSMENTS TOWARDS MATHEMATICAL PROFICIENCY

Lambda initially found it difficult to create questions which fit the characteristics of four of the proficiency strands. The questions Lambda redesigned were procedural questions increasing in their level of difficulty. The definition of each of the strands was given to Lambda, and each of the strands was explained and discussed. Lambda stated that he understood the first three strands of proficiency (procedural fluency, adaptive reasoning, and strategic competence) as levels of difficulty, with the procedural fluency being the easiest, followed by conceptual understanding, and then strategic competence. Lambda understood the adaptive reasoning strand as creating scenarios where students need to explain the

solution to a problem in words. To illustrate this, below are examples of questions on exponents, which he designed in each category:

> Procedural fluency: Simplify: $x^2 \times x^3$
> Conceptual understanding: Simplify: $(2x^3)^2$
> Strategic competence: Simplify: $x^2 \times x^3 \times (2x^2)^3$
> Adaptive reasoning: Johnny said the answer to $x^2 \times x^3 \times (2x^2)^3$ is equal to $8x^{11}$. Sam disagrees and thinks the answer is $6x^{11}$. Explain in words who is right and the mistake the other person made

Lambda, similarly to Phi and Alpha, felt that his students would battle with the redesigned assessment because the students have not been exposed to the type of questions asked.

Lambda went through several iterations redesigning assessments to promote at least four of the mathematical proficiency strands. Below are examples of questions of the final assessment which he designed on each of the strands on exponents:

> Conceptual understanding: Give at least four questions which focuses on each of the four laws of exponents, where the solution is $5x^3$.
> Procedural fluency: Simplify: $(x^3)^2 \times (x^2 \times x^3)^2 \times \left(\frac{x^3}{x^5}\right)$
> Strategic competence: Simplify: $(200 \times 10^{-5}) \times (3 \times 10^4)$
> Adaptive reasoning: Explain in words the property of the exterior exponents. Explain why $(2x)^2 = 2^2x^2$ but $(2 + x)^2 \neq 2^2 + x^2$

By looking carefully at the questions Lambda designed and categorised, it is clear that he prioritises procedural fluency. Lambda made interesting observations when he discussed the assessment he redesigned. He commented that he feels that his students battle most with procedural fluency, which will result in them not being able to answer questions which focus on conceptual understanding, strategic competence, or adaptive reasoning.

> "I can see that this is now an assessment where students are assessed, which is valuable to me and for the students, but also that this assessment can contribute to learning. It is not asking 20 questions, and students will have time to think and to make sense, to construct, to solidify concepts […] It will bring about real learning" (Lambda, II-LAM2)

This was significant from someone who, in the analysing assessments section, expressed very negative feelings about assessment. Lambda was asked to explain what he saw as "real learning" and commented that it is learning where students will not just forget concepts, but that these concepts will be ingrained in them, which will contribute to how deeply they understand the concepts. Lambda's comment of "real learning" is strongly aligned to the characteristic of "active learning" in the model for learning and teaching mathematics (DBE, 2018). He also valued three further characteristics of a "learning-centred classroom": "concept development", "justifying answers", and "practising procedures". His emphasis on procedural questions is better understood if one considers that he was classified, similarly to Alpha, as a "traditionalist" assessment designer and practitioner who assesses his senior-phase students in the form of written tests, worksheets, and exercises from the textbook. Lambda was not able to design assessment items which assessed students' conceptual understanding or strategic competence. Although he started to design questions which focussed on justifying answers, his strong societal conceptions of assessment dominate his pedagogical conceptions of assessments, such as "active learning". Lambda's experience of designing assessment showed the danger of confounding the proficiency strands with the four cognitive levels in the current South African Mathematics curriculum: knowledge, routine procedures, complex procedures, and problem-solving.

5.4.2.5 ETA: DESIGNING CLASSROOM-BASED ASSESSMENTS TOWARDS MATHEMATICAL PROFICIENCY

For Eta, learning new phrases which describe a student's mathematical strength or weakness was powerful and would make a difference in how he will report a student's progress: "I talk about these concepts all the time like the student can do the routine stuff but doesn't yet have a solid understanding of the intricacies. Now I use a word for the specific concept, and everyone will understand what is meant" (Eta, II-ETA2).

Eta's comments speak to the challenge mathematics teachers often face in using terminology to describe areas of strengths and weaknesses. Eta was able to develop more than one assessment which focussed on promoting the strands of mathematical proficiency. He spoke about the importance of understanding how essential the productive disposition is for students and for the feedback he provides to students and their parents: "The fifth strand, productive disposition, has always played a central role in my feedback. I believe that it is true that how you feel about the subject matter highly influences your progress and performance" (Eta, II-ETA2).

He commented that, in the past, he has not purposefully developed assessments that focus on a variety of important aspects. Eta feels it is of greater importance to report on what students know: "Do they understand conceptually but struggle with procedural fluency?" He also noted that students could be trained and, hence, learn how to solve complex questions "without having to display real mathematical reasoning or possessing strategic competence" (Eta, II-ETA2).

Eta was the only participating teacher who did not view the strands of mathematical proficiency as four dimensions as it is referred to in the model of mathematics teaching and learning (DBE, 2018). Eta is of the opinion that procedural fluency is ingrained in conceptual understanding, strategic competence, and adaptive reasoning. He further commented that it

would be impossible to assess conceptual understanding, strategic competence, or adaptive reasoning without assessing procedural fluency. He noted that most of these areas will overlap in some way or other, but that the assessment will focus on all the strands.

Below are examples of questions that Eta developed which promote mathematical proficiency.

Procedural fluency:

1. Simplify: $3x + 2x + 5x$
2. Simplify: $\frac{x^4y^5}{x^2y^3}$

Conceptual understanding:

1. Simplify: $(2x^2)^2$
2. Simplify: $2^5 \times 2^2$
3. Simplify: $(x + y)^{-2}$

Strategic competence:

1. Simplify: $\frac{x^{-1}+y^{-1}}{xy}$

Adaptive reasoning:

1. Show that $x^2 \times x^3$ is not equal to x^6
2. Explain with proper justification why $2^0 = 1$ but 0^0 is undefined

Conceptual Understanding and Adaptive reasoning:

Attempts have been made to answer the given questions. Errors have been made. State in words what errors have been made and redo the question correctly:

1. $-7x^{-3} = \frac{1}{7x^3}$
2. $\frac{6^{2x}}{2^{x}.3^{x+1}}$

   $= \frac{6^{2x}}{6^{2x+1}}$

   $= \frac{1}{6}$

Although he commented that the mathematical proficiency strands are interwoven, the questions he designed were not actually so different from the original assessment. I do think that one explanation for this is that some mathematical content areas, especially in the higher grades, allow greater variation in the type of questions which can be asked. Another reason might be Eta's limited experience in designing classroom-based assessments.

After the assessment was redesigned, Eta commented on the importance of the proficiency strands operating in a seamless and balanced way.

> "I think they will be fine. I suspect it might give a boost to students who are very strong on one of the strands to develop specific skills to become stronger in more strands. I suspect it will also show the intuitive, lazier student, that hard work is required; that there is very little use of conceptual understanding without procedural fluency. I think it is important for students to understand that, to be proficient in mathematics, it requires a balance of very different nodes" (Eta, II-ETA2)

It is clear from Eta's comment, and confirmed by placing his beliefs in each of the continuums across two orientations, although he holds mixed conceptions of assessment, his pedagogical, assessment culture conceptions of assessment overpower his societal, testing culture, conceptions of assessment. His pedagogical conceptions of assessment are defined by: its defined functions and purposes; what he perceives as the official curriculum within the school structure and where he positions himself in relation to the subject matter; and how he understands learning and his students.

5.4.2.6 OMEGA: DESIGNING CLASSROOM-BASED ASSESSMENTS TOWARDS MATHEMATICAL PROFICIENCY

Omega showed enthusiasm during the 40-minute session designing and redesigning assessments questions which promote the strands of mathematical proficiency. She was critical of the assessments which she designed and she sought critical feedback. She commented on the importance of being more intentional about what she wants to achieve

from classroom-based assessments. She believed that assessments do not have to be comfortable for students, and that there is a need for assessments to play a multi-dimensional role: "I think it is important for the teacher and students if the students are exposed to a variety of assessment techniques and assessments which focus on different facets" (Omega, II-OME2).

Her beliefs of assessment as playing a multi-dimensional role, and how she feels about the students' reactions to assessments, are thoroughly different from Alpha, Phi, and Lambda, who all spoke about the danger of changing a format of assessment from that which is known to students. Omega is of the view that the students she teaches initially will find these assessments challenging, but that the assessments will be beneficial for them for two reasons: the first is to give students and teachers proper feedback on students' progress in specific areas; the second advantage is that it will force the teacher to ensure that the teaching prepares students for the assessments. She added that it would most likely result in teachers focussing on other areas much more than only on procedural fluency.

Omega noted that some content areas lend themselves much better to assessments which focus on a broader purpose, like assessments that assess proficiency. She sees Algebra as a tool, where the emphasis is on procedural fluency: "I am not saying that it is impossible to assess the different areas in Algebra; I think it is much easier to design an assessment on a section which is on the application of Algebra" (Omega, II-OME2).

Omega designed an assessment on straight-line graphs which focussed on the strands of mathematics proficiency. Characteristics of a "learning-centred classroom" were observed in Omega's attempts to adapt assessments, such as purposeful assessment, addressing students' errors, justifying answers, making sense of mathematics, and concept development. She explained that she believes it is important for students to speak mathematics, and that the students' responses and layout must bear proof of their proficiency with this characteristic of

a “learning-centred classroom”: “I am a little pedantic about students communicating their thoughts and ideas. I do a lot of cognition activities with them.”

Below are questions from an assessment Omega developed and categorised which assesses conceptual understand and adaptive reasoning:

1. Explain in words what the gradient of a line is.
2. Explain how you can determine the gradient of a line. Make use of an example to assist you.
3. Show 2 different ways of sketching a straight line. Make up your own linear equation and
   sketch it in two different ways.
4. How do you know if a point lies on a straight line? Make use of an example to assist you.
5. How do you determine the equation of a straight line when the graph is given.
6. Explain how you can determine the equation of a line which is parallel to another line going through a point, in words. Then find the equation of the line parallel to $y = 2x - 1$ which goes through the point $(3\,;2)$.
7. Explain how you can determine the equation of a line which is perpendicular to another line going through a point, in words. Then find the equation of the line perpendicular to $y = 2x - 1$ which goes through the point $(3\,;\,2)$

When Omega’s beliefs concerning assessment were categorised in each of the continuums and located in one of the two orientations in the conception model of assessment, it was clear that, similar to Eta, she held mixed conceptions of assessment, but her pedagogical conceptions of assessment weighted more heavily and influenced her assessment practices to a greater extent compared to her societal conceptions of assessment. Her pedagogical conceptions of assessment also established an assessment culture which fits in with the characteristics of a “learning-centred classroom”. She could adapt and design assessment with more freedom and thought compared to Alpha, Phi and Lambda. One can argue that the reason for this is because she has much more experience compared to the other participating

teachers. We are reminded that Omega was classified as the "optimistic innovator" assessment designer and practitioner who collects data from all the "learning activities" she uses in lessons. Her conceptions of assessments are aligned to the characteristics of a "learning-centred classroom", which is the reason why she could design and redesign assessment questions that promote mathematical proficiency.

5.5 DILEMMAS TEACHERS EXPERIENCED ADAPTING THEIR CLASSROOM-BASED ASSESSMENT PRACTICES

My experiences working with teachers, as well as in the literature I reviewed, suggest that as teachers incorporate new ideas to their assessment practices and is committed to transforming their assessment practices, they are likely to face various challenges. I witnessed that for each teacher the challenges, as well as the degree of the challenges, the participating teachers experienced in redesigning assessments towards mathematical proficiency, differed substantially.

All the participating teachers commented that their desire to change their classroom-based assessment had an impact on how they thought about teaching and learning. I decided to analyse the challenges they face designing and implementing transformed classroom-based assessments by focusing on their aim for constructivist teaching. I will use an adapted analytic framework, which I referred to in my literature review, developed by Windchitl (2002), and amended by Suurtamm and Koch (2014) in terms of a more specific focus on assessment, to frame the challenges that I observed and which was communicated to me by the teachers. Focusing on these challenges enables us in the wider Mathematics research community to value the complexity of educational change, which is necessary to advance

mathematics teaching and learning, and to suggest ways in which teachers can be supported to further develop their teaching and assessment practice.

The adapted framework takes the teachers' assessment practices before the strands of mathematical proficiency were introduced, as well as the teachers' general views about the curriculum, assessment and the role of the students which was discussed in the earlier chapters in consideration. I needed to remind myself throughout that the goal was not only to evaluate the teachers' assessment practices or views, but also to gain an understanding of the teachers' experiences concerning assessment. This is crucial to present my findings on the challenges teachers experience designing, transforming and incorporating new ideas to their classroom-based assessments.

The four types of dilemmas of Windschilt (2002), conceptual, pedagogical, cultural, and political, are aspects of teachers intellectual and lives experiences that prevent theoretical ideals of constructivism from being realised in school settings. All four types of dilemmas were observed by every teacher, but the degree of the dilemmas varied substantially. Four frames of reference are used to describe these dilemmas. *Conceptual dilemmas* are rooted in teachers' attempts to understand the philosophical, psychological, and epistemological underpinnings of constructivism. *Pedagogical dilemmas* for teachers arise from the more complex approaches to designing curriculum and fashioning learning experiences that constructivism demands. *Cultural dilemmas* emerge between teachers and students during radical reorientation of classroom roles and expectations necessary to accommodate the constructivist ethos. *Political dilemmas* are associated with resistance from various stakeholders in school communities when institutional norms are questioned and routines of privilege and authority are disturbed.

The present findings seem to be consistent with the findings of Windschilt, that while highlighting the characteristics of each type of dilemma can be very useful, the dilemmas may not always fit neatly into one of the four domains and therefore overlapping and interconnections between dilemmas will exist.

5.5.1 CONCEPTUAL DILEMMAS

Conceptual dilemmas arose in the designing of classroom-based assessments which promotes Kilpatrick's strands of mathematical proficiency, as teachers attempted to understand the conceptual underpinnings of their own theories and thinking of what it means for a student to be proficient in mathematics. I found that all the teachers experienced conceptual dilemmas frequently in the beginning phase when they redesigned their assessments. It was also evident that thinking about the purpose of designing and using classroom-based assessments were absent from most of the teachers in the beginning stages of the study. It is important to report that I have not found any instances where the dilemma of the teacher could only be categorised as conceptual and that the conceptual dilemma presented itself in the other dilemmas.

I will use a comment made by Phi to illustrate an example of an experience which falls in three different domains.

> "Although I make use of alternative techniques, I cannot use it for marks. It is frustrating because I feel that students get more out of the more informal assessments, because it serves two purposes: for me to know where they are at, and for the students to learn while being assessed. I do not trust how valid marks of group work are. I am scared that the marks from other techniques may not be an accurate reflection of learners' ability. Tests give me a better sense of learners' ability. Students will not respond well if I change what they are used to" (Phi, GI-A4)

In the first part of her comment, the challenge Phi finds herself in can be described as a tension between what she wants to achieve from classroom-based assessments (a conceptual dilemma) and the frustration she experiences of having to convince the school's administration and students (cultural dilemma) that, without conducting generic traditional forms of assessments, that her ideas will contribute towards mathematical learning. It became clear from the last part of her comment that even though she was convinced about designing using classroom-based assessments which focuses more on learning, she was hesitant to use the assessments because of "the risk involved" which I categorised as both a cultural and political dilemma. The reason I describe her experiences of the fear of the risk involved also as a political dilemma is because her thinking about assessment is not aligned with the thinking of the school, district and provincial. Later in the interviewed she expressed further frustration with the pressure she faces from the school and district on marks. She feels that to give a mark, like 60%, can disguise the feedback of the progress the student is making in the different content areas and that she would rather use a rubric or to report on the students' progress in specific areas.

5.5.2 PEDAGOGICAL DILEMMAS

The pedagogical dilemmas arose when teachers had to search 'how to' act on ideas they have on assessment. Various assessment dilemmas were observed which includes the process of how to design classroom-based assessment that promotes mathematical proficiency, and to convince oneself of the benefits of finding time to conduct forms of classroom-based assessments which is over and above what is required.

5.5.3 CULTURAL DILEMMAS

The cultural dilemma was frequently observed from the teachers when it came to redesigning classroom-based assessments which promotes the strands of mathematical proficiency. Cultural dilemmas around designing classroom-based assessments arose when new assessment practices or ideas about assessments threatened existing cultural practices. Most of the discussions around this challenge were around the teachers from school A being concerned about how the change will affect the students, mainly because of beliefs about limited abilities of their students. Discussions concentrated around expectations about classroom discussions and the concerns of colleagues, students, parents, district and the school about the consistency of the transformed assessments. The fear of students' being uncomfortable with a change to assessment practices and because of a shift in classroom culture were also discussed by all the teachers. Phi commented that she has been discouraged form using alternative forms of assessment by the district inspectors with the reason being the consistency of using assessments across classes. This was interesting in itself because it means that teachers will be discouraged from using new ideas or approaches in their assessment design if it is in contrast to the assessment practices of colleagues due to a fear of consistency.

From discussing the challenges of making changes to his assessment practices, Lambda provided an explanation of a challenge which also falls into the cultural dilemma domain.

> "I guess there is a fear that if I change the type of assessments I deploy, that the students will feel insecure and actually do worse. It is easier to continue with what you know works well and know how to develop" (Lambda, GI-A4))

Lambda explained that he has tried to ask types of questions similar to what he designed in the redesigning process, but that factors such as workload, and teaching of different subjects, has hindered him from following through.

I have categorised the experiences of Alpha as a pedagogical and cultural dilemma. explained that the biggest concerns he has about changing his assessment practices was around his fear of trying something very new and different to what he is used to which might work as intended, and finding the time and pedagogical approach to design and use the transformed assessments.

> "There is a fear of trying something new, as well as trying something new and then it doesn't work. I do not have enough experience and confidence to make major changes. So much time is spent on assuring that we finish the curriculum, to do what is asked from us. It is very difficult to fit innovation into the academic program, there is just not enough time" (Alpha, GI-A4).

The role of parents in changing the assessment practices were only mentioned by the teachers from School B. Eta commented that parents expect formal and traditional assessments, similar to what they received when they were in school, to monitor the progress which their children are making. Eta and Omega referred to the end of term assessments of the grade 8s and grade 9s where the assessment take the form of a guided discovery to introduce a concept which is unfamiliar to students. Examples of the guided investigations included formal constructions in Geometry, introduction to set theory, mathematical modelling, and statistical applications. They both spoke about how they were challenged when the students only received a competency rubric which detailed the level at which the students performed in different categories without any including any marks. They talked about how the culture had to change and for parents to be on-board by trusting the process. For Omega, one of the positive effects of changing the culture around assessments were that parents "backed away a bit and let the student be independent in owning their learning" (Omega, GI-B4). For Eta it was "important to stay current, even if it means to do something your not familiar with" (Eta, GI-B4).

5.5.4 POLITICAL DILEMMAS

The political dilemmas that arose in designing classroom-based assessments centred around conflict between teachers thinking about assessment, teaching and learning, with the prescribed curriculum. The teachers talked through their desire to report about students' progress in each of the proficiency strands but being limited in the structure of the end of term reports. The conflict between the specific goals and aims of the Curriculum and Policy Statement, and what they perceive is expected from them also came to light. All the discussions about the teachers' different views of the curriculum presented here.

Honing into the challenges that teachers face when they bring new ideas to their assessment practices provided valuable insights. I found that the adapted framework helped me to better understand teachers' thinking and transformed assessment practices as they implemented new ideas to their assessment practices. To be able to categorise the comments made by the teachers about the challenges they face redesigning assessments into different categories helped me unravel the challenges and frustrations teachers experience by focusing on the individual types of dilemmas. Every single comment made by the teachers about their challenges could be categorised in at least one type of dilemma. Therefore, it is my view that the four types of dilemmas extensively encapsulate the varied challenges the teachers face when they want to act on their new ideas about designing classroom-based assessments. As Suurtamm and Koch (2014) pointed out, developing an in-depth understanding of the conceptual, pedagogical, cultural and political challenges teachers face is the first step in better understanding the complexity of changing assessments. An understanding and acknowledgement by teachers that each of the dilemma domains are essential is not only important for professional development designers to support teachers, but more important for teachers to acknowledge to.

The lack of resources that the teachers from School A referred to and the understanding of the types of activities that are most effective for constructivism to take place, which falls under the pedagogical dilemmas, requires different forms of support than any of the other dilemmas. The different views of assessments by colleagues, parents, district officials and students which manifested in a short period of time causes immense frustration to the teachers. The teachers can be supported by ongoing forms of communication to the different stakeholders to make classroom-based assessment practices transparent to everyone. It was clear that conversations between the parties about the intended purpose of conducting classroom-based assessments were absent. Understanding and acknowledging cultural and political dilemmas will result in a better working relationship and trust between theses stakeholders which is vital for students.

The overlapping and interconnections between dilemmas was a surprise for me. Almost all of the comments were categorised in more than one dilemma which, for me, points to the extend of the challenges that the teachers face to strive towards constructivism.

Although my observations are based on the experiences of a small number of teachers in two schools, the observations are in line with the observations of other studies of teachers' assessment practices. It must be noted that research about the challenges that the teachers face when integrating new ideas to their teaching or assessment practices are scares, and that there is a need for theoretical contributions on the better understand and contribute to the literature.

My findings confirm the findings of Suurtamm (2014), Lund (2008), Shepard (2001), and; Gipps (1999) that teachers' perspectives on classroom assessment that draw on cognitive, constructivist, and sociocultural views of learning have shifted from a view of assessment as an event that objectively measures the acquisition of knowledge toward a view of assessment as a social practice that provides continual information to support student learning. Only after the research was their consensus between the teachers that instruction and assessment are seamless processes (Suurtamm, 2014) that supports students' learning through continuous feedback to teachers and students. We recognised that learning is not linear, but multi-dimensional and that complex processes requires innovative assessment practices. Teachers have their own beliefs and established classroom practices that unavoidably interact with current thinking about mathematics education and assessment, but these beliefs should be challenged to enhance mathematical teaching and learning.

5.6 CONCLUSION

I asked each of the teachers to redesign a classroom-based assessment that promotes the five strands of mathematical proficiency. The designing and redesigning of classroom-based assessments that promote the first four strands of mathematical proficiency was considerably more complex and interlinked than I anticipated. The purpose of redesigning classroom-based assessments was less on producing a perfect assessment instrument, but more on understanding the process of designing, critically evaluating, and redesigning the assessments. Mathematics teachers in South Africa are asked to adapt their teaching and assessment practices to: teach mathematics for conceptual understanding; teach so that learners develop procedural fluency; develop learners' strategic competence; provide multiple and varied opportunities for learners to develop their mathematical reasoning skills; and, lastly, promote a learning-centred classroom. It is vital to understand what factors

greatly influence teachers' assessment practices, especially if teachers are expected to amend their assessment teaching and practices, which is the case with the implementation of the Mathematics Teaching and Learning Framework for South Africa (DBE, 2018).

5.6.1 THE LEARNING-CENTRED CLASSROOM

The model of teaching and learning mathematics in the Mathematics teaching and learning framework for South Africa assisted us in understanding why the participating teachers found it challenging to incorporate new ideas into their assessment, and to design assessments towards mathematical proficiency. The model subscribes the first four mathematical proficiency strands (conceptual understanding, strategic competence, procedural fluency, and adaptive reasoning), each of which is underpinned by a "learning-centred classroom". The participating teachers' who found it challenging to design assessments to assess the students' proficiency with the first four strands, held societal conceptions of assessment, and had a testing culture of assessment. The model interprets that participating teachers' challenge with the assessment design towards proficiency lies in their culture of assessment. The model of mathematics learning and teaching explains that the "learning-centred classroom" must consist of activities and practices such as addressing learners' errors, purposeful assessment, connecting concepts, active learning, and making sense of mathematics. The problem is that the "learning-centred classroom" is strongly aligned to the practices associated with pedagogical, assessment culture conceptions of assessment, as opposed to societal, testing culture conceptions of assessment.

I believe that the mathematical framework correctly underpins each of the four dimensions (conceptual understanding, strategic competence, procedural fluency, and adaptive reasoning) with the "learning-centred classroom". The challenge, therefore, is that, for teachers to have a teaching and learning culture associated with the "learning-centred

classroom", their conceptions make for extensive hurdles blocking the way, which will have a direct impact on how they teach and assess their students for mathematical proficiency. Therefore, in order for teachers to incorporate new ideas and adapt their assessment towards mathematical proficiency, it is important for teachers and professional development designers to be aware of the extensive effect that teachers' conceptions have on their assessment and teaching practices. The teachers' conceptions of assessment, either as pedagogical conceptions or societal conceptions, are shaped by: (a) assessment's defined functions and purposes; (b) what they perceive as the official curriculum within the school structure and where they position themselves in relation to the subject matter; and (c) how they understand learning and their students.

5.6.2 TEACHERS SHIFTING ASSESSMENT PRACTICES

I realised that to view all teachers as the same would be misinterpreting the diversity of the mathematics teachers in South African schools. Some of the teachers could adapt and redesign their assessments without difficulties, while for others it proved an enormous strain. The exposure and experience of designing assessments varied greatly. None of the teachers received professional development on designing classroom-based assessments, which is odd if one considers the important role classroom-based assessments play in the learning process. In a study on transforming assessment practices in Canada, Suurtamm (2014) found that any request for teachers to shift their assessment practices to align with different perspectives may pose challenges for teachers. It might be because a change in teachers' assessment practices may be unfamiliar to teachers and may test their deeply held notions about the purpose of education and the nature of mathematics teaching and learning (Ball, 2003; Shepard, 2001; Black and Wiliam, 1998). Teachers are situated in a complex landscape of accountability in which they are often portrayed as technicians tasked with implementing

prescribed curriculum, policies, and procedures (Suurtamm, 2014; Cochran Smith and Lytle, 2009). A substantial amount of time had to be spent on aligning these notions. Walking the journey with each of the teachers gave me insight into their beliefs about all the underlying factors at play when it comes to designing assessments. The teachers' conceptions on the purpose of assessment, combined with subject knowledge, were the most important characteristics when it came to redesign classroom-based assessments effectively in a way that promotes the strands of mathematical proficiency.

5.6.3 LEARNING OF MATHEMATICS – INTEGRATING ASSESSMENT AND INSTRUCTION

The teachers' contrasting views of the purpose of designing and conducting classroom-based assessments provided insight into their views on the learning of mathematics. The relationship between instruction and assessment, whereby assessment guides instruction, to which both Alpha and Lambda referred when they talked about beliefs about assessment, were absent from the process of developing assessments, as well as in the redesigning of classroom-based assessments. Alpha and Lambda considered the purpose of conducting classroom-based assessments as a means of assessing knowledge and to adhere to the minimum requirements which the curriculum demands, thereby isolating assessment from learning. This was concerning, keeping in mind that current perspectives on classroom-based assessments which draw on cognitive, constructivist, and sociocultural views of learning have shifted from a view of assessment as an event that objectively measures the acquisition of knowledge towards a view of assessment as a social practice that provides continual information to support student learning (Suurtamm, 2014; Lund, 2008, Shepard, 2001, Gipps, 1999). Both Alpha and Lambda conceived of assessment, instruction, and learning as seamlessly linked towards the end of the redesigning phase, but only after realising that

learning is multi-dimensional and that complex processes require innovated and varied assessment practices (Brookhart, 2003; Delandshere and Petrosky, 1998; Gipps, 1999).

5.6.4 THE MATHEMATICAL PROFICIENCY STRANDS

It is challenging to assess and differentiate between the different strands, as most early concepts are focussed on procedural fluency. Procedural fluency is often ingrained into strategic competence, adaptive reasoning, and conceptual understanding. The mathematical proficiency strands are not independent but instead "represent different aspects of a complex whole", thus leading to the notion of intertwined strands (Kilpatrick et al., 2001). The participating teachers individually assessed each of the strands of mathematical proficiency, but it is important to remember that "the dimensions can be focused on individually, but they are all interconnected" (DBE, 2018).

Numerous studies (Suh, 2007; Samuelson, 2010; Langa and Setati, 2007; Moodley, 2008; Pillay 2006; Ally, 2011) have found that procedural fluency is the dominating proficiency strand, not only when it comes to classifying questions in assessments, but also when considering the problems teachers do with students. Productive disposition has been thought of as the hidden strand (Siegfried, 2012). Seven essential indicators for assessing for productive disposition were conceptualised: (1) mathematics as a sense-making endeavour; (2) mathematics as beautiful or useful and worthwhile; (3) beliefs that one can, with appropriate effort, learn mathematics; (4) mathematical habits of mind; (5) mathematical integrity and academic risk-taking; (6) positive goals and motivation; and (7) self-efficacy. A study by Jacobson and Kilpatrick (2015) found that an essential element of productive disposition teachers affect, which includes partial cognitive traits such as attitudes and beliefs, as well as non-cognitive traits such as motivation and grit, is often defined in opposition to purely cognitive traits such as mathematical knowledge. The researchers

wrestled with how to conceptualise and measure constructs that are sensitive to the content and context of instruction. The central conjecture is that change in practice is deeply entwined with simultaneous, interdependent change in teacher knowledge and effect.

CHAPTER 6:

CONCLUSION

The purpose of this chapter is to summarise and conclude the research which was conducted in this study. The chapter is divided into six sections. The first section provides an overview of the research by briefly outlining the aims and background of the study, the methodology adopted for data collection, as well as my approach to the analysis of the data. The second section presents a summary of the results, highlighting the key findings of the study. Each of the finding's aspects (the functions and purposes of assessment, the perceived curriculum, the context, the expectations of students) concerning the teachers' conceptions of assessment, represented in figure 16, is discussed against societal and pedagogical conceptions of assessment and the resulting assessment practices. The third section provides an argument about the implications of the research findings for professional practice, by discussing four principles of assessments that this study found, which are key for teachers to be able to incorporate new ideas into their design and use of classroom-based assessments, and to adapt their classroom-based assessment to promote a learning-centred classroom. Finally, the three sections elaborate on the limitations of the study, followed by the implications of the research findings, while also providing practical recommendations and suggestions for further research.

6.1 OVERVIEW OF THE RESEARCH

The previous five chapters of this dissertation out the purpose of this study, positioned the topic in the literature in the two theoretical perspectives chapters, outlined the methodology and research design, and discussed the qualitative research findings. The rationale of this

research study was to investigate and learn how the assessments of secondary-school mathematics teachers could be designed for mathematical proficiency to achieve a professional development agenda. My study thus aims to contribute to the research literature on the professional development of secondary-school mathematics teachers. One of the aims of the research is to respond to on-going calls that have been made for research into how teachers assimilate new ideas about their classroom-based assessment into their practice. This study on designing assessments towards mathematical proficiency is especially relevant as the Mathematics Teaching and Learning Framework (DBE, 2018) draws on Kilpatrick's et al.'s (2001) five strands of mathematical proficiency to bring about the transformation of mathematics in South Africa. The Mathematics Teaching and Learning Framework (DBE, 2018) emphasises that "a ground-breaking and sustainable intervention that will change the approach to teaching Mathematics is required" (DBE, 2018, p11) for teachers to change the way in which they present mathematics, conduct classroom practices, and engage with learners in their classes. The framework model (DBE, 2018) not only draws on Kilpatrick's et al.'s (2001) five strands of mathematical proficiency, but its dimensions also represent an adaption of the strands to the South African context. Furthermore, the framework focusses on the relationship between teaching and learning mathematics, and emphasises the critical role that assessment plays in this relationship. I believe that the most effective way we can make changes to the quality of education in South Africa is to focus on teachers. Teachers are viewed as essential agents of change in the on-going attempt to reform education, but they are also significant obstacles to change and education reform: "Classroom assessment requires a great deal of time and effort; teachers may spend as much as 40% of their time directly involved in assessment-related activities. Yet teachers are neither trained nor prepared to face this demanding task" (Stiggins, 1988, p.224). There is a need to consider whether the teachers' conceptions of assessment influence their assessment practices, or, as

Pehkonen (1994) theorised, teachers' conceptions are formed by acting on school practices, including the learning experience the teacher experienced as a student, and the influences of the environment where the teachers teach. The three subsidiary research questions which this study attempts to answer are: (1) How do teachers describe and justify their current classroom-based assessment practices?; (2) How do secondary-school mathematics teachers adapt their assessments to towards assessing mathematical proficiency?; and (3) What are the challenges teachers experience in incorporating new ideas in the design of classroom-based assessments?

6.2 SUMMARY OF KEY FINDINGS

This chapter presents the key findings of the research by drawing together all the themes and threads which arose throughout the research study. I framed the data by using the theoretical framework, which was presented in Chapter 3. The three main concepts of the theoretical framework, which are adapted from Belbase (2012) are (1) teachers' beliefs; (2) teachers' assessment practices of mathematical proficiency (MP); and (3) teachers' knowledge of mathematical proficiency (MP). In this study I promoted teachers' knowledge of mathematical proficiency (MP) as described by Kilpatrick et al., (2001). As noted in the previous section, having teachers reflect on and take control of the process of designing and using formative classroom-based assessments contributes to the professional development of teachers and gives the mathematics community a better understanding of the complexity of adjusting assessments. The findings respond to the overarching aim of my research to better understand how secondary mathematics teachers can redesign their classroom-based assessments towards mathematical proficiency. The findings answer the three subsidiary research questions which this study attempted to answer: (1) How do teachers describe and justify their current classroom-based assessment practices? (2) How do Secondary School Mathematics teachers adapt their

assessments to towards assessing mathematical proficiency? (3) What are the challenges teachers experience incorporating new ideas in the design of classroom-based assessments?

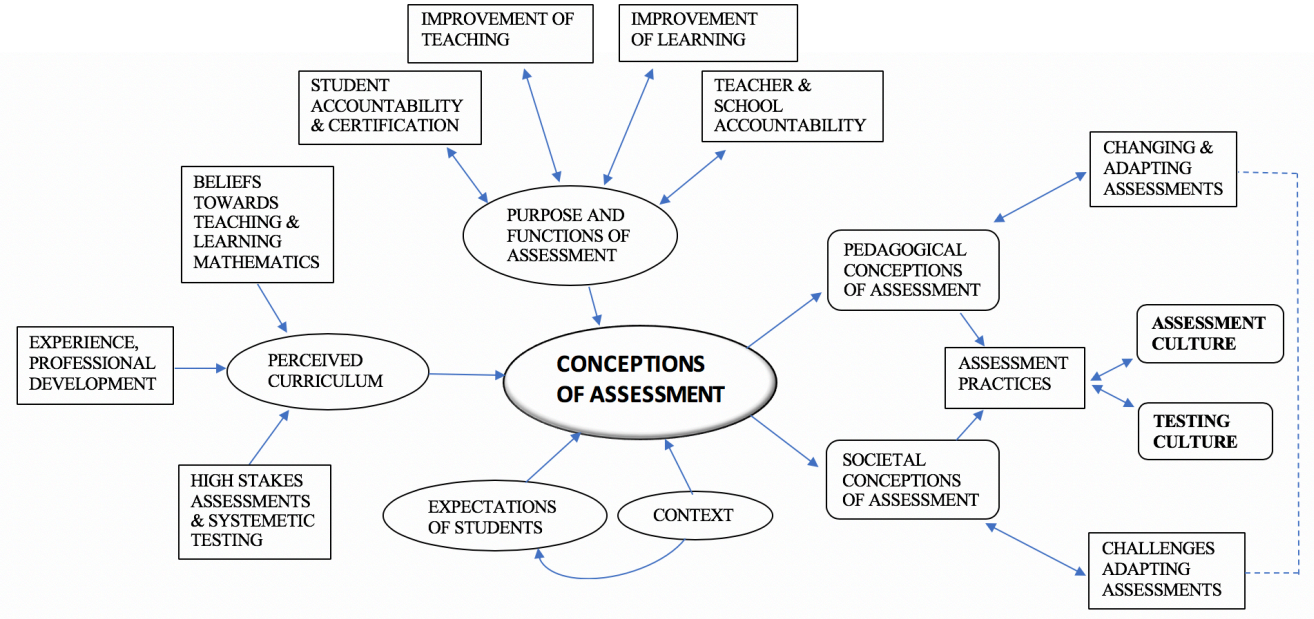

Figure 16: Summary of the study's key findings

The discussion of the findings places teachers' conceptions of assessments at the centre. In Figure 16, the direction of the arrows is indicative of the influence it asserts. The discussion of the findings further explains how each of these four key aspects (purpose and function of assessment; the perceived curriculum; expectations of students; and school context) shape teachers' conceptions of assessment, which results in them having either societal conceptions of assessment or pedagogical conceptions of assessment. Societal or pedagogical conceptions of assessment affect assessment practices, and result in teachers having an assessment culture or testing culture of assessment. Lastly, I will present my findings on how teachers can adapt and incorporate new ideas in their assessments, by locating and linking changing of assessments, as well as the challenges of changing assessments to the two resulting conceptions of assessment. An illustration of the findings of the research conducted is indicative of interconnections between these three aims, as illustrated in figure 16 above. This

study found that classroom-based assessments drives the teaching and learning practices. The teachers' use and design of classroom-based assessments towards mathematical proficiency gave me a window into their beliefs. Furthermore, my intervention allowed me to consider the complex relationship between teachers' knowledge of mathematical proficiency, teachers' classroom-based assessment practices and teachers' beliefs concerning assessment. This argues the importance of distinguishing between teachers' beliefs and teachers' conceptions of assessment.

6.2.1 TEACHERS' CONCEPTIONS OF ASSESSMENT

In my quest to understand how teachers justify their assessment practices, adapt their assessments towards mathematical proficiency, as well the challenges teachers face in incorporating new ideas in assessments, the aspect identified at the centre of a complex directed network of influences was the teachers' conceptions of assessment. I was taken aback by this finding, as I initially thought of the teachers' beliefs concerning teaching and learning to have the biggest effect on their assessment practices. Teachers' beliefs concerning teaching and learning were only one of the aspects that directly affects, constructs, and defines teachers' conceptions of assessment. When it became evident that the participating teachers either had an assessment culture or a testing culture of assessment, I found that pedagogical or societal conceptions of assessment had the most significant effect on the respective cultures of assessment, which, in turn, described the assessment practices. In order to better understand the teachers of assessments, I made use of Delandshere & Jones's (1999) three assertions of conceptions of assessment: Teachers' beliefs about assessment are shaped by: its defined functions and purposes; what they perceive as the official curriculum within the school structure and where they position themselves in relation to the subject matter; and how they understand learning and their students. The three assertions of conceptions of

assessment, together with a four-continuum model of conceptions of assessment, assisted me in homing in on the key aspects and major influencers, such as: teachers' beliefs of teaching and learning mathematics; teachers' experience and professional development; beliefs of the intended curriculum, the effects of high-stakes examinations and systemic testing, school context and the learning environment; and how teachers viewed their students. Purposes and functions of assessment were described by investigating to what extent teachers believed assessment is used to improve learning and teaching, as well as for accountability and certification purposes of all the role-players.

6.2.1.1 CONSEQUENCES OF SOCIETAL AND PEDAGOGICAL CONCEPTIONS OF ASSESSMENT

I found that the best way to understand fully the degree of influence which each of the two conceptions has on classroom practices is to look critically at the differences between the societal and pedagogical conceptions.

The first difference is how assessment can be used as a tool for improving learning. Teachers' pedagogical conceptions are paramount to being able to advocate a learning-centred classroom, whereas teachers' societal conceptions will continue to create conflict when using a "testing culture" of assessment for learning purposes. The study found, from analysing the teachers' pedagogical conceptions of assessment used as a tool for improving learning, that: (1) assessment can serve a didactical purpose; (2) assessment can create learning situations to enhance students' strategic competence; and (3) assessment can create learning situations for students to learn from their mistakes. The participating teachers' societal conceptions of assessments used as a tool for the improvement of learning revealed two major conclusions: (1) the students' awareness of the degree of the progress they have made was the end-result of learning and are classified as "assessment of learning"; and (2)

teachers' conceptions of assessment being used for student motivational purposes exposes significant challenges. This is in stark contrast to pedagogical conceptions of assessment, which enhance a testing culture, and endorse "assessment for learning", which in turn enable teachers and students to seek and interpret evidence of their learning to decide where the students are positioned in their learning, where they need to go in relation to their goals, and how best to achieve the goals.

The second difference between the two types of conceptions is how the teacher positions problem-solving. Societal conceptions of assessment, which accommodate a testing culture, see problem-solving as higher-order problems, similar to the upper end of Bloom's adapted taxonomy. In contrast, pedagogical conceptions, which accommodate an assessment culture, see problem-solving as embedded in teaching and learning, and form the basis of a learning-centred classroom. Here, problem-solving skills are seen to consist of conceptual understanding, adaptive reasoning, and strategic competence, as well as procedural fluency to a certain degree. Although problem-solving is seen as being embedded in a learning-centred classroom by teachers, their formative classroom-based assessments did not accommodate for or include problem-solving; rather, problem-solving was used to measure higher-order problems in "assessment of learning".

The third difference resides in the degree of feedback that the assessment generates. The purposes of using specific types of assessment must foresee the specific type of feedback and assessment data that the assessment will generate. Current perspectives in classroom assessment (e.g. Brookhart, 2003; Suurtamm et al., 2016) encourage the use of a range of assessment strategies, tools, and formats, providing multiple opportunities for students to demonstrate their learning, making strong use of formative feedback on a timely and regular basis, and including students in the assessment process. We learned from reviewing the literature on formative classroom-based assessment that feedback is at the heart of this form

of assessment. Yet, comments – such as "We don't always have appropriate feedback opportunities after assessment, which minimises the opportunity the student has to learn from the assessment and for me to make changes to my teaching" (Omega), and assessment "often has little impact, as assessment is done after content has been taught" (Lambda) – illustrate that teachers often use formative classroom-assessments for summative purposes, which limits the effectiveness and quality of the feedback that the assessment generates. For teachers to have pedagogical conceptions of assessment, which aligns to an assessment culture and, ultimately, a learning-centred classroom, the qualitative and descriptive assessment feedback, as opposed to merely giving quantitative feedback, is critically important. The importance of the feedback is not only essential for teachers, but also for students about present understanding, performance and skill development, which will accelerate learning (see Harlen and James, 1997; Sadler, 1998). This study found that a vacuum exists in the classroom-based assessment process regarding students receiving feedback about their learning with advice on what they can do to improve. As a consequence, students are not active participants in their evaluating their own learning and understanding.

6.2.2 THE PERCEIVED CURRICULUM

6.2.2.1 TEACHERS' BELIEFS OF TEACHING AND LEARNING

I showed in the earlier chapters that the literature on teachers incorporating new ideas in the teaching and assessment practices is overflowing with evidence that real and lasting change is achieved only if teachers' belief systems support the underlying premises of the changes they are asked to implement (see Chapman, 2002). When one considers this aspect, it is therefore insufficient merely to provide teachers with curriculum resources, materials, and ideas, without attending to the teacher's beliefs of teaching and learning mathematics. The teachers' beliefs of what students should be able to demonstrate mathematically, linked to a range of

the mathematical strands (chapter 5.2.2). The teachers' teaching experience, as well as the professional development they received, did not correspond to specific strands. Linking the teachers' beliefs of teaching and learning mathematics to the five strands of mathematical proficiency was important for two reasons: firstly, it showed that teachers' beliefs systems concerning learning and teaching mathematics would be able to accommodate Kilpatrick's five strands of mathematical proficiency, which, secondly, means teachers would be able to design classroom-based assessments towards mathematical proficiency.

The study found that teachers' beliefs concerning teaching and learning and their assessment practices were not closely correlated. Although the teachers' beliefs of teaching and learning mathematics showed that they strive to develop four of the five mathematical strands, their classroom-based assessments, which they have designed, tell a different story. It was if they knew what was beneficial to do, but were hesitant to do it because of their concern about how making changes would impact the students' performance in high-stakes examinations and systemic testing. I found that the teachers' beliefs of learning and teaching mathematics had an influence on their perceived official curriculum. My findings did not confirm the findings of Griffiths, Gore and Ladwig (2006) that teachers' beliefs about teaching and learning mathematics affected their teaching and assessment practices to a greater degree than teaching experience and socio-economic school context do. It was not their beliefs of teaching and learning that had the greatest effect; rather, it was their conceptions of assessment, especially in terms of pedagogical conceptions versus societal conceptions of assessment, that affected their classroom and assessment practices.

6.2.2.2 EXPERIENCE AND PROFESSIONAL DEVELOPMENT

As stated in Stiggins (1988, p. 363): "Classroom assessment requires a great deal of time and effort; teachers may spend as much as 40% of their time directly involved in assessment-

related activities. Yet teachers are neither trained nor prepared to face this demanding task". The sad reality, if one considers Stiggins's comment, which was published more than 30 years ago, is that not much has changed to support, train, and equip teachers with the tools to design and use formative classroom-based assessments effectively. The Strategic Planning document of the Department of Basic Education, Republic of South Africa (DBE, 2011, p. 77) states: "The problem of poor quality teaching and poor subject matter knowledge of our teachers, a legacy of apartheid teacher training, is one of the greatest impediments to improved delivery of quality education in the system as a whole."

This study found that teachers spend minimum time designing and planning formative classroom-based assessments and that formative classroom-based assessments fulfil a summative purpose. The frequent assessment of students during the learning process allows teachers to adjust their instruction to address learning deficiencies and misconceptions before it is too late and student motivation decreases (Stiggins, 1999). I was surprised that some of the teachers never questioned the effectiveness of the classroom-based assessments, and whether the purposes of designing and using classroom-based assessments will deliver the desired feedback to both the teacher and student. Although I was not as surprised by the lack of professional development, training, and exposure the teachers received in designing classroom-based assessments, I was surprised at how little thought, time, and energy they have spent on formative classroom-based assessments. None of the participating teachers was confident from the start about incorporating new ideas into his/her assessment practices, and the teachers of School A felt that they assess, to a certain degree, in a similar way as they were assessed as students. Collaboration between staff members teaching the same grade of students was inconsistent between the teachers at School A. The findings indicate that professional development, which can be seen of as "assessment as learning", is required to support teachers' formative assessment practice in the classroom, which is theorised as

"assessment for learning". Van der Nest et al. (2018) claims that professional development relating to classroom-based assessments are of significant importance in order to support teachers with a deeper insight into knowledge domains through engagement with the given activity sets.

The Mathematics Teaching and Learning Framework (DBE, 2018) responded to the lack of professional development in South Africa, by providing teachers with a clearer idea of how the framework could be implemented with examples of how the four continuums might be visible in mathematics classrooms. I believe that supplementing the theoretical background to the proposed balanced approach with worked exemplars which bring the dimensions of this balanced approach to life across all phases in the sector is a step in the right direction.

6.2.2.3 HIGH-STAKES ASSESSMENTS AND SYSTEMIC TESTING

As I explained in the first chapter, this study was not about discrediting summative assessments, nor assessments, which have the perspectives of assessment of learning. I believe that in a balanced classroom-based assessment system, both summative and formative assessments are essential for information gathering. I also believe, however, that assessments can either undermine or encourage learning. This study confirmed that inevitable outcome of high-stakes testing or "teaching to the test" is the narrowing of the curriculum to focus only on what will be assessed, as well as categorising students from an uncompounded perspective, according to what the assessment determined they can or cannot do. We need to ask how we can ensure that teachers' assessment and teaching practices are conducive to a learning-centred classroom, at the same time as meeting short-term certification or accountability goals of high-stakes assessments and systemic testing. Not all the findings were negative. While all teachers acknowledged that their teaching and assessment decisions

were heavily influenced by high-stakes assessments, the teachers who hold pedagogical conceptions of assessment, and as a result have an assessment culture conducive to a learning-centred classroom, also state that they tried to teach beyond the assessment; in other words, they were not "teaching to the test". The study found that it is possible for teachers' assessment practices not to be paralysed by the influence and consumption of the accountability and certification goals of high-stakes assessments and systemic testing, given that they held pedagogical conceptions of assessment. Therefore, it will be possible for teachers to use the balance of formative classroom-based assessment and summative assessments to have cultures of assessment conducive to a learning-centred classroom.

6.2.3 PURPOSE AND FUNCTIONS OF ASSESSMENT

The study has witnessed the intense tensions that exist between assessment of learning and assessment for learning when teachers design and use assessment. Ultimately, what determines whether an assessment is classified as formative (assessment for learning) or summative (assessment of learning), is dependent on the purpose of the assessment, how the results are used, and the feedback that the assessment will generate. It was essential for me to realise and acknowledge that, for teachers, the purpose for which any assessment is developed and being upheld is an imperative aspect of the assessment. Nevertheless, a classroom-based assessment that is designed to provide formative feedback is only formative, in the sense of being an assessment for learning, if the teacher uses the assessment to provide qualitative and descriptive feedback for the students. If the teacher only uses the formative assessment to dispense a grade or quantitative feedback, however, one needs to ask whether that assessment is still formative. I believe that how assessment data will be interpreted, which includes the type of feedback that the assessment will provide, is an accurate indication of how the assessment should be labelled, as this denotes the true purpose of the

assessment. I believe that teachers' conceptions of assessment – which consist of and are fed by multiple beliefs, such as their expectations of their students, their beliefs about teaching and learning mathematics, and their beliefs of the purposes of assessment – result in them having either a pedagogical or societal conception of assessment. This in turn results in them confining to either an assessment culture, which is conducive to a learning-centred classroom, or a societal conception of assessment. It was clear that teachers did not spent as much time as they would have preferred on designing and planning formative classroom-based assessments, and that formative classroom-based assessments fulfilled a summative purpose. The frequent assessment of students during the learning process allows teachers to adjust their instruction to address learning deficiencies and misconceptions before it is too late, and student motivation decreases (Stiggins, 1999).

6.2.4 EXPECTATIONS OF STUDENTS

Following from the previous section, I found that teachers use assessment, which initially was intended to measure, to categorise students to perceived perceptions of abilities, therefore labelling and creating, rather than to measure. I found, similar to Stobart (2008), that because assessment does not objectively measure what is already there, but rather creates and shapes what is measured, it is capable of "making up people". Assessment can take an idea or speculation and make it seem, through using measurement and giving names and classifications to it, as though it really exists (Stobart, 2008). This study found that, although teachers at both schools subscribed to the ideals of socio-constructivism and that all students have the ability to do mathematics, the comments they made in the semi-structured interviews about the students they teach point to beliefs of the ability of their students as being stable, and limits the effectiveness of effort). Teachers would make comments such as "our students in our schools". There was an interesting exchange that took place between the

Alpha, who is the principal of the government lower quintile school (School A) and one of the teachers who repeatedly referred to "our type of learners". The participating teachers at School A commented on how the education system treated all students as if they are the same. The teachers at School A shared calmly and empathetically that their students are behind the curve and that it is foolish to compare students from contrasting socio-economic backgrounds who live in better socio-economic conditions.

Teachers' beliefs about their students' abilities, as well as the teachers' expectations of their students, corresponded to their beliefs of teaching and learning mathematics. For example, teachers who held societal conceptions of assessment had lower expectations of what their students were able to achieve, compared to teachers who held pedagogical conceptions of assessment. For the teachers who held societal conceptions of assessment inducive of a testing culture, mathematics is seen as a set of rules to be learned; the correct solution matters most, and it is the goal of the student to get correct solutions; teachers need to exercise complete control over mathematics learning and assessment activities; mathematics ability is mostly fixed and stable, influenced, and ultimately determined by the students context; and assessment results serve as extrinsic rewards and strategies for motivating students to become proficient in mathematics, as well as to behave and engage in the mathematics classroom. In contrast, teachers who had high expectations of their students also held beliefs, including that: mathematics can be used as a tool to develop higher-order thinking of multi-faceted problems; the ultimate goal of students doing mathematics is to understand mathematics conceptually; each student is an individual and should be given some degree of flexibility and freedom to be active in evaluating their own learning; students' ability to achieve in mathematics is susceptible to change; and teaching and learning activities to develop students is essential. The study found that the teachers' beliefs

concerning their expectations and ability of the students they teach are greatly influenced by their beliefs about teaching and learning mathematics.

The teachers' expectations of their students play an enormous part in the students' learning. One example of this is that the teachers' views of their students' abilities determine the cognitive demand of the problems and assessment items which the teacher exposes his/her students to in lessons and assessments.

6.2.5 CONTEXT AND CLASSROOM ENVIRONMENT

In this study, teachers' assessment practices were studied in terms of the classroom environments that they created, and, more specifically, the extent to which their classroom environments were aligned with the principles of a learning-centred classroom. This study found that the context, which includes the learning environment, feeds teachers' conceptions of assessment, and, hence, affects their assessment practices. This finding corresponds to the findings of Green (1971) and Belbase (2012) that teachers' beliefs and conceptions are formed by the context. Similarly to Jakubowski and Tobin's findings (1991), teachers will aspire to make changes in their classroom environments only if they deem such effort worthwhile. There was a need, therefore, to consider whether the teachers' conceptions of assessment influence their assessment practices, or whether teachers' conceptions are formed by acting on school practices, including the learning experience the teacher experienced as a student, and the influences of the environment where the teachers teach. The school and learning environment, the teachers' perceptions of the students' abilities, the teachers' expectations of their students considering the students' socio-economic backgrounds, curriculum and external assessment pressures perceived by teachers, all had a significant impact on the way in which teachers enacted their beliefs. The study did find that the context, in terms of the classroom-environment that the teacher creates, has the most significant

impact on practices. The created classroom and classroom-assessment context, although greatly influenced by the factors mentioned earlier, stems from the teachers' conceptions of assessments. This study found that teachers who hold more traditional beliefs of learning and teaching mathematics and societal conceptions of assessment give their students less autonomy. Furthermore, teachers' conceptions of assessment and the relationship between social contexts, which include social norms such as the roles and function of the teacher and students, were found to be very strong.

6.2.6 CHALLENGES OF ADAPTING CLASSROOM-BASED ASSESSMENTS

The next section responds to the third subsidiary research question to understand the challenges the teachers face designing their classroom-based assessments towards mathematical proficiency. This study has found that when teachers attempt to incorporate new ideas in their assessment practices, they found the process to be problematic, filled with multiple obstacles. The study also established that teachers' societal conceptions of assessment, which manifest in a testing culture, outweigh their pedagogical conceptions, and as a consequence, are a far greater influence on their formative classroom-based assessment practices than was the case with their pedagogical conceptions. The study notes that teachers cannot simply be expected to adapt their assessments, especially if they do not consider the multi-dimensional nature of their conceptions of assessment. Finally, this study has found societal conceptions to be a major obstacle in enhancing a learning-centred classroom. I will even go further to say that societal conceptions do not accommodate a learning-centred classroom and that the perspectives of societal conceptions of assessment are mutually exclusive of a learning-centred classroom. This finding of the study, concerning the dilemmas teachers face in designing assessments, concurs with the findings of Windschitl (2002): while highlighting the characteristics of each type of dilemma (conceptual,

pedagogical, cultural and political) can be very useful, the dilemmas may not always fit neatly into one of the four domains and therefore overlaps and interconnections between dilemmas will exist. Professional development which focusses on teachers adopting pedagogical conceptions needs to occur if teachers are to be expected to adopt their assessment practices towards mathematical proficiency, and ultimately to enhance the learning-centred classroom.

The last finding on which I want to focus on involves the integration of the five strands of mathematical proficiency and Bloom's taxonomy. The framework which was discussed in chapter 3.4 places the five strands of mathematical proficiency on the circumference of a circle. The five nodes of mathematical proficiency form a pentagon that represents mathematical proficiency, and the size of the flexible circle is indicative of the cognitive demand of classroom-based assessments. Because the teachers were familiar with the four cognitive levels of Bloom's taxonomy: knowledge; procedural knowledge; complex procedures; and problem-solving, I integrated Bloom's taxonomy and the five strands of mathematical proficiency. The participating teachers initially made the mistake of seeing the five strands of mathematical proficiency as mathematical concepts that increase in cognitive demand. This study has found that the all the participating teachers designed classroom-based assessments which promoted mathematical proficiency at a lower level cognitive level. The result of this is that teachers who were able to design parts of a classroom-based assessment which focused on more than procedural fluency, could not integrate the mathematical strands and the goal of mathematical proficiency with a range of cognitive demands. The participating teachers found it difficult to distinguish between a question which focuses on assessing conceptual understanding at a knowledge level or a complex level. For classroom-based assessments to be designed to mathematical proficiency, teachers need to integrate the

cognitive demand of classroom-based assessments with the five strands of mathematical proficiency.

6.2.7 CONCLUSION

This study concurs with Stiggins (2002) that, "if we are finally to connect assessment to school improvement in meaningful ways, we must come to see assessment through new eyes" (Stiggins, 2002, p. 758). To treat assessment as a one-dimensional aspect of teaching and learning that will naturally occur will not advance learning, nor improve teaching. The nature of assessment remains critically important not only because the findings suggest that the classroom practices of teachers do not happen incidentally, but also, as Schoenfeld (2007) found, what you test is what you get. Assessing students does not by itself result in increased student accomplishment, much like a pig never fattened because it was weighted (Fulcher et al., 2014).

The study found that the teachers' epistemological perspectives about how mathematical knowledge is acquired, and their ontological perspectives of their personal conceptions of the nature of reality, affect how they design classroom-based assessments. The relationship between the teachers' epistemological perspectives and their views on the importance of learning and teaching mathematics appears to be more complex than the study initially anticipated. There exists, therefore, the reality that teachers can prepare students, by means of creating a learning environment and culture of teaching and assessment, in a way that is comfortable to the teachers' conceptions of assessment, and not necessarily as the most effective way to advance learning.

Although teachers are essential agents of change in the on-going attempt to reform education, they are also significant obstacles to change and education reform. Current reforms in mathematics educations, such as the mathematics teaching and learning Framework for South Africa, (DBE, 2018) will demand of teachers to adapt their assessment

and teaching practices to be conducive to a learning-centred classroom. This study has found that teachers cannot simply be expected to adapt their assessments without adapting their conceptions of assessments. Teachers' conceptions of assessment are formed by an entangled network of beliefs, including beliefs of teaching and learning mathematics, beliefs of the purposes of assessment, beliefs of the expectations of their students and beliefs concerning the ability of their students. In order to effect teacher change, the teachers' conceptions of assessment must be aligned to the perspectives of pedagogical conceptions of assessment, which results in having an assessment culture of assessment. Teachers' use and design of formative classroom-based assessments for summative purposes, in term of generating quantitative feedback for grading purposes, is the result of teachers having mixed societal and pedagogical conceptions of assessment, where the societal conceptions of assessment outweigh the pedagogical conceptions, and teachers therefore promote a testing culture above culture of assessment, which is not conducive to a learning-centred classroom.

The school and learning environment, described as the context, has a significant effect on teachers' belief systems, and ultimately, their conceptions of assessment. This study used Shepard's (2000) learning-centred classroom as a conceptual framework. The analysis of teachers adapting their assessments towards mathematical proficiency, as well as understanding how they justify their assessment practices, showed that teachers' learning, curriculum and assessment theories are not exhaustively describing what is happening when teachers are expected to incorporate new ideas into their assessment practices. Without considering the prodigious effect and relationship between teachers' conceptions and their classroom-assessment practices, the attempt to bring changes to assessment will be both short-term and superficial. There is a need, therefore, for teachers to become aware of their own beliefs and conceptions of their classroom-based practices. Teachers' belief systems are not simply "fixed" through a process of replacing certain beliefs with more desirable beliefs.

Rather, teachers' beliefs must be challenged in such a way that desirable beliefs are seen by teachers as the most sensible beliefs to which they should cohere (Leatham, 2006). Both Green (1971) and Thompson (1992) explain that, because beliefs are held in clusters, cross-fertilisation among clusters is prevented, and thus makes it possible to hold conflicting sets of beliefs. This clustering property helped to explain some of the inconsistencies that the study found among the beliefs of the participating teachers.

To varying extents, each of the teachers had realised that new norms of not only teacher behaviour but also student behaviour had to be adopted in order to place students at the core of the assessment and feedback processes. Without students being active participants in evaluating their own learning and understanding, the effects of assessment will continue to be irrelevant. Evidence from this study suggests that teachers' participation in research projects such as the one described is an authentic and meaningful way in which they can begin to acquire the current discourse of formative classroom-based assessment.

6.3 FOUR KEY PRINCIPLES OF CLASSROOM-BASED ASSESSMENTS

This study found that there are four key principles of assessments, which are vital for teachers to be able to incorporate new ideas into their design and use of classroom-based assessments, and to adapt their classroom-based assessment to promote a learning-centred classroom. I believe that by adopting these principles, teachers' conceptions of assessment will be aligned to the perspectives of pedagogical conceptions of assessment which will promote an assessment culture above a testing culture.

The first principle is that the characteristics of **a learning-centred assessment classroom** must be seen as the centre of achieving a socio-constructivist goal. A learning-centred classroom, which integrates teaching with assessment for learning, is a foundation of striving for the development of conceptual understanding, procedural fluency, adaptive

reasoning, and strategic competence. The learning culture in the classroom, which is established by the teacher, has a significant impact on the student's view of the subject matter and the student's involvement in his/her own progress. When a learning-centred classroom is endorsed by teachers, the narrowing of the curriculum as an effect of high-stakes assessments and systemic tests will be terminated. Qualitative and descriptive assessment feedback is at the heart of designing and using assessments to enhance a learning-centred classroom.

The second principle addresses the relationship between teaching and assessment: **classroom-based assessment should be fully embedded with instruction**. One of the functions of classroom-based assessments, which is one of the key beliefs teachers hold and which affects their conceptions of assessments, is that classroom-based assessments should improve, monitor, and direct teaching. Assessment should, therefore, be an on-going process, which is done before, during, and after teaching, for the sole purpose to advance teaching, and, ultimately, the learning that takes place.

The third principle builds on the second principle and homes in on the specific functions and purposes of assessment. The fact is that assessment fulfils many different functions, and the appropriate form of assessment should be used for the appropriate reasons to fulfil the appropriate function. Understanding of and planning the purpose of assessment are vital to **eradicate conflict between formative classroom-based assessments and summative assessments.** There should be a clear distinction between using "assessment for learning", "assessment as learning", and "assessment of learning". Classroom-based assessments must fulfil a greater purpose than merely collecting data in the form of marks for reporting and certification purposes. Although a classroom-based assessment may be designed and packaged as a formative (assessment for learning) or summative (assessment of learning) assessment, it is the actual methodology, data analysis, and use of the results that determine whether an assessment is formative or summative. Teachers' use of formal or

informal summative assessments, which are aligned to "assessment of learning", should not outweigh the use of formative classroom-based assessments, which are aligned to "assessment for learning".

Lastly, the fourth principle sees **students as active participants in learning** by monitoring and evaluating their own understanding. Characteristics of a learning-centred classroom (DBE, 2018), include phrases such as "active learning", "making sense of mathematics", "concept development", and "addressing learners' errors". To reach the goals of developing a learning-centred classroom, students must be active participants, placed at the centre. There is thus a further need for students to evaluate their own learning, as well as the learning of their peers. The setting of clear goals of what has to be learned, and towards being mathematically proficient, is vital for teachers and students to consider possible ways of reaching these goals. Classroom-based assessments should allow students to become aware of their competencies, not only for diagnostic purposes but for the advancing, promoting, and improvement of learning that needs to take place. The fourth and first principles further accentuate the importance of students developing a productive disposition, with the teachers and students emphasising the learning-centred classroom with a clear understanding of how proficiency strands and knowledge are constructed. Teachers' beliefs of their students' abilities and their expectations of their students are indispensable.

6.4 LIMITATIONS OF THE CURRENT STUDY

The qualitative nature of this research study and the small sample of participating teachers and schools limit both the application of the findings and the scope of the research. Specific limitations of the study include my involvement as a researcher. Although I sketched the image of me being a fellow companion with the participating teachers to understand how we can redesign our classroom-based assessments towards mathematical proficiency, I was still

viewed as a researcher and less as a fellow companion. This was even more apparent when I worked with the teachers of School B, since there were restrictions on myself as a fellow teacher. Although all the participating teachers were eager to participate in the study, I was fully aware of the danger of drawing more conclusions than I should. I only focussed on gathering data from teachers and did not gather data from students and administrators. In order to maintain the trust between myself and the participants, I decided not to exert pressure on the participants when they could not provide me assessment instruments I requested.

6.5 IMPLICATIONS OF THE RESEARCH

Although based on a small sample of secondary-school mathematics teachers, the results provide interesting insights into how teachers can adapt their assessment practices according to calls made from current educational reforms, including the Mathematics Teaching and Learning Framework for South Africa (DBE, 2018), to better understand how teachers can change their classroom practice as suggested by the professional development initiative.

The four key principles of assessment (discussed in 6.3) will provide teachers with the theoretical perspectives which could advance their conceptions of assessment towards the perspectives of pedagogical conceptions of assessment, and which will promote an assessment culture above a testing culture. A major finding suggests a strong relationship between teachers' assessment practices and their conceptions of assessments. The most effective way for professional development designers to succeed in teachers adapting their assessment practices is to view the teachers' assessment practices through the lens of their conceptions of assessment. For professional development programmes to be effective in bringing the intended change, two criteria are essential: firstly, socio-constructivism theoretical perspectives, such as the perspectives of the learning-centred classroom (DBE,

2018), must be placed at the core; and, secondly, teachers' beliefs of teaching and learning mathematics do not exhaustively explain their assessment practices. The most significant influence, however, on the teachers' classroom assessment practices were: teachers' conceptions of assessment, which are fed and constructed by teachers' beliefs of teaching and learning mathematics; teachers' beliefs concerning the purpose and functions of assessment; teachers' beliefs about the abilities and expectations of the students they teach; the learning-environment and school context; and teachers' belief of the perceived curriculum.

The study showed that pedagogical conceptions of assessment contribute to an assessment culture, and are conducive to a learning-centred classroom. In contrast, teachers' societal conceptions of assessment contribute to a testing culture of assessment, with the perspectives of "assessment of learning", as opposed to "assessment for learning". The purpose of the assessments, as well as the feedback and data that the assessments generate, defines the type of assessment. The purpose of assessment, the assessment data, and assessment feedback are all embedded in teachers' conceptions of assessment. It is important for professional development designers to understand that teachers cannot be asked to bring effective changes to their formative classroom-based assessment practices without shifting their societal conceptions of assessments to pedagogical conceptions of assessment.

6.6 THEORETICAL CONTRIBUTIONS OF THE RESEARCH

6.6.1 BELIEFS AND CONCEPTIONS

The first theoretical contribution of my research study pertains to the distinction between mathematics teachers' beliefs and their conceptions. In my theoretical framework I used Delandshere & Jones's (1999) three assertions to frame my research of teachers' beliefs. Delandshere & Jones (1999) argued that teachers' classroom-based assessments are shaped by their beliefs (1) of the purposes and functions of assessment; (2) about what they perceive

the official curriculum is within the school structure and where they position themselves with regard to the subject matter; and (3) of how they understand learning and their expectations of their students. I found that the beliefs of these three aspects does not form yet another belief, it forms teachers' conceptions of assessment. The teachers' beliefs of each of these aspects concerning assessment (the purposes and functions of assessment, the perceived the official curriculum, where they position themselves with regard to the subject matter; how they understand learning; and their expectations of their students) are fluid and can change. The culmination of these beliefs forms a conception of assessment. The teachers' conceptions of assessment can thus be seen as an entangled network of multiple beliefs. I found that teachers' conceptions of assessment are impenetrable, and that the only way to change conceptions is to focus on subconstructs of the entangled network of beliefs concerning assessment that forms conceptions of assessment.

6.6.2 THE RELATIONSHIPS BETWEEN BELIEFS, KNOWLEDGE AND ASSESSMENT

In my theoretical framework, I interpret the relationship between teaching, learning and assessment from the perspective of developing teachers' assessment as a network: The circle represents the given context in which the participants teach. The area of the triangle that is shaped by connecting the three vertices with one another, describes the extend of the teacher change, dependent on the school context. This context is not fixed, as it can expand or shrink as the relationships between the nodes change. The edges in the network describe the relationship between the teachers' knowledge and beliefs; beliefs and assessment practices; and knowledge and assessment practices.

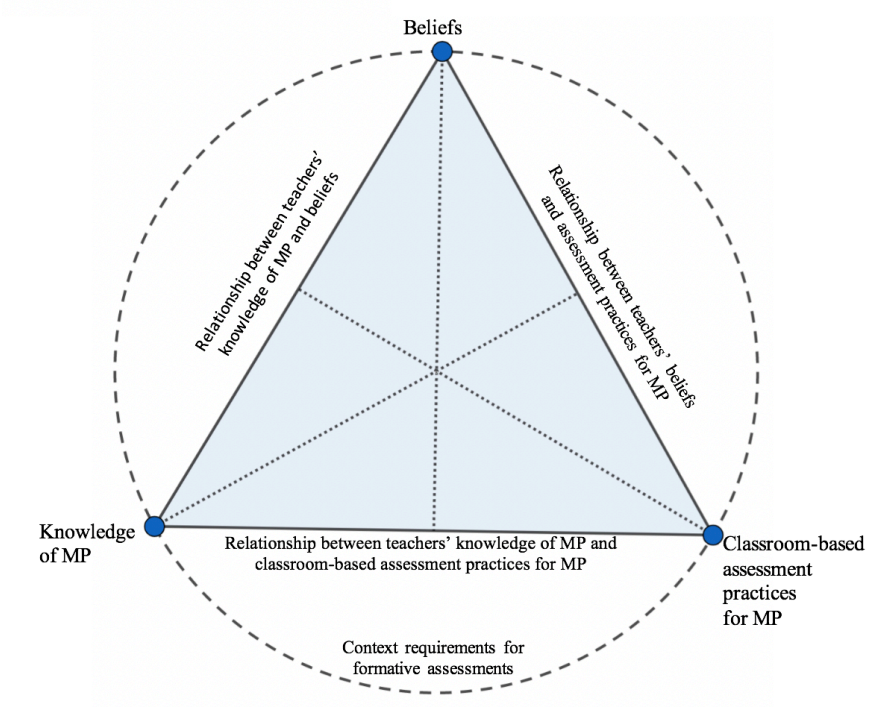

Figure 17: The interrelationships between knowledge, beliefs and assessment

The effect and influence of teachers' beliefs on teachers adapting their classroom-based assessments towards mathematical proficiency are illustrated with the perpendicular bisector linking the relationship between knowledge and assessment with beliefs, which is illustrated in figure 17. Similarly, the other two perpendicular bisectors illustrates the influence of teachers' knowledge on the relationship between their beliefs and assessment practices, as well as teachers' assessment practices influences the teachers' knowledge and beliefs.

In this study, optimal teacher change can be seen as teachers being able to adapt their classroom-based assessments towards mathematical proficiency which promotes constructivism. In order to achieve optimal teacher change, in a given context, the edges which are formed by connecting each of the vertices with one another, will need to form an equilateral triangle. Edges of equal length are significant for two reasons. Firstly, because the equilateral triangle will have the greatest area, which metaphorically results in optimal

teacher change. Secondly, because the equal lengths are indicative of teachers' beliefs, assessment practices and knowledge being in equilibrium, as the length of each edge is indicative of the strength of the relationship between each of the main concepts.

When these relationships are indicative of an equilateral triangle, the intersection of the perpendicular bisectors linking the relationship between knowledge and assessment with beliefs will be positioned at the centre of the circle. The position of these intersections is significant. The centre of the circle is fractal with respect to the relationship between teaching, learning and assessment. Therefore, when the intersection of the perpendicular bisectors linking the relationship between knowledge and assessment with beliefs is positioned at the centre of the circle, there is an equilibrium between mathematics teaching, learning and assessment, as is illustrated in figure 18.

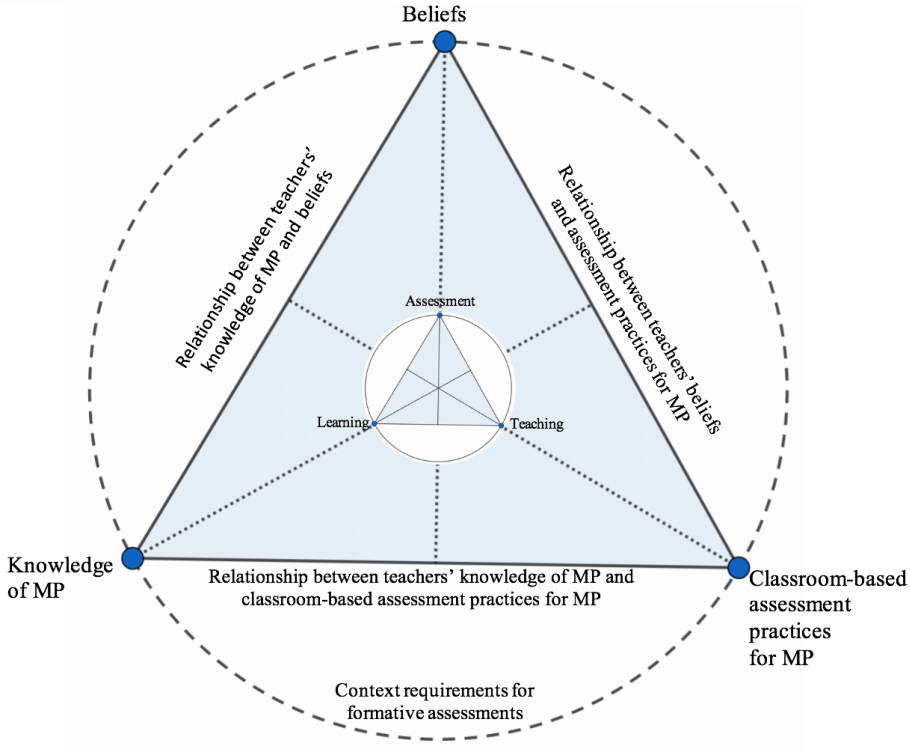

Figure 18: Interrelationships between Beliefs, Knowledge and Classroom-based Assessment practices

Finally, when considering Belbase's (2012) model for teacher change, I argue that different kinds of assessment become available if the teacher change is focused on as the independent. The dependent and independent relationship are therefore essential considerations when analysing and interpreting the participating teachers' assessment practices.

6.7 RECOMMENDATION OF FURTHER RESEARCH

I firstly want to refer to a practical recommendation to assist teachers in adapting and incorporating new ideas to their assessment practices. There is a need for South African teachers to design formative classroom-based assessments which are in line with socio-constructivist perspectives, such as the framework model of teaching and learning mathematics (DBE, 2018). I believe that there is a need for an online database to be created where teachers can upload the formative classroom-based assessments which they have designed. This will serve four purposes: firstly, teachers will gain experience designing formative classroom-based assessments aligned to a learning-centred classroom; secondly, teachers will receive valuable, constructive feedback on their formative classroom-based assessments; thirdly, the platform will provide teachers who are caught up in societal conceptions of assessments with "assessment for learning" classroom-based resources to use with their students; and, lastly, students can access and use these formative classroom-based assessments to advance their learning and understanding.

There are two recommendations for further research. The first recommendation for further research pertains to effective classroom-based assessments and feedback. While there is convincing evidence that indicates that formative assessment is effective in raising levels of student achievement (see chapter 2.3.3), there is a need for research to be extended. There is a need for mathematics teachers to have a better understanding of how they can provide the

students with descriptive feedback to classroom-based assessments to promote a learning-centred classroom.

The second recommendation is a long-term study on how teachers incorporate new ideas into their assessment practices and the effect this has on their teaching practices. There is a need to understand better how teachers can use classroom-based assessments, which focus on problem-solving, as a crucial strategy for teaching students to think for themselves, and enhance conceptual understanding of content in the mathematics curriculum. Research on the impact of formative assessments on underachieving students, therefore, is needed.

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APPENDIX 1: REC (HUMANITIES APPROVAL LETTER)

UNIVERSITEIT
STELLENBOSCH
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NOTICE OF APPROVAL
Response to Stipulations

31 May 2017

Project number: SU-HSD-003819

Project title: A DESIGN EXPERIMENT THAT ALLOWS SECONDARY SCHOOL MATHEMATICS TEACHERS TO REASSESS THEIR ASSESSMENT AND TEACHING PRACTICES TOWARDS MATHEMATICAL PROFICIENCY

Dear Jean-Pierre Le Roux

Your response to stipulations submitted on 18 May 2017 was reviewed by the REC: Humanities and has been accepted.

Please note the following about your approved submission:

Ethics approval period: 9 January 2017 – 8 January 2020

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (SU-HSD-003819) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary).

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Human Research (Humanities)

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.
The Research Ethics Committee: Humanities complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2nd Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.

APPENDIX 2: CONSENT TO PARTICIPATE IN RESEARCH

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jou kennisvennoot • your knowledge partner

STELLENBOSCH UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

LEARNING TO CLASSROOM-BASED ASSESSMENTS FOR MATHEMATICAL PROFICIENCY

A CASE STUDY OF SECONDARY SCHOOL MATHEMATICS TEACHERS ASSESSING THEIR CLASSROOM-BASED ASSESSMENTS TOWARDS MATHEMATICAL PROFICIENCY

You are asked to participate in a research study conducted by Jean-Pierre (JP) le Roux, a Masters Student, from the Department of Curriculum Studies at Stellenbosch University. The results from this study will enable me to complete my thesis which is a requirement to attain this degree. You were selected as a possible participant in this study because you are a Secondary School Mathematics Teacher.

1. PURPOSE OF THE STUDY

The purpose of the study is to conduct a design experiment that allows secondary school Mathematics teachers to reassess their assessment and teaching practices towards mathematical proficiency.

2. PROCEDURES

If you volunteer to participate in this study, I would ask you to do the following things:

- Read the consent to participate in the study.
- Understand that your participation in this study is voluntary.
- Understand that participants may withdraw from the study at any time.
- Understand that participants' names and that of the school will not be mentioned.
- Hence, direct quotes in the final document will be used anonymously, for ethical concern.
- Understand that here are no risks predicted to participate in the study
- Understand that audio and video material that will be used to record the interviews and design experiment will only be accessible to the researcher and his supervisor.
- Read the summary of the research and recommendations which will be made available to the school principal and the teachers who participated.

I am inviting you to participate in individual interviews about how your current classroom-based assessments in Mathematics. The interviews will take approximately five hours in total of your time spread over a period of five to seven weeks. You will be asked if I can observe how you assess your students.
Secondly, you will be asked to volunteer to take part in a case study to realign your assessments towards mathematical proficiency. The designing of classroom-based assessments will be done with

myself and with other participating teachers with similar teaching conditions and will take place over two afternoons.
Lastly, you will be asked to participate in individual interviews about your experience with designing and adapting assessments and to what extend it made an impact on how you develop or view classroom-based assessments.
To avoid interruption of the school timetable, the interviews and design of assessments will be scheduled by appointment, after school and be located at the school.

3. POTENTIAL RISKS AND DISCOMFORTS

There are no foreseeable risks, discomforts, or inconveniences that this study presents. If discomforts or inconveniences arise from the interviews or design experiment, I will be respectful of these.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

This study may benefit both participants and none-participants to better understand how Secondary School Mathematics teachers can reassess their assessment and teaching practices towards mathematical proficiency.

5. CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.
Confidentiality will be maintained by means of storing the data securely on the researcher's personal computer where it will be encrypted with a password. The researcher and her supervisors are the only people who will have access to the data. The data obtained during the study will be video and audio recorded and will then be transcribed verbatim by the researcher. You will have access to the digital recordings of the process so that you may verify or change anything that you said. These recordings and transcriptions will be kept for 5 years and then they will be destroyed. The names and identifying details of the participating teachers and the school will not be used in the resulting thesis or any publication.

6. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to participate in any aspect of the process, and still remain in the study. The researcher may withdraw you from this research if circumstances arise which warrant him doing so.

7. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

JP le Roux (Researcher)
0713718476
leroux.j@gmail.com

Dr Erna Lampen (Supervisor)
021 808 2292
ernalampen@sun.ac.za

8. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to me by JP le Roux in English / Afrikaans and I am in command of this language or it was satisfactorily translated to me. I was given the opportunity to ask questions and these questions were answered to my satisfaction.
I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

_____ _____

Name of Subject/Participant **School Name**

_____ _____

Signature of Subject/Participant **Date**

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _____. He/she was encouraged and given ample time to ask me any questions. This conversation was conducted in English / Afrikaans.

_____ _____

Signature of Investigator **Date**

APPENDIX 3: WCED PERMISSION TO CONDUCT RESEARCH LETTER

Directorate: Research

Audrey.wyngaard@westerncape.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20170112 –7189
ENQUIRIES: Dr A T Wyngaard

Mr Jean-Pierre Le Roux
92 La Provence Road
Welgelegen
Cape Town
8001

Dear Mr Jean-Pierre Le Roux

RESEARCH PROPOSAL: A DESIGN EXPERIMENT THAT ALLOWS SECONDARY SCHOOL MATHEMATICS TEACHERS TO REASSESS THEIR ASSESSMENT AND TEACHING PRACTICES TOWARDS MATHEMATICAL PROFICIENCY

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **01 February 2017 till 01 August 2017**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 12 January 2017

APPENDIX 4: EVALUATING CLASSROOM-BASED ASSESSMENTS: CLASSROOM-BASED ASSESSMENT A

GRADE 9
MATHEMATICS TEST A
40 MARKS ; 50 MINUTES

QUESTION 1

a) Simplify and write answers with positive exponents:

1) $x^3y^2 \times x^2y^4$ (2)
2) $2x^4 \times 3x^5$ (2)
3) $(4xy^2)^2$ (3)
4) $\frac{x^5y^6}{x^2y^8}$ (2)
5) $(2x^0)^2$ (2)

b) Simplify the following (show all working):

1) $\left(2\sqrt{x}\right)^2$ (2)
2) $\left(\frac{2x}{3y}\right)^2$ (2)
3) $\sqrt{25x^{64}}$ (2)

c) Calculate the value of the following if $a = 2,\ b = -1\ \ and\ \ c = 3$:

1) $a + b$ (1)
2) $2a - c$ (2)
3) $2a - b + c$ (3)

[23]

QUESTION 2

a) Determine the product by removing the brackets and simplify where necessary:

1) $2x(3z + 4y)$ (2)
2) $(x + 5)(x - 2)$ (3)
3) $(2x + y)^2$ (3)
4) $2x^2y^3(3x^2y^2 - x + 2xy^2)$ (3)

b) Simplify the following:

$\frac{6x^2y+8x^3y^2+4xy^2}{2xy}$ (3)

c) Add the following fractions: $\frac{4x}{5} + \frac{5x}{6} + \frac{5}{2}$ (3)

[17]

APPENDIX 5: EVALUATING CLASSROOM-BASED ASSESSMENTS: CLASSROOM-BASED ASSESSMENT B

GRADE 9

MATHEMATICS TEST B

30 MARKS; 40 MINUTES

QUESTION 1

Factorise each of the following:

a) $2xy - x^2$ (2)

b) $3xy^2 - 9xy^3 + 6x^2y^2$ (3)

c) $x^2 - 16$ (2)

d) $25x^2 - 400y^2$ (3)

e) $3x^2 - 27$ (3)

f) $2(x - y) + 5(y - x)$ (3)

[16]

QUESTION 2

Solve for x:

a) $3x + 3 = 6$ (1)

b) $6x + 5 = 2x + 3$ (2)

c) $2(3x + 1) = 4(x + 2)$ (3)

d) $\frac{100}{x} = 1$ (1)

e) $\frac{4}{5x} + \frac{5x}{6x} = \frac{5}{2}$ (4)

[11]

QUESTION 3

Solve for x and y simultaneously:

$y = 2x - 4$ & $y + x = 5$ (3)

[3]