FORMATIVE ASSESSMENT IN SENIOR PHASE MATHEMATICS

BY

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Thesis submitted in fulfilment of the requirements for the degree

PHILOSOPHIAE DOCTOR

In the

DEPARTMENT OF CURRICULUM STUDIES
FACULTY OF EDUCATION
UNIVERSITY OF THE FREE STATE
BLOEMFONTEIN

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JUNE 2011

DECLARATION

I hereby declare that the work which is submitted here is the result of my own independent investigation and that all sources I have used or quoted have been indicated and acknowledged by means of complete references. Furthermore, I declare that the work is being submitted for the first time at this university/faculty towards the Philosophiae Doctor degree and that it has never been submitted to any other university/faculty for the purpose of obtaining a degree.

13/06/2011

Reinette van der Merwe **Date**

DEDICATED TO MY DAD

Who taught me to love mathematics

and Miera – the future

"Take what you need; act as you must, and you will obtain that for which you wish!" René Descartes

ACKNOWLEDGEMENTS

I would hereby like to acknowledge the following persons for their assistance and contribution to this research project:

God, my Heavenly Father. It is only through His grace that I was able to persevere and complete this study.

My promoter, Prof. G. F. Du Toit – without his inputs, assistance, encouragement and wisdom, this study would never have been possible.

My husband, Jaco, for his patience, love and support and my daughter, Nadine, who assisted and supported me all the way.

Jeanne van der Westhuizen who assisted me with the language editing and Kate Smit who assisted with the processing of the data.

My mother, Mickey Basson for her encouragement.

All the teachers who voluntarily participated in this research, as well as their learners.

My colleagues, friends and family – who always believed that I could complete this study.

The Department of Education who gave me permission to do this research project at Motheo schools.

SUMMARY

There is a crisis in mathematics teaching and learning in South Africa. Both national and international tests have shown that South African learners do not have the mathematical knowledge and skills that are expected of them at a certain age.

Research has proven that the effective use of formative assessment can assist to improve learners' performance in mathematics. However, for this to happen a very specific teaching-learning environment should prevail in mathematics classrooms.

The aim of this study is twofold: Firstly, it investigated whether mathematics teachers at certain schools used formative assessment to improve learners' performance in their mathematics classrooms and to establish the extent of their use of formative assessment for this purpose. Secondly, the study considered whether these teachers created suitable teaching-learning environments in which effective formative assessment could take place in their classrooms.

Both national and international sources were used in the literature study to investigate formative assessment in the outcomes-based paradigm. The researcher concluded that formative assessment is best described in terms of seven attributes. These attributes and how they should be applied in mathematics classrooms to improve teaching and learning were investigated. Furthermore, the researcher investigated the nature of teaching-learning environments that would support the effective use of formative assessment in mathematics classrooms.

A combined research design, that included both qualitative and quantitative research methods, was used to investigate how formative assessment was being applied in certain grade 8 and 9 mathematics classrooms as well as the nature of the existing teaching-learning environments. Both the teachers and the learners at the participating schools took part in the study. The teachers' classes were observed, whereafter interviews were conducted and the documents of both the teachers and the learners were analysed. Other data were collected using questionnaires answered by all learners taught by the teachers who participated in the research study.

It was concluded that the participating teachers did not use formative assessment effectively to improve teaching and learning of mathematics. The teachers' knowledge of formative assessment and their planning for its implementation were questioned. Teaching-learning environments did not satisfy the conditions needed to support effective formative assessment in mathematics classrooms.

The importance of effective training for teachers was recommended. Nonetheless, training can only succeed if it is followed by in-school support of teachers. The role of the mathematics learning facilitator (subject advisor) and/or senior mathematics teachers can be extended by using section B of the learners' questionnaire as a diagnostic instrument to identify teachers' shortcomings regarding formative assessment as well as to establish suitable teaching-learning environments. The learners of the specific teacher (who is being supported in the use of formative assessment) will complete this questionnaire. Classroom observations and interviews conducted with the mathematics teacher will be used to find possible reasons for the identified shortcomings. This should be followed by support to the teacher in order to eliminate problem areas. However, support should not occur in a single session only, but should rather be a continuous process where the teacher and learning facilitator/senior teacher work together to ensure a high standard of teaching mathematics to learners.

OPSOMMING

Die onderrig en leer van Wiskunde in Suid-Afrika verkeer in ‘n krisis. Beide nasionale en internasionale toetsing het aangedui dat Suid-Afrikaanse leerders nie oor die wiskundige kennis en vaardighede beskik wat op ‘n sekere ouderdom van hulle verwag word nie.

Navorsing wat gedoen is, dui daarop dat die effektiewe gebruik van formatiewe assessering aangewend kan word om leerders se prestasie in wiskunde te verbeter. Gunstige onderrig- en leeromgewings werk ondersteunend mee tot die effektiewe gebruik van formatiewe assessering.

Die doel van hierdie studie is tweeledig: Eerstens is ondersoek ingestel na die stand van formatiewe assessering in graad 8 en 9 wiskunde-klaskamers in die Motheo distrik. Tweedens is gekyk tot watter mate onderrig- en leeromgewings ondersteunend meewerk ten opsigte van formatiewe assessering in hierdie klaskamers.

Beide nasionale en internasionale bronne is in die literatuurstudie geraadpleeg om formatiewe assessering in ‘n uitkomsgebaseerde paradigma te ondersoek. Die navorser het tot die gevolgtrekking gekom dat formatiewe assessering op die beste wyse in terme van sewe kenmerke beskryf kan word. Hierdie sewe kenmerke en hoe dit aangewend moet word in die wiskunde-klaskamer om onderrig en leer te bevorder, is ondersoek. Die navorser het ook ondersoek ingestel na die aard van die onderrig- en leeromgewing wat nodig is om effektiewe gebruik van formatiewe assessering in wiskunde-klaskamers te implementeer.

‘n Gekombineerde navorsingsontwerp, wat beide kwalitatiewe en kwantitatiewe navorsingsmetodes insluit, is gebruik om ondersoek in te stel hoe formatiewe assessering plaasvind in graad 8 en 9 wiskunde-klaskamers in die Motheo distrik, asook die aard van bestaande onderrig- en leeromgewings. Onderwysers en leerders is betrek in die navorsing. Lesaanbiedings van onderwysers is waargeneem, waarna onderhoude met hulle gevoer is en dokumente van beide onderwysers en leerlinge geanaliseer is. Data is verder bekom van leerders van betrokke onderwysers deur gebruik te maak van 'n vraelys.

Daar is bevind dat onderwysers nie effektief van formatiewe assessering gebruik maak om die onderrig en leer van wiskunde te bevorder nie. Onderwysers se kennis van en beplanning vir formatiewe assessering kan bevraagteken word. Onderrig- en leeromgewings in wiskunde klaskamers het nie aan die vereistes voldoen om suksesvolle formatiewe assessering te ondersteun nie.

Die belangrikheid van doeltreffende opleiding van onderwysers word opnuut aanbeveel. Opleiding kan slegs geslaagd wees indien dit opgevolg word deur ondersteuning aan wiskunde-onderwysers by skole te verleen. Die rol van wiskunde leerfasiliteerders (vakadviseurs) en/of kundige onderwysers kan voorts uitgebrei word deur onder andere van 'n vraelys as diagnostiese instrument gebruik te maak. Sodoende kan tekortkominge ten opsigte van formatiewe assessering, asook leemtes in onderrig- en leeromgewing vir 'n spesifieke onderwyser bepaal word. Die leerders word ook in die proses betrek. Klaskamerobservasies en onderhoude as opvolg-strategieë tot die geïdentifiseerde leemtes, verleen 'n diepere dimensie van betekenisgewing aan elke onderwyser se unieke situasie. Die uitkoms dien as basis vir die daarstelling van 'n interafhanklike ondersteuningsprogram wat oor 'n tydperk strek, waar die onderwyser(es) en die leerfasiliteerder/senior onderwyser saamwerk om wiskunde-onderwys van gehalte aan leerders te bied.

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LIST OF ACRONYMS

AMESA	Association for mathematics education in South Africa
C2005	Curriculum 2005
CASS	Continuous assessment
DoE	Department of Education (National Department)
FET	Further Education and Training
FSDoE	Free State Department of Education
GET	General Education and Training (band)
HSRC	Human Science Research Council
ICT	Information and Communication Technology Services
IQMS	Integrated Quality Management System
LOLT	Language of learning and teaching
NCS	National Curriculum Statement
NSC	National Senior Certificate
OBA	Outcomes-based assessment
OBE	Outcomes-based education
SMGD	School management and governance developer
SPSS	Statistical Package for the Social Sciences
SRL	Self-regulated learning
TIMSS	Trends in International Mathematics and Science Study

CHAPTER 1

ORIENTATION

1.1 INTRODUCTION

When South Africa entered a new era after the democratic elections in 1994, the education system that had existed under the previous dispensation was transformed; and, in 1998, a new curriculum was implemented in South African schools. This was known as Curriculum 2005 (C2005). The changes in the South African education system were in line with worldwide trends to adapt education to meet the demands of a changing world. According to many educationists all over the world, a content-based education model had become obsolete (Steyn & Wilkinson 1998:206). This, together with the current massive technological, economic and social changes, made it necessary to improve the standard of learning achieved through schooling (Brandt 1994:iii).

Van Wyk and Mothata (1998:1) describe the former South African education system as one that catered "for passive learners, was driven by examinations, often entailed learning parrot-fashion and was characterised by a syllabus that was content-based …". Steyn and Wilkinson (1998:203) add the unimaginative teaching methods used by teachers and major inequalities that existed in schools, to this list.

In order to address the crisis, an outcomes-based curriculum was developed for education in South Africa. The expectation for C2005 was essentially that it would bring about a shift from the traditional content-based curriculum to an outcomes-based curriculum that was more contemporary (DoE 1997:1). C2005 had three design features (Harley & Wedekind 2004:197):

- The curriculum was based on outcomes. This feature became so prominent that the terms "outcomes-based education (OBE)" and "C2005" became synonymous.

- The second design feature focused on an integrated knowledge system. This led to the integration of subjects into learning areas (cf. 1.7.5). Teachers were also expected to integrate learning areas where possible to make teaching more meaningful and applicable to real-life situations.

- Finally, the pedagogy promoted was learner-centred, thus emphasising the important role that the learner had to play in learning. This did not just apply to the classroom situation. The emphasis was to develop life-long learners. Learners should become responsible for their own learning.

An important feature of OBE is assessment (Janse van Rensburg 1998:82; Van der Horst & McDonald 1997:12). Assessment in the outcomes-based paradigm is no longer a separate entity, but an integral part of teaching and learning. Biggs (s.a.:1,2) describes this as "constructive alignment", implying that the curriculum - with all the intended outcomes, the teaching methods and the assessment tasks - should all be aligned and integrated to support high-level learning. Ultimately the purpose of schools is the education of learners - and assessment must contribute to the purpose. If it does not do so, assessment will have little value (James 1998:171).

1.2 A NEW ASSESSMENT PARADIGM

In OBE assessment is done for different purposes. For example, summative assessment is used to summarise learners' performance; while formative assessment is used to enhance their performance. Moon and Schulman (1995:10) maintain that formative assessment is integral to the instructional process where the assessment is used to direct or modify lesson planning in order to improve learning. Such assessments, which are embedded in instruction, provide important sources of information both for instructional decisions as well as for monitoring the progress of learners (Stenmark 1991:3). This attitude deviates from the traditional approach where assessment is mainly used for grading and summative purposes (Brooks 2002:18).

C2005 required a new assessment paradigm for teachers. This paradigm refers to the mindset of teachers who were used to the traditional assessment system and had to change to a new approach to assessment that is integrated in teaching and learning. Such a paradigm shift implies not just a shift in the philosophy of teaching, but also a modification of a teacher's attitude towards teaching and learning. A change of this nature demands special competencies of teachers and, as a result, presents new challenges (Pang 2001:172). It was predicted that a change in the assessment paradigm would eventually determine the success of C2005 to a great extent (Du Toit et al. 2000:iii).

1.3 STATEMENT OF THE PROBLEM

1.3.1 Background

C2005 - as a curriculum for a "new" South Africa - held many promises. In contrast to the previous curriculum that was blamed for transforming eager and questioning learners into passive, uninterested persons practising rote memorisation, the new curriculum aimed to develop learners' critical thinking, skills and attitudes (DoE 1997:8; Steyn & Wilkinson 1998:206). The expectation was that the outcomes-based curriculum in South Africa would help to improve the quality of education at school and enable South African learners to compete globally (Botha 2002:361; Van Rooyen & Prinsloo 2002:2).

C2005 did not only focus on what learners should know at the end of a course of learning and teaching, but also on what learners could actually do with their knowledge. Mothata (1998:13) proposes that learners should be able to use their acquired knowledge in the real world and become competent citizens. Learners, as active and engaged citizens, should be able to respond to a changing world (Sternberg 2008:25).

The implementation of C2005 was troublesome from the outset and a review committee was appointed to investigate the problems experienced with it. In particular, the system of assessment was criticised (Chisholm 2000). The suggestion of the review committee was that C2005 had to be streamlined and strengthened. The result was the Revised National Curriculum Statement (RNCS) for Grades R – 9, published in 2002 (DoE 2002a:2). In 2006 the name was changed and from then on the curriculum was only known as the National Curriculum Statement (NCS). OBE, and by implication outcomes-based assessment (OBA), remained the design feature of the NCS, but the complicated outcomes-based terminology was simplified and curriculum documents were written in a more user-friendly manner.

In 2009, Ms Angela Motshekga, the National Minister of Education, initiated another process to identify the problems being experienced with the NCS. A panel of experts was appointed to investigate the problems and various stakeholders were invited to contribute (DoE 2009:5). Once again assessment proved to be one of the most problematic areas and the report to the minister stated clearly that assessment was the area that had received most criticism (DoE 2009:6). The minister gazetted certain changes to the NCS with immediate effect, but made it clear that the underlying principles and values of the NCS that emphasised a learner-centred pedagogy remained unchanged (Malope 2009:2).

As the NCS is the current curriculum prescribed at South African schools (except for some independent schools), this term will be used to refer to the

South African outcomes-based curriculum in this thesis. Curriculum 2005, the first version of South Africa's outcomes based curriculum will be referred to as C2005.

1.3.2 Problems related to the teaching and learning of mathematics

In 2000, 2004 and 2008, systemic assessment was done in a sample of South African schools in order to measure the performance of the education system. This was accomplished by measuring the learners' performance in relation to national indicators (DoE 2002b:94). For mathematics the results were alarming. In 2004, only 16,59% of grade 6 learners in the Free State obtained more than 50% in a standardised summative mathematics test. This percentage of learners obtaining more than 50% in a standardised test dropped to 11,78% in 2008 (FSDoE 2010:63). The results indicated that effective learning was not taking place in mathematics and raised questions once again regarding the implementation of the outcomes-based curriculum.

International studies also proved that South African learners were lagging behind. One of the studies conducted was the Trends in International Mathematics and Science Study (TIMSS) that is done every four years. From the results of this study it was evident that the performance of learners from South Africa was worse than that of learners in other developing countries. The Human Science Research Council (HSRC) conducted these tests in 1999 and 2003 to evaluate learners at grade 8 level in mathematics. In both years South Africa had the lowest mean score in mathematics of all participating countries (HSRC 2003:2). Learners' achievement scores in mathematics were simply not on par with what was expected from them – neither in comparison with other developing countries nor in relation to the expectations of C2005.

In 2007 South Africa pulled out of the TIMSS tests and a moratorium was placed on any further testing until 2011 (Rademeyer 2007:19; Govender

2007:7). The reason given for this withdrawal was that that the National DoE first wanted to focus on the problems in the teaching and learning of mathematics and try to improve them.

From the foregoing discussion it can be concluded that both national and international tests indicate that South African learners are unable to perform tasks that demonstrate their understanding of the key mathematics skills and the knowledge expected from learners at a certain age (Chuenyane 2008:2; Rademeyer 2008:5; Rademeyer 2009:1). This undesirable situation is exacerbated by the high expectations of the NCS that were implemented in the Further Education and Training Band (FET) (cf. 1.7.1) in 2006 in grade 10. According to this, all learners are required to study Mathematics or Mathematical Literacy up to grade 12 level as part of the FET curriculum in order to qualify for the National Senior Certificate (NSC). Mathematical Literacy is described as "developing competencies that are needed by individuals to make sense of, participate in and contribute to a twenty-first century world" (DoE 2007c:7), while mathematics is described as "enabling creative and logical reasoning about problems in the physical and social world and in the context of mathematics itself" (DoE 2003:9). Both subjects demand a strong foundation in mathematics in the General Education and Training Band (GET) (cf. 1.7.1).

Mathematics teaching today is becoming significantly more complex than in the past. The NCS for both GET and FET expects much more from learners than to perform routine calculations and the mere application of algorithms. Learners need to think critically and solve problems in context. They should be able to use mathematical relationships in social, economical, environmental and cultural relations (DoE 2002b:4). In the words of De Corte, Verschaffel and Masiu (2004:365-366) "…the 20th century [has] induced a growing need for the acquisition by all citizens of aspects of high literacy, such as thinking (critically), solving complex problems, regulating one's own learning and communication skills …". This naturally will affect the way in which assessment is done in mathematics.

1.3.3 Problems related to OBA

Niss (1993:4) indicates that if the traditional approach to assessment in the teaching of mathematics is the only method used, any effort to improve the teaching of this subject will be slowed down and even hindered. Several authors agree with Niss and maintain that traditional ways of assessment do not contribute to teaching in an outcomes-based environment, neither do they assist in an education that strives to educate all learners well (AMESA 2001:4; Chappuis 2007; Du Toit et al. 2000:iii). Accordingly, reformed assessment practices were introduced together with the outcomes-based curriculum in 1998. This implied that the assessment of mathematics had to be done continuously to monitor learners' progress and to identify problems and misconceptions as they appeared. This would benefit mathematics learners in South Africa as the early diagnosis of problems meant that they could be addressed as they arose.

As already stated, the National DoE has acknowledged that assessment has been a difficult issue for teachers since the introduction of C2005 (AMESA 2001:4). Several reasons have been put forward to explain this. As described in 1.2, a new assessment paradigm was required by the introduction of OBE. Referring to this shift in attitude, Vandeyar and Killen (2006:33) propose firstly that it is very difficult to change the assessment practices of experienced teachers. Many teachers view tests and examinations as sufficient forms of assessment because evaluation has always been done like this (old paradigm). Macmillan (2005:1) even goes so far as to state that assessment done in the traditional way is usually used to control classes.

Secondly, teachers view assessment as being in competition with teaching rather than an integral part of it (Heritage 2007:140). This makes assessment simply an add-on. Consequently teachers complain about the time they have to spend on assessment and the increase in workload (DoE 2005:2). This situation is worsened by that fact that high school teachers are appraised according to the grade 12 learners' performance in their final examination. As a result, high school teachers tend to teach in order to obtain the optimal performance of their learners in this standardised examination, a practice described by Boudett et al. (2005:700) as a kind of "drill and kill" type of teaching.

Wilmot (2005:70) points out a third aspect to consider. She explains that the mechanics of assessment in OBE are not easy to understand and work with. In order to work properly with criterion referenced assessment (cf. 2.4.4) and to use different assessors, a teacher needs a high level of competence. As South African teachers do not have a good track record as assessors (Malcolm 2001:207), it can be expected that teachers will find it difficult to implement a contemporary assessment system.

1.3.4 Problems related to the training of teachers to implement OBA

In order for OBA to be successful, it is imperative that the teachers should be able to implement the OBE model effectively (Shasha 2004:56). Teachers thus need proper training. It has already been widely proven that the training of teachers in the implementation of C2005 was insufficient (Chisholm 2000; Harley & Wedekind 2004:200; Van Der Merwe 2005:5; Van Tonder 2000:390). Chisholm (2000) reports that teachers generally have a rather "shallow understanding of the principles of C2005/OBE" and that teachers have, in many cases, developed a false clarity that is evident in the mismatch between what they claim to know and the manner in which they externalise that understanding in the classroom. This includes certain aspects of assessment. In the light of the above, it is clear why teachers express their dismay and confusion after attending workshops to implement C2005 (Pithouse 2001:154-158).

Van der Merwe (2005:128) investigated the in-service training of teachers that was intended to prepare them to implement the NCS in the Motheo district and the findings of this research support the views expressed above. The teachers who took part in this research indicated that they needed more training to be successful in the classroom.

1.3.5 International perspective

Various other countries have introduced contemporary ideas for teaching, learning and assessment, making assessment an integral part of the teaching and learning process. Countries such as Spain, Italy, the United Kingdom, Portugal, Australia, the United States and Canada are among these (Bazzini 1993:99; Brown 1993:71 - 82; Dreyer 2008a:2; Leal & Abrantes 1993:174; Rico 1993:10; Stephens & Money 1993:156).

Niss (1993:5) points out that international experience shows that teachers find it difficult to set assessment tasks that will provide genuine assistance to learners in order to understand and master mathematics; and that they also struggle to use the results of assessment tasks to guide their planning in order to improve their teaching practice. NCTM (2001:18) mentions in this regard that teachers are overwhelmed by changing methods of instruction and the implementation of OBA if both happen simultaneously.

1.3.6 Positive effects of formative assessment

From the foregoing discussions, it can be concluded that despite various attempts to implement OBA in South African schools correctly, it has been difficult to put into practice. The question that arises is whether education in

South Africa should continue on the path of OBA practices given the difficulties in training teachers in its implementation.

In 1.2 formative assessment as part of OBA was discussed as one of the purposes for doing mathematics. The research of Black and Wiliam (1998) seems to prove that there is a very positive side to formative assessment if it is correctly applied to teaching and learning. Black and Wiliam were particularly interested in formative assessment (cf. 2.4.5.2, 3.2.1, 3.2.2, 3.2.3) and its effect on the learning process. They reviewed almost 700 research studies and chose the most relevant 250 studies that had been carried out over a period of 10 years. These studies attempted to determine the effectiveness of formative assessment to improve learners' achievements in mathematics (amongst other subjects). The researchers found that these studies indicated a positive correlation between the effective use of formative assessment and an improvement in learners' scholarship (Brooks 2002:16; Irons 2008:17; James 1998:179; Wiliam 1999:15) and they concluded that the proper use of formative assessment did indeed boost learners' performance.

Furthermore, the researchers did not simply show that formative assessment had contributed positively to learners' success, but also that under-achieving learners and learners with disabilities had benefited most from formative assessment (Brooks 2002:16). This can be attributed to the fact that formative assessment supports the OBE principles of expanded opportunities and high expectations (cf. 2.3.4.2, 2.3.4.3) and therefore counteracts the idea that learners perform poorly because of a lack of ability (Boston 2002). Formative assessment indicates to learners how they can capitalise on their strengths and how to correct their weaknesses (Sternberg 2008:26). As the current curriculum in South Africa is outcomes-based and formative assessment forms part of OBA, it is a challenge to investigate whether teachers use formative assessment within an OBE paradigm and how they carry out the formative assessment.

In order for formative assessment to be effective and raise the performance of learners, an effective teaching-learning environment should prevail in the classroom (Black & William 2008). This will ultimately imply a change in the roles of both teachers and learners. Teachers should facilitate learning and be instrumental in the process of effective learning and learners should be accountable for their own learning in such an environment.

Although there is evidence that some teachers in South Africa undeniably use assessment which is designed to inform them about their learners' progress, there is also strong evidence to suggest that these teachers are in the minority (Vandeyar & Killen 2006:33).

1.3.7 Questions arising

From the stated problems, the questions that arise are:

- How does the theoretical body of knowledge support the claim that formative assessment can positively contribute to teaching and learning?

- What is formative assessment and how should it be applied to improve teaching and learning in the mathematics classroom?

- What characteristics of a teaching-learning environment contribute to effective formative assessment in the mathematics classroom?

- Does formative assessment take place in Senior Phase mathematics classrooms?

- What is the nature of the teaching-learning environment in Senior Phase mathematics classrooms? and

- How can mathematics teachers be assisted to implement effective formative assessment in their classrooms?

1.4 AIMS AND OBJECTIVES OF THE STUDY

In an outcomes-based environment, the processes are just as important as the products (Du Toit & Du Toit 2004:6). An OBA approach is an integrated approach implying that both process and product are interwoven in the holistic development of the learner. This requires skills and competence from the teachers. Summative assessment and other traditional assessment practices are not sufficient to assess both the processes and the products. According to Pahad (1999:247), appropriate assessment practices are essential for the successful implementation of C2005.

Mathematics teachers in the Senior Phase (cf. 1.7.1) have been trained to implement the OBA paradigm in the NCS. The over arcing aim of this study is to investigate whether mathematics teachers use formative assessment and to establish the extent of their use of formative assessment as a means to improve learners' performance in their mathematics classrooms. An additional aim is to consider whether they create suitable teaching-learning environments in their classrooms in which effective formative assessment can take place. In order to achieve these aims, the following objectives were established. This research project aims:

- to undertake a literature study to determine from the existing knowledge how formative assessment can positively contribute to teaching and learning;

- to understand how formative assessment can be effected in the mathematics classroom in order to improve teaching and learning;

- to investigate the features of a learning environment that would support formative assessment in mathematics classrooms;

- to investigate how formative assessment takes place in Senior Phase mathematics classrooms;

- to investigate the nature of the teaching-learning environments in Senior Phase mathematics classroom; and

- to make recommendations on how mathematics teachers can be assisted to implement effective formative assessment in their classrooms.

Critics have been sceptical about the use of OBE in South African schools. It is not the aim of this study to investigate the value of OBE or OBA, and hence the researcher will not defend or criticise the use of OBE or OBA in South African schools. As the curriculum used in South African schools at the time of this research project was outcomes-based, the framework for formative assessment will be done with reference to an outcomes-based curriculum.

If all factors that have an effect on formative assessment in the mathematics classroom were considered, the study would be too comprehensive and hence it is necessary to demarcate the domain of the study.

1.5 DEMARCATION OF THE RESEARCH AREA

The study is concerned with the mathematics learning area as one of the eight compulsory learning areas in GET. Because of the poor results in national and international testing and the inadequate performance of South African learners, the improvement of the performance of learners in mathematics is currently one of the imperatives of the Department of Basic Education.

The study focuses on the formative assessment done by mathematics teachers in their teaching of mathematics in the Senior Phase, especially in grades 8 and 9. These grades were chosen because the researcher interacted with mathematics teachers in secondary schools continuously as a learning facilitator. It must be taken into consideration that grade 7, which is the first grade of the Senior Phase, is traditionally situated within the primary school, while grades 8 and 9 form part of secondary schools. The researcher has had access to teachers who work at secondary schools and over several years has built up a relationship of trust with them.

Geographically the study is restricted to the grades 8 and 9 mathematics teachers and learners in the Motheo district. As mentioned earlier, the reason for this choice is that the researcher works in this district. Another reason is that the schools and learners in the Motheo district performed best in the final Senior Certificate Examination (grade 12) as well as in mathematics in 2008 (which was the first year in which learners wrote the Senior Certificate examination based on the NCS). This was an indication of a certain level of competence in the teaching and learning of mathematics and an indication of the practices that contributed to the schools' success in mathematics.

Teachers and learners of schools with different demographics were included in the study in order to capture perceptions and attitudes of teachers from different backgrounds. Schools were classified according to their location, the language of learning and teaching (LoLT) and the race of learners attending the schools. Schools from both advantaged and disadvantaged communities were included.

1.6 RESEARCH DESIGN AND METHODS

In the sections below, the literature study that will be conducted followed by a mixed methods approach where both the qualitative and quantitative research methods (which were used to investigate formative assessment in grade 8 and 9 mathematics classrooms, as well as the teaching-learning environment) will be described.

1.6.1 Literature study

The literature study answers the first three research questions (cf. 1.3.7). The existing literature on OBE, OBA, formative assessment and the teaching-learning environments promoting effective formative assessment are investigated. This study is conducted from a constructivist epistemological perspective. From an interpretive paradigm the researcher seeks understanding from the literature of formative assessment done in an outcomes-based environment to improve teaching and learning. This provides the means to contextualise the study and to address the stated objectives.

1.6.2 Empirical investigation

The mixed methods approach of the empirical research that was undertaken in this study will be described below.

1.6.2.1 Mixed methods research

The literature study will be followed by an empirical investigation to answer the fourth and fifth research questions (cf. 1.3.7). The empirical investigation uses a mixed methods approach and more specifically, the triangulation design: convergence model. First of all, a qualitative study is undertaken to collect and analyse data using qualitative methods. This is followed by a quantitative study where data is collected and analysed in a quantitative way. During interpretation the qualitative and quantitative data are compared and validated (Creswell & Plano Clark 2007:66) so that well-substantiated conclusions can be drawn.

The population for the entire study was all the grade 8 and 9 mathematics teachers in the Motheo district, together with the learners that they teach. Stratified purposive sampling was used in the selection of schools to include in the study. Selection of the sample depended on particular characteristics of the schools. Schools were classified into four categories based on their location, the language of learning and teaching (LoLT) and the race of learners attending the schools (cf. 5.2.3.5). Two schools from every category were included.

One grade 8 and/or 9 mathematics teacher per chosen school was requested to volunteer for the study, thus using volunteer sampling of teachers in selected schools. All the grade 8 and 9 mathematics learners taught by the mathematics teachers participating in the study formed part of the sample.

1.6.2.1.1 The qualitative study

A non-experimental research design was employed in the qualitative study to determine the use of formative assessment and the prevailing teaching-learning environments in mathematics classrooms in the district mentioned. The researcher focuses on different cases in order to obtain a rich and holistic in-depth description of formative assessment taking place in grade 8 and 9 mathematics classes. Three qualitative research instruments, namely interviews, observation and document analyses were applied in this research. Semi-structured interviews were conducted with mathematics teachers of the sampled schools. In the semi-structured interviews, teachers were asked to answer a pre-set list of questions, but the interview remained flexible to allow for individual participation and contribution. Concepts relevant to formative assessment and the teaching-learning environment were explained to teachers who did not know the meaning of the terminology used in the questions.

Triangulation was used to increase the validity and reliable of the qualitative study. This implies that first of all, a teacher was observed in class while teaching mathematics. This was followed by an analysis of certain documents where both the teacher's documents and learners' documents pertaining to formative assessment were scrutinised for supporting and/or contradicting evidence. Finally, teachers were interviewed. This whole process was piloted with teachers who did not form part of the final sample of this research to assure validity and to make adaptations should it be deemed necessary.

1.6.2.1.2 The quantitative study

The quantitative study was done using a questionnaire administered to all grade 8 and 9 mathematics learners taught by the teachers participating in the study. The questionnaire was based on the findings of the literature study and included a section on formative assessment and a section on the teaching-learning environment. The purpose of the questionnaire was to gain insight into learners' experience of formative assessment and the teaching-learning environment in the mathematics classrooms.

Questionnaires were analysed by the Information and Communication Technology Services (ICT) of the University of the Free State using the Statistical Package for the Social Sciences version 17.0 (SPSS). Excel spreadsheets and relevant graphs were used by the researcher for further analysis of statistical data as well as for presentation.

1.7 CLARIFICATION OF CONCEPTS

1.7.1 Senior Phase, GET and FET

The term "Senior Phase" refers to grades 7, 8 and 9. There are three phases in the General Education and Training band (GET) namely, the Foundation Phase (gr. R – 3), the Intermediate Phase (gr. 4 – 6) and the Senior Phase (gr. 7 – 9). The Further Education and Training band (FET) refers to grades 10 – 12.

1.7.2 Curriculum 2005

"Curriculum 2005" (C2005) refers to the South African version of OBE. It was the first version of the post-apartheid National Curriculum Statement and has been described as "the uniting vision for transforming apartheid education" (DoE s.a.:6). An outcomes-based approach to education and training is built on outcomes and a learner-centred approach. The initial implementation of C2005 was January 1998. The implementation of this curriculum occurred in phases.

1.7.3 National Curriculum Statement (NCS)

A Ministerial Project Committee was appointed in 2000 by the National Minister of Education to strengthen and streamline C2005. The result of this project was the Revised National Curriculum Statement published in 2002, now only known as the National Curriculum Statement (DoE 2002a:2). The National Curriculum Statement Grades R – 9 replaced the Statement of the National Curriculum for Grades R – 9, which was approved in 1997. In 2006 the NCS was implemented in grade 7 and in 2007 the NCS was implemented in grades 8 and 9.

1.7.4 Traditional curriculum

This term is used in this thesis to refer to the curriculum that prevailed in all South African schools before the introduction of OBE in 1998. This curriculum was predominantly teacher centred and syllabus driven. Assessment (then known as evaluation) was mostly done through tests and examinations.

1.7.5 Learning area

The term “learning area” refers to a field of knowledge, skills and values, as well as unique connections with other fields of knowledge and learning areas. There are eight learning areas in the GET phase of which Mathematics is one. In C2005 the Mathematics learning area was described as Mathematical literacy, Mathematics and Mathematical Sciences (MLMMS), but was replaced with the term “Mathematics” in the NCS.

1.7.6 Outcomes and outcomes-based education (OBE)

According to Spady (1994:1), OBE implies that everything in an educational system is organised according to what the learners are expected to be able to do successfully after the completion of the learning experience. These final products are known as outcomes. For this reason, this approach to teaching and learning requires that what learners need to achieve as their final product should be very clear from the very start when planning for teaching and learning. Accordingly, teachers start the learning process with these expectations and plan from there. The role of the teacher is to guide learners to achieve outcomes by employing multiple teaching strategies. The role of the learners is to attain the outcomes. Assessment plays an essential role in OBE (Siebörger & Macintosch 2004:33).

1.7.7 Department of Education, Department of Basic Education, Free State Department of Education

The appellations “National Department of Education” (National DoE) and “Department of Education” (DoE) both refer to the National Department of Education (countrywide). In 2010 the name of the (National) Department of Education for grades R – 12 was changed to the Department of Basic Education. The researcher will use the term “Department of Education” throughout this thesis to refer to the National Department of Education (DoE) or the Department of Basic Education, except where mentioning sources where the relevant term as mentioned in the source will be used. The term "Free State Department of Education" (FSDoE) will be used when reference is made to the provincial Department of Education (in the Free State).

1.8 DIVISION OF CHAPTERS

Chapter 1 provides the introduction to this study. In this chapter the problem pertaining to the study is discussed; and based on the problem statement, research questions are formulated. In other words, the aim of the study is stated and the objectives that will be pursued to reach this aim are indicated. Finally the research area is demarcated, the method of research is described and concepts clarified.

In order to answer the first research questions posed in 1.3.7, a literature study is undertaken in chapter 2. The literature study investigates OBA, starting with learning theories relevant to OBE and a definition of learning. South Africa's transformative approach to OBE is discussed and the roles of the teacher, learner and learning material are discussed. The role of outcomes, the principles of OBE and their relevance to mathematics are also discussed. Thereupon OBA is discussed, the relevant terminology is clarified, the nature of OBA is indicated and different types of OBA explained.

Chapter 3 deals with formative assessment in mathematics and answers the second research question raised in 1.3.7. In order to define formative assessment, it is contrasted with summative assessment. Seven attributes of formative assessment are identified. Each attribute and how it should be applied in the mathematics classroom are investigated.

The aim of chapter 4 is to answer the third research question (cf. 1.3.7). The nature of the teaching-learning environment that should prevail in mathematics classrooms to support effective formative assessment will be researched in the literature.

In chapter 5, the research design to investigate research questions four and five (cf. 1.3.7) are described. Reasons are stated for using a mixed methods research methodology. The qualitative study is discussed first, followed by the discussion of the quantitative study. The population is defined and the sampling method explained. In the qualitative research design, interviews, observation and the analysis of documents are used to collect data. Each of these methods is discussed and the way in which issues of validity and reliability are dealt with is indicated. Piloting is also considered. In the subsequent quantitative study, the design of the questionnaire is explained, as well as the validity and reliability of the questionnaire. The final discussion concerns how the data was analysed.

In chapter 6, an analysis of the data described in chapter 5 is done. An analysis of the qualitative data is performed first, followed by the analysis of the quantitative data. The qualitative and quantitative data are then triangulated to answer research questions four and five.

The conclusions that are drawn in chapter 7, and the recommendations made are based on the analysis of the data collected. In this chapter, research question six (cf. 1.3.7) is answered.

1.9 SUMMARY

In this chapter, it was argued that the assessment required by OBE required of teachers to consider an alternative assessment paradigm. It was also stated that the teaching and learning of mathematics need attention. Learners in South Africa lag behind the rest of the world in their competency in mathematics and cannot compete with their peers in other countries. Formative assessment practices, together with an appropriate teaching-learning environment, have proven to enhance learners' performance in mathematics in other countries. It is thus necessary to investigate whether formative assessment practices are being used and the extent of their application in mathematics classrooms in South Africa. In addition, it is essential to consider whether the teaching-learning environment in these classrooms is conducive to the use of formative assessment.

Based on this, a problem statement and objectives were formulated to assist in the investigation of the problem stated. The research design that was used to investigate the questions raised by the problem was discussed and relevant terminology was explained.

In the next chapter, a literature study will be done to determine from the existing literature how formative assessment can positively contribute to teaching and learning. The study will also include an investigation to conceptualise formative assessment within the outcomes-based paradigm.

CHAPTER 2

EFFECTIVE LEARNING AND THE OUTCOMES-BASED PARADIGM

2.1 INTRODUCTION

The reasons for implementing a South African version of an outcomes-based curriculum were explained in Chapter 1. The chapter also emphasised that the change in curriculum was intended to bring about necessary changes in education in South Africa. Concerns about the quality of teaching and learning taking place in mathematics classrooms were raised. The expectation was that an outcomes-based approach to teaching, learning and assessment would eventually ensure that learners performed better at mathematics.

This chapter considers the theoretical framework for assessment. This framework will be investigated in the context of an outcomes-based curriculum as this was the curriculum used in schools during the time of this research project. In order to be able to contextualise assessment within an outcomes-based environment, it is necessary to understand the concept of OBE and its theoretical underpinning. It is also necessary to investigate what learning means and how it is understood in an outcomes-based environment.

2.2 THEORETICAL FRAMEWORK

The word "philosophy" is explained in the South African Concise Oxford Dictionary as "the study of the fundamental nature of knowledge, reality and existence" (Dictionary Unit for South African English 2002:876). This study of the nature of knowledge is known as epistemology (James 2006:48). It strives for an explanation of what knowing means and attempts to understand how humans come to know something. Theories of how learning occurs or theories of knowledge are thus included in a study of epistemology.

Franzsen (1997:102), James (2006:49) and Vandeyar and Killen (2006:32) agree that the teachers' views on how learning occurs and how knowledge is acquired influence the way in which they see their roles as teachers and assessors. From this it can be deduced that if teachers took cognisance of theories about the acquisition of knowledge and sought to understand the learning process, they would gain insight that would encourage them to question the relevance of their own ideas about teaching and persuade them to consider changing teaching practices that prove to be ineffective (Franzsen 1997:103).

Pedagogic models function within a theoretical framework which is not absolute (Steyn & Wilkinson 1998:203). Consequently, more than one learning theory can be accommodated within a particular theoretical framework. For example, Steyn and Wilkinson (1998:203) found that behaviourism, social reconstructivism, pragmatism and critical theory could be presented on a continuum which would reflect the theoretical framework of the South African outcomes-based model.

Parkay and Hass (2000:165) distinguish between behavioural and cognitive learning theories. They argue that both these sets of learning theories influence teaching practices and so it is necessary that a study of both the behavioural and cognitive learning theories should be made.

2.2.1 Behavioural learning theory

2.2.1.1 Explaining behaviourism

Taking a behaviourist stance, Parkay and Hass (2000:166) describe learning as a conditioning process where a stimulus is used to induce a response.

Behaviourists disregard the activities of the mind and focus on learning that takes place by means of conditioning and repetition. They maintain that a new behavioural pattern should be repeated until it becomes automatic (Arnold & Yeomans 2005:9).

Hence, Arnold and Yeomans (2005:10) rightfully describe the behaviourist view of learning as something happening to a person who remains passive. Behavioural learning theories do not attempt to explain the cognitive processes involved in learning.

2.2.1.2 Implications for mathematics teaching, learning and assessment

A mathematics teacher teaching from a behaviourist view will usually teach mathematics to learners by using algorithms (”recipes”) or procedures. Du Toit (1993:142) deduces that the mechanical learning of algorithms precludes meaning and understanding. A typical behaviourist lesson usually starts with the teacher demonstrating the correct procedure followed by the learners continuing to practice the procedure on similar problems, applying the drill and practice method (Maree 2004:245; Sanni 2007:40; Schifter 2007:23). The teacher does not necessarily promote understanding of the problem, but rather encourages the memorisation of the procedure that can be recalled on demand.

Killen (2010:11) distinguishes between knowledge and understanding as follows: “Knowledge can be considered as facts or information to be remembered and reproduced – understanding is something more than that.” Killen (2010:12) proceeds to define understanding as what happens when something has meaning for learners or when something makes sense to them. As learners are unique, their understandings will differ (Van Niekerk & Killen 2000:92). Van de Walle, Karp and Bay-Williams (2010:23) distinguish between relational and instrumental understanding. They describe relational understanding as "knowing what to do and why" and instrumental understanding as "doing without understanding".

Learners taught from a behaviourist perspective struggle to solve mathematical problems that they are not used to or have not yet practiced. As soon as a problem is formulated outside the normal pattern, learners struggle to apply the rule or the algorithm. Another disadvantage is that specific procedures only apply to certain types of problems.

Direct instruction is an example of a teaching method that falls within the behavioural learning theories. Killen (2010:126) refers to direct instruction as whole-class teaching using expository techniques. "Expository" refers to teacher-centred teaching where the teacher is the main source of information and transfers knowledge to the learners (Von Glasersfeld 1996:178). As *tabula rasa* (i.e. without preconceived ideas) learners are "filled" with knowledge. The focus is mostly on the development of lower level cognitive skills with the expectation that these will eventually become thinking-skills (Darling-Hammond & Falk 1997:54). It can be deduced that in the behaviourist paradigm, mathematics is taught as a set of definitions and facts.

In a behaviourist paradigm typical assessment involves formal, teacher-directed, standardised tests, identifying deficits in learning and ranking learners. These tests do no more than test memory and rote learning and do not necessarily involve understanding (Vandeyar & Killen 2006:32). In mathematics, answers of sums determine correct or incorrect performance (emphases of product). Remedy of poor performance takes place by practicing incorrect items. Non-specific praise is often the positive feedback given (James 2006:54-55). Unwanted behaviour (incorrect answers) is deterred by punishment (Harlen 2006a:67).

2.2.2 Cognitive learning theories

Cognitive psychologists view as significant the mental processes that take place when learning occurs. Although there are many prominent cognitive psychologists, the work of Piaget (who initiated ideas of constructivism) and Vygotsky (who added the social processes resulting in social constructivism) will be investigated.

2.2.2.1 The work of Piaget

Van Harmelen and Bolt (2000:35) describe Piaget as the pioneer of cognitive psychology as it was he who initiated the idea that knowledge is constructed in the mind. De Ribaupierre and Rieben (1996:97) emphasise that, unlike the empiricist perspectives, Piaget never considered knowledge as a replication of external realities (such as the teacher in the example as explained in 2.2.1.2).

2.2.2.1.1 Piaget's developmental stages

Through his research, Piaget identified four stages of intellectual development in children and indicated what learners' abilities would be during each stage (Kruger 1997:228). Although Piaget related the stages to children's ages, his theory was later adapted when it became apparent that the age at which someone entered and exited each stage differed from person to person (Bell 1978:101; Bell 1980:60; Kruger 1997:230; Muijs and Reynolds 2005:17). The order in which Piaget's stages occur is relatively fixed; and children should move from the one stage to the next stage without skipping a stage (Kruger 1997:230; Von Glasersfeld 1996:72). Von Glasersfeld also emphasises that one aspect of a child's development may be in one stage and another aspect in another stage. For the study of mathematics this can imply that learners can be in the formal operational stage when doing algebra, but be still in the concrete operational stage when doing geometry.

The last two stages, namely the concrete operational stage (seven to eleven years) and the formal operational stage (eleven years and onwards) (Bell 1980:67), are of special importance to teachers teaching in the Senior Phase (grade 7 to 9) since it is to be expected that learners are usually in one of these stages when they are in the Senior Phase or in the transitional period between the two stages.

In the concrete operational stage, concrete objects may assist learners to think when children struggle to deal with abstract ideas. Kruger (1997:229) summarises the stage as follows: "children are able to think logically about concrete things, but cannot reason abstractly".

In the formal operational stage, all that was learned in the previous stages remains intact. Children rely less on concrete examples and can use logical and hypothetical thinking. Children are also able to link information and concepts (Arnold & Yeomans 2005:17). However, Muijs and Reynolds (2001:80) note that not all learners reach this stage.

2.2.2.1.2 Piaget's theory of learning

Piaget describes intellectual development as processes where information is assimilated and accommodated in mental structures. Assimilation is described as the way in which new structures are related to existing structures, or the way in which old structures develop into new structures. It is the process through which information is taken in or absorbed (Pulaski 1980:9). Piaget's empirical work demonstrates that any given level of knowledge is a result of the reorganisation of a previous level (Cobb 1988:87; De Ribaupierre & Rieben 1996:98). Should existing knowledge be incorrectly organised, learners will find it virtually impossible to comprehend new information (Kruger 1997:231). This important aspect of building new knowledge on existing, prior-knowledge will form part of the definition of learning in 2.2.5.

Accommodation can be described as the reshuffling of current information in order to accommodate the new information. Van Harmelen and Bolt (2000:33) describe this as the "aha" part of the learning process, where learning has taken place and the learner knows and realises it.

As learners move through the developmental stages, the processes of accommodation and assimilation are influenced by the factors described in the paragraphs below (Bell 1980:67).

a) Maturation

Maturation refers to the physiological growth of the brain and nervous system (Bell 1980:67), the "unfolding of biological changes that are genetically programmed into us at birth" (Muijs & Reynolds 2001:79). As people mature, their understanding of their world increases. Learners have different abilities and also mature at different rates. Teachers should be aware that more mature learners perform tasks on a different level of success from their immature learners (Bell 1978:101) and should consequently not expect learners to reveal the same levels of insight and sophistication when solving mathematical problems.

b) Physical experiences or activities

The ways in which learners interact with physical objects and gather data about them reflects their experience of the physical world (Bell 1980:67).

An example from the field of mathematics is where learners studying the properties of 3-D solids should work with real models of what is illustrated in their text books. In the following sketch the cube is drawn with angles at the back that are not 90^o angles. This has been drawn like this to give the impression of depth:

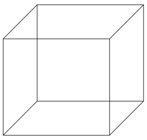


Figure 2.1: Diagrammatical representation of a cube

Learners might struggle to see that all the faces are squares since not all angles appear to be 90° when the cube is depicted in the form of a diagram, as illustrated above. Yet, having the physical object in class would address this problem.

c) Logical-mathematical experiences

These types of experiences refer to the intellectual actions which learners perform as they adjust their mental schemas to their experiences (Bell 1980:67). Bell (1980:60) describes schemas as sequences of actions that are well defined.

The following example illustrates a logical-mathematical experience: when grade 9 learners are asked to factorise $x^2 - 1$, they can usually give the answer relatively easily: $(x - 1)(x + 1)$. If they were asked to calculate the following: $1\,001^2 - 999^2$, learners immediately want to use their calculators. However, with logical reasoning as well as their existing knowledge, learners could argue that the factors are: $(1\,001 - 999)(1\,001 + 999)$, simplify the problem to $(2)(2\,000)$ and get the answer of 4 000 without using a calculator at all.

d) Social experiences

This expression, also known as social transmission, refers to the interaction between learners and all other people and is important for the maturity of the development of the learner's logic (Bell 1980:67). When learners interact with others, they learn from each other. Certain knowledge cannot be taught and learners need to gain this knowledge by communicating with other learners or with the teacher. This can happen verbally or in writing. In this regard, Du Toit (1993:125) explains that learners cannot discover for themselves the meaning of certain mathematical symbols such as "$\sqrt{\ }$" or "$\equiv$". It needs to be communicated to them either verbally or in writing.

e) Equilibration

Bell (1978:101) describes equilibrium as the state where both the learner and teacher feel satisfied that learning has taken place. When the learner is confronted with new learning material, disequilibrium occurs. This refers to the position where a learner is no longer mentally stable because of his or her new experiences. The learner can only return to a state of equilibrium once assimilation and accommodation have taken place (Bell 1980:68).

2.2.2.1.3 Implication for mathematics teaching, learning and assessment

Knowledge of Piaget's developmental stages, as well as the factors influencing thought processes, can assist mathematics teachers in more than one way. Firstly, teachers will know not to teach an aspect to learners who are not yet ready to learn it. Bell (1978:101) cites the following example: Imagine a teacher who expects 12- or 13-year-old learners (at the beginning of the Senior Phase) to prove a mathematical theorem. Learners who are at the concrete operational stage will not yet have developed the intellectual skills that are necessary to do this. Learners just entering the stage of formal operations will also be unable to prove the theorem. It would thus be unfair of the teacher to expect these learners to perform the task. Should the teacher, however, recognise the present stage of the learner's development, he or she would be able to assist the learner (through teaching and assessment) to move to a next stage. In this way the learner will be guided to prove the theorem. Piaget's developmental stages and the manner in which knowledge of them can influence the teaching-learning environment will be addressed in 4.6.2.2.

Secondly, teachers can use the knowledge of the developmental stages to identify shortcomings in learners' knowledge of mathematics (through assessment) and enable them to assist learners by adjusting their teaching to meet the needs and abilities of their learners (Kruger 1997:230). Thirdly, the knowledge about developmental stages as well as factors influencing learning can assist teachers to develop teaching, learning and assessment activities to assist learners to progress to a next stage (Du Toit 1993:152).

It must be noted that there will be cases where learners fail to accommodate information that has been assimilated correctly. This implies that prior knowledge constructed by learners is not always correct. Chapter 3 will investigate how formative assessment will assist teachers to deal with such problems.

2.2.2.1.4 Piaget's vision for learning

Piaget criticises teachers for allowing learners to sit passively in classes, dealing with content that they find meaningless and irrelevant (Pulaski 1980:202). Piaget wants learners to investigate the world and try to understand it; for in this way they will construct their own knowledge (Kruger 1997:231). Especially in the case of mathematics, Piaget emphasises the importance of relevant activity in addition to self-directed problem solving. He sees this as the proper basis for development that will allow more abstract conceptual understanding to take place (Wood 1998:228).

2.2.2.2 The work of Vygotsky

The work of Vygotsky (1896 – 1934) focuses on the role of social and cultural influences on learning. Both Arnold and Yeomans (2005:133) and Riddle

(1999) indicate that Vygotsky viewed social interactions as being vital to the learning process and that these interactions influence cognitive development profoundly.

Vygotsky disagrees with Piaget on the role of maturation because he does not regard maturation as the only factor that assists learners to achieve advanced thinking skills (Muijs & Reynolds 2005:17). Instead, Vygotsky proposes his idea of the "zone of proximal development" (Arnold & Yeomans 2005:133). He argues that children are susceptible to certain new knowledge at any time in their lives, regardless of their developmental stage, and that the acquisition of this learning must be effected with the assistance of a teacher or a more capable peer to assist the child to reach new heights of knowledge within a specific domain. For this, Vygotsky proposes social interaction as crucial (Kruger 1997:232).

The zone of proximal development can be described as the distance or "opening" that exists between the learner's actual level of development and the potential level of development. The actual level of development is determined when the learner is solving problems pertaining to a certain situation independently. The potential level of development will be determined by the level on which a learner can solve the same problems under adult guidance or with the assistance of more capable peers (De Corte & Weinert 1996:xxv). This will thus be the higher level which the teacher wants the learner to attain eventually. Muijs and Reynolds (2001:80) refer to a process of "scaffolding" that takes place in the so-called zone of proximal development. Teachers, other learners and adults provide learners' thoughts with these scaffolds as he or she moves from a lower to a higher level. Once a learner reaches the higher level, the "scaffolds" are no longer needed. Since learners differ from one another, not all learn the same way in the zone of proximal development. Some can learn more than others, some need more scaffolds than others.

An analysis of Vygotsky’s zone of proximal development led to the idea of “dynamic assessment” that focuses on the interconnectedness of teaching, learning and assessment. Shepard (2000b:10) describes this as a type of interactive assessment. By using interactive assessment, teachers not only gain insight into the extent of their learners’ understanding, but also an indication of what assistance should be rendered. The idea of dynamic assessment corresponds with the idea of formative assessment that forms the focus of this research.

Vygotsky also focuses on the necessity of viewing language and culture as the primary means through which humans make meaning in the construction of knowledge (Van Harmelen & Bolt 2000:36; Wood 1998:11). Culture can also influence teaching and learning in another way: it can influence learners’ experience of failure. It is the researcher’s experience that South African learners do not see mistakes in mathematics as opportunities to learn. Rather, they regard their mistakes as a sign of failure.

2.2.2.3 Reflecting on the work of Piaget and Vygotsky

Although there are definite differences between the theories of Piaget and those of Vygotsky, it is evident from the foregoing discussions that both Piaget and Vygotsky believe that learning takes place through active interaction with the environment. One of the differences between Piaget and Vygotsky’s work lies in the fact that Vygotsky stresses that this interaction should be with “a living representative of the culture” (James 2006:48, 55; Muijs & Reynolds 2001:81), making social interaction a non-negotiable part of the teaching-and-learning process.

The work of Piaget and Vygotsky have led to the development of learning theories that differ from those advocated by behaviourism (as discussed in 2.2.1.1), known as the cognitive learning theories. Both Piaget and Vygotsky view knowledge as something that learners must construct individually and/or socially. It must be noted that the contemporary view of classroom assessment as part of the teaching and learning process is a result of the cognitive learning and curriculum theories (McMillan 2007:14).

2.2.3 Constructivism

2.2.3.1 Explaining constructivism

According to Njisane (1992:28), the verb "to construct" refers to learners' structures that have been gradually built up from separate components. This differs from the behaviourist learning theory discussed in 2.2.1.1 and 2.2.1.2 where the role of the teacher is to fill learners with knowledge. Muijs and Reynolds (2005:61-62) describe it as follows: "… constructivism starts from the assumption that knowledge, no matter how it is defined, is formed in people's brain[s] …", and later: "This view is in contrast to that of the so-called 'realist' position, which states that 'The truth is out there' …". Consequently it may be said that constructivism implies that the truth is found within a person and is thus not something outside that needs to be discovered.

Moreover, constructivism implies that new knowledge should be integrated into existing internal structures as suggested by Piaget (cf. 2.2.2.1.2) and Vygotsky (cf. 2.2.2.2) (Troutman & Lichtenberg 1995:25). Chen (2001:262) explains that learners construct meaning individually from learning material by relating it to what they already know. What they already know includes their informal knowledge. By consolidating old knowledge through practice and then extending the knowledge to new situations, new knowledge is acquired. From this it becomes clear that, for the constructivist, the behaviourists' ideas of stimulus and reinforcement are viewed as naïve and misleading (Von Glasersfeld 1996:178).

Troutman and Lichtenberg (1995:25) as well as Kamii and Lewis (1990:34-35) agree that (for mathematics) constructivism implies that learning is not done by spectating, but by actually doing and connecting**.** All of these authors emphasise that learners must be active participants in the construction of knowledge. This does not mean that learners should be left alone to construct knowledge for themselves, but that teachers must establish a powerful teaching-learning environment where learners are allowed to explore their own methods for solving problems and teachers should allow learners to acquire a mathematical disposition (De Corte 2000:37). The teaching-learning environment conducive to a constructivist approach will be addressed in chapter 4.

Educational research into the teaching and learning of mathematics offers compelling evidence that learning in mathematics takes place more effectively if learners are allowed to construct mathematical understanding themselves (Kamii & Lewis 1990:34). In order to explain constructivism in mathematics, the following example cited by Cangelosi (2000:2-4) will be used: A teacher wanting to explain to learners the idea that a circle has a radius and that all radii of a circle are always equal in length allows the learners to play a game beginning with all learners standing on a straight line. The teacher puts a ball in front of them as follows:

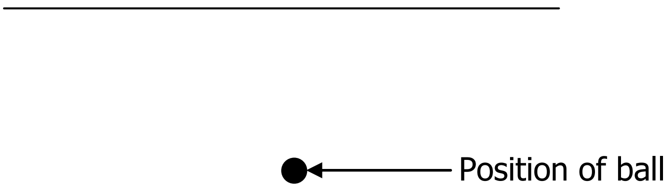


Figure 2.2: Explanation of game played in constructivist lesson

The teacher calls out the names of two learners randomly. Both learners run towards the ball and the first learner to reach the ball kicks it. For this, the learner scores one point. The aim is to see who can score the most points. Learners soon start to complain that the game is not fair since some learners are further away from the ball than others. The teacher allows the learners to change the rules of the game to be fairer. After deliberations the learners come up with the following way to play the game:

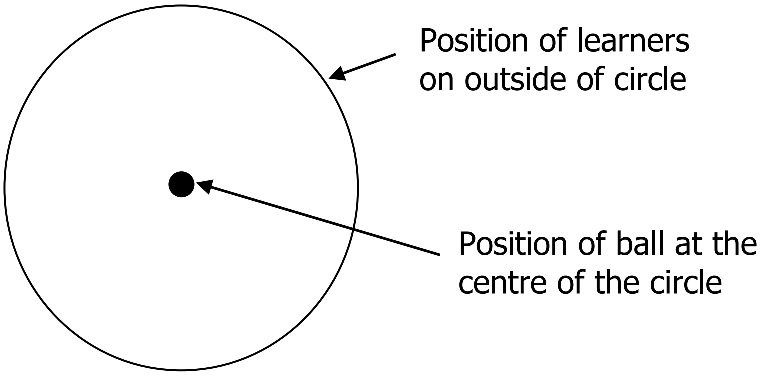


Figure 2.3: Changed rules for the game in figure 2.2

Learners realise that when they are all positioned on the circumference of a circle and the ball is placed in the middle of the circle, they are all the same distance away from the ball. Should the learners make a drawing of this, they will, in fact, construct a circle with a midpoint and conclude that the radii of the circle are all of the same length or that any point on the circumference of the circle is always exactly the same distance away from the centre of the circle.

2.2.3.2 Distinguishing between radical and social constructivism

Liu and Matthews (2005:387) indicate that there are two prominent variants of constructivism today: cognitive (also known as personal or radical) constructivism and social (also known as realist) constructivism. Radical constructivism is mostly in accordance with Piaget's work, and theorists (such as Ausubel, Bruner and Von Glasersfeld) who align themselves with this line of thought focus on intrapersonal processes of the individual construction of knowledge (Liu & Matthews 2005:387). Liu and Matthews (2005:387) continue to explain that for this group of theorists, knowledge is individually constructed or discovered. Learner-centredness and discovery-orientated learning are emphasised. Social environment and social interaction are seen as mere stimuli for individual cognitive conflict.

Social constructivists place the social environment at the centre of learning – and it is thus seen as being situation specific and context bound (Liu & Matthews 2005:388). The work of Vygotsky is of importance here. According to De Corte and Weinert (1996:xxv), social constructivism can be described as the process through which someone constructs knowledge in the presence of other humans where interaction, negotiation and collaboration occur. Social interaction is, therefore, included in constructivism as a requirement for the learning process to take place.

The researcher therefore proposes that:

social constructivism = constructivism + social interaction

According to Kim (2001), social constructivism is based on certain assumptions such as the belief that human activity constructs reality – it cannot be discovered (emphasising "constructivism"). In this regard, De Corte (2000:37) mentions that learning is, to a certain extent, always constructive. This is true even if information is simply transmitted to learners, for example when a mathematics teacher shows learners a specific method to solve a problem (as was discussed in 2.2.1.2).

A second assumption is that knowledge is socially and culturally constructed (with the emphasis on the social aspect). Learning is a social process and meaningful learning occurs through social activities. It must be noted that this does not imply that learning cannot also take place individually (De Corte 2000:37).

The researcher argues that there is a place for both radical constructivism and social constructivism in the teaching and learning of mathematics because all learners are different. Some learners learn better by themselves (individually – as emphasised by Piaget) while others learners learn better in the presence of others (socially – as emphasised by Vygotsky). There is also a good chance that learners learn more from their peers than from teachers because peers are more likely to use language that their contemporaries understand.

According to the theory of social constructivism, mathematics is also viewed as a social construction (Ernest 1991:3). Ernest (1991:42) indicates that there are grounds for this view since language requires both socially constructed and linguistic knowledge and its conventions provide a basis for mathematical knowledge. Furthermore, learners' subjective mathematical knowledge is turned into objective mathematical knowledge by a social process. Subjective mathematical knowledge refers to a person's thoughts, while objective knowledge refers to the person's thoughts that have become public (Ernest 1991:43).

2.2.4 Behaviourism versus social constructivism

Essentially behaviourism can be considered as an approach which emphasises the product of learning, the desire for learners to achieve certain learning behaviours and perform specific actions (Steyn & Wilkinson 1998:206). Social constructivism is more concerned with the process of learning and the aim is to assist learners construct not merely their own meanings, but also knowledge, attitudes and abilities (De Corte 2000:38; Steyn & Wilkinson 1998:206) without losing sight of the product.

Teachers are usually neither constructivists nor behaviourists completely, but find themselves somewhere on the continuum between the two learning theories. Each teacher's position *vis-à-vis* each theory influences the way he/she teaches, assesses and structures a teaching-learning environment (Du Toit et al. 2000:17).

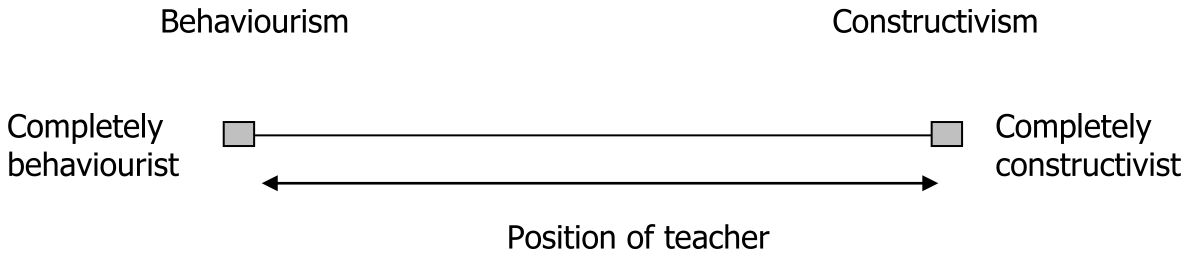


Figure 2.4: The constructivism/behaviourism continuum

James (2006:48) notes that in reality it is possible for teachers to combine behaviours associated with both behaviourism and constructivism in the teaching-learning situation. It is also true that some views of a learning theory can overlap with those of another learning theory.

The current NCS is in line with social constructivism (Wilmot 2003:313). The rest of this investigation will address teaching, learning and assessment within the paradigm of social constructivism.

2.2.5 Defining learning

In 2.2.2 the work of Piaget and Vygotsky were discussed. Constructivism (cf. 2.2.3.1) and social constructivism (cf. 2.2.3.2) were consequently discussed as the learning theories associated with the work of Piaget and Vygotsky. A definition for learning echoing the work of Piaget and Vygotsky and in line with the deductions made about learning in 2.2.3.1 and 2.2.3.2 can be found in the work of De Corte. In the field of study that investigates learning, researchers generally agree on De Corte's definition of learning (De Corte, Verschaffel & Masui 2004:365). According to De Corte (1996:37 – 38), effective learning is a process of building knowledge through making meaning that adheres to the characteristics described in the paragraphs below.

2.2.5.1 Learning is constructive

Learners can actively construct their own knowledge and skills. According to Muijs & Reynolds (2005:62), this implies that learners should be guided to make meaning of what is to be learned and then actively engage with the learning material. The effect of this on the teaching and learning of mathematics is that learners should not just follow procedures without understanding them (the algorithmic or procedural approach (cf. 2.2.1.2)), but teachers should assist learners to construct their own meaning (like in the example of Cangelossi – cf. 2.2.3.1). Muijs and Reynolds (2005:63) summarise this as follows: "Learning, for the constructivist, is a search for meaning". Constructivism is not a neat process. Zmuda (2008:42) warns that learners must be prepared to engage in a struggle in order for proper learning to take place. Constructivism emphasises learners' activity: learners acquire knowledge and skills through active cognitive processing (De Corte 1996:37).

2.2.5.2 Learning is cumulative

This aspect is actually built into the idea of "constructivism". When learners build new knowledge, it must be built on some foundation. This basis is what learners already know ("existing knowledge") or what they can do (De Corte 1995:41). Mathematics is a learning area where learners struggle to understand new work if pre-knowledge is not present. Based on what learners already know, they will actively process new information. Van de Walle, Karp and Bay-Williams (2010:23) put forward an explanation of understanding that includes the idea that learning is cumulative: "Understanding can be defined as a measure of the quality and quantity of connections that an idea has with existing ideas".

However, it is true to say that not all existing knowledge is always correct. This can be detected through assessment. This emphasises once again that the teacher has an important role to play in constructivist learning. The teacher's presence should always be felt: to guide the learner and assist where necessary. De Corte (1995:41) considers both formal and informal prior-knowledge as crucial for subsequent knowledge.

2.2.5.3 Learning is self-regulated

According to De Corte (1995:41) self-regulated learning forms part of the metacognitive aspect of learning. Boekaerts (1997:161), as well as various other researchers, has already established that learners can manage and monitor their own learning including building knowledge and acquiring skills. De Corte (2000:34,40) describes one of the benefits of self-regulation as the fact that more self-regulated learners can assume more control over their learning and thus become active agents and equal partners in their learning. De Corte (2000:41) suggests that learners should reflect on their own learning and determine what they know and identify areas in which they need more information.

Learners who are able to regulate their own learning will approach problems in unfamiliar situations in more than one way (De Corte 1995:38). Another positive impact of self-regulated learning is that the more learners control their own learning, the less dependent they are on instructional support (De Corte 1995:41).

2.2.5.4 Learning is goal orientated

De Corte (1995:41) emphasises that although learning can take place incidentally, it is much more meaningful if it "is facilitated by an explicit awareness" towards a goal. Learners should be allowed to set their own goals and orientate themselves towards this goal. Outcomes can be reduced to more specific objectives that are derived from assessment standards (cf. 1.7.6). Fisher and Frey (2008:34) explain that objectives make it easier for learners to activate the background knowledge that they need to build new concepts. Outcomes should, therefore, be stated at the beginning of the learning process in order for learners to set objectives in line with outcomes. This will ensure that learning is most productive. This idea is in line with one of the principles of OBE, namely "clarity of focus". This will be discussed in 2.3.4.1.

Should learners not set their own goals, De Corte (1995:41) suggests that learning could also be successful if learners worked towards a predefined goal set by the teacher or textbook with the prerequisite that learners should accept this goal.

For Boekaerts and Corno (2005:203), there is a positive correlation between learners' ability to self-regulate learning and to set and pursue learning goals. Boekaerts (1997:174) emphasises that it is important that learners set their own goals in terms of short- and long-term perspectives and that the teacher should assist them to do so. After learners have set their own goals (broken into objectives), they should monitor their progress to attain them.

2.2.5.5 Learning is situated and collaborative

De Corte (2000:40) mentions that powerful teaching-learning environments should embed learners' constructive acquisition activities in context. This emphasises the importance of authentic, real life situations. In this way, learning can be seen to be situated.

In line with social constructivism, the role that peers, teachers, parents and other people play in learning cannot be ignored. Accordingly, Muijs and Reynolds (2005:63) conclude that it is best for learners to construct knowledge socially. This can be done through group work, discussion and the use of co-operative learning (cf. 2.3.6).

2.2.5.6 Learning differs from person to person

Social interaction and collaboration as discussed above does not exclude the possibility that students also acquire new knowledge individually. The uniqueness of every learner should be recognised and also that learners learn in different ways (Muijs & Reynolds 2005:63). From the work of De Corte (1996:38) it is obvious that learners do not only differ cognitively, but also affectively such as in their levels of motivation.

Furthermore, teachers should acknowledge that learners have different learning styles: some are global thinkers, others think logically; some learn fast, others slowly. Teachers should accommodate all of these differences when deciding upon effective teaching and assessment strategies.

2.2.6 Learning and assessment

Based on the definition above (cf. 2.2.5), learning can be described as an ongoing process where learners actively process information, linking it to their existing knowledge. According to McMillan (2007:12), effective assessment promotes this process. Therefore it can be claimed that assessment forms an important part of the teaching and learning process and that this definition of learning will also have an impact on a study of assessment. Assessment should be aligned with teaching and learning, according to Biggs (s.a.:1).

2.2.7 Principles of effective learning

From the previous discussions, the general principals of learning can be summarised as:

- Learning should always start from a learners' current understanding. To identify prior knowledge and understanding is essential.

- Learners should be active in the learning process. Teachers must design lessons to optimise learners' activity. Learners must actively construct knowledge and make meaning of new learning material.

- Effective interaction in discussion will provide the social element of learning. Discussion should take place between learners themselves, learners and teachers and also among teachers. Through discussion, reflection takes place and feedback is possible (cf. 3.6.2, 3.7.6).

- Metacognition should be practiced by learners. This calls for both judgement of their present understanding and a good understanding of the learning purpose and the criteria in order to be able to judge whether the purpose of the lesson has been achieved. This will enable learners to manage and control their own thinking (self-regulation).

- Teaching in context should be explored as far as possible. Learning will make more sense to learners if it is connected to real life situations.

- Teachers must acknowledge the different needs of different learners. Learners learn in different ways and at different paces.

- Learners need to set goals for themselves and focus on achieving their goals. Breaking goals down into objectives makes it easier for learners to monitor progress towards achieving objectives and goals.

2.3 MATHEMATICS AND THE NCS

The NCS functions within the theoretical framework of social constructivism (cf. 2.2.4). In the paragraphs to follow the NCS will be measured against the principles of effective learning.

2.3.1 A transformational perspective on curriculum

Spady, who is acknowledged as the founder of OBE, argued that it is not how and when learners learn, but what learners learn and whether (if) learning takes place that is important (Du Toit & Du Toit 2004:4). The outcomes-based curricula (and thus the NCS in mathematics) are examples of using a transformational perspective on a curriculum. Sönge and Moletsane (1997:263) argue that, from the transformational perspective, the focus is on the learner and the personal, social and transpersonal changes in the learner that are brought about by schooling. The active learner is emphasised and the role of the mathematics teacher becomes that of facilitator, mediator and scaffolder (Wilmot 2003:313) (cf. 2.2.2.2, 2.3.5.1). This contrasts with the focus of the previous curriculum that portrays a transmission perspective, placing the emphasis on the teacher as transmitter of knowledge to the passive and receptive learner (cf. 2.2.1.2). The main sources of information in this instance are the teacher and the curriculum (Sönge & Moletsane 1997:263).

Spady (1994:31) refers to schools following a curriculum based on the transmission perspective as "industrial age schools" and claim that these schools "inherently constrain learning success for many students".

2.3.2 The assumptions of OBE

OBE is based on the tenet that the focus should be on the learner and the school and that the potential of every learner should be acknowledged. Spady (1994:9) states that every learner can be successful on condition that the school provides the environment that supports effective teaching and learning. When learners are successful in their learning, they try to be even more successful in their learning. In short: success breeds success.

Killen (2010:57) observes that the traditional notion that some learners were expected to fail has been eliminated in the outcomes-based approach. This implies that teachers should allow learners several attempts to achieve outcomes when assessment takes place. The first assumption of OBE acknowledges the uniqueness of every learner emphasising that learning is individually different (cf. 2.2.5.6).

2.3.3 Outcomes

Spady (1994:18) defines outcomes as "… high-quality, culminating demonstrations of significant learning in context" and also as "… clear learning results that we want learners to demonstrate at the end of significant learning experiences. "High quality" refers to deep understanding and not rote learning. It also implies high levels of competence (Killen 2010:55). By including "culminating" in this definition, Spady emphasises that learners will demonstrate outcomes after a significant learning process has taken place (Killen 2010:54).

"Demonstrations" are key to Spady's definition. Demonstrations imply that learners must in fact be able to perform outcomes. Assessment should therefore aim to identify whether learners can actually perform outcomes.

2.3.4 The principles of OBE

Principles of OBE (such as clarity of focus, design down, high expectations and expanded opportunities) are important directives in the teaching of mathematics. For example, when dealing with factorisation, learners should be informed about what they are going to do (to factorise), what it is that they must do to get there (take out the common factor, difference between squares) and how will they know that they are finally there (factorise successfully).

2.3.4.1 Clarity of focus

This principle emphasises that teachers should be clear about what they want their learners to be able to do at the end of the learning experience (Spady 1994:11). In OBE, the whole learning process (including planning and assessment) is directed by the outcomes. As already stated in 2.2.6, Biggs suggests that there should be an alignment of outcomes, planning and assessment. This makes the learning process goal orientated, as suggested by De Corte's definition of learning (cf. 2.2.5.4).

The principle of clarity of focus further implies that the success of learners becomes top priority when instruction and assessment are planned in mathematics. OBE teachers are encouraged to know their learners' learning rates and learning styles and to design lessons and assessment tasks that will suit these needs of their learners (cf. 2.2.5.6) that differ from context to context.

2.3.4.2 Expanded opportunity

This principle acknowledges that every learner is an individual and should be treated as such (cf. 2.2.5.6). It emphasises that teachers should be flexible about how learners can achieve an outcome and also requires that teachers give learners more than one chance to learn important work and to demonstrate that they have acquired some learning. Learners should be given numerous opportunities and adequate time to achieve the outcomes. For example, learners who are anxious in a situation may fail to use mathematical skills correctly, despite being perfectly able to demonstrate the skill in less strenuous circumstances (Geldenhuys 2000:24). This calls for the regular assessment of progress and action plans for intervention strategies (Janse van Rensburg 1998:90).

Du Toit and Du Toit (2004:5) propose that this principle of expanded opportunity implies that teachers should change their teaching methods to ensure successful learning for all. If a teacher teaches a certain topic in mathematics and establishes that learners are not coping, the teaching strategy should be adapted in order to assist learners to understand the topic. In order to accomplish this, teachers need to assess learners continuously, reflect on the assessment and, based on the outcomes of assessment, devise a new strategy.

2.3.4.3 High expectations

An assumption of OBE is that all learners can be successful (cf. 2.3.2). Accordingly, this statement underlines the high expectations that should be established for all learners. Moreover, it requires patience and dedication from the teacher because it is clear that not all learners will be successful at the same date and in the same way.

In this regard assessment can be used fruitfully: learners may, in fact, improve their performances if another assessment strategy or opportunity had been used. This concept is built into the ideas of continuous assessment and formative assessment (cf. 2.4.5.2, 2.4.5.5, 3.2). Again, no restriction should be placed on the number of learners that can be successful (cf. 2.3.2) (Du Toit & Du Toit 2004:5; Macmillan 2005:1). Through applicable assessment, growth towards high expectations can be fostered (AMESA 2001:16).

2.3.4.4 Design down

This fourth principle implies that teachers should identify what they want their learners to achieve (the end-product) and then to design teaching, learning and assessment around this (Spady 1994:20). When education is seen in this way, it is clear that the outcomes (cf. 2.3.3) shape teaching, learning and assessment.

2.3.5 Expectations of the teacher, learner and learning material

2.3.5.1 The role of the teacher

In February 2000, the Norms and Standards for Educators were announced publicly in the Government Gazette. This policy set out to describe the seven roles of educators. The word "educator" in this case refers to any person teaching or educating learners (Killen 2010:396). For this study the word "teacher" will be used. For the purpose of this study, the roles of the teachers as mediators and assessors of learning are important and will be discussed.

2.3.5.1.1 The teacher as learning mediator

The first role of a teacher mentioned in the policy is that of learning mediator. Potenza (2002) explains that a mediator is somebody who mediates "between" parties. In this case the teacher acts as a mediator between the learner and several sources of information: the teacher himself/herself, the learners and the learning material. Teachers should not transmit information to learners, but should design creative learning experiences that promote active learning (Kotzé 1999:32; Kruger 1997:218).

In a social constructivist classroom, the role of the teacher takes on the dimension of facilitating learning. This diverges from the traditional approach which regards the teacher as a "source of all knowledge" (Kamii & Lewis 1996:34,35; Killen 2010:2; Maphumulo & Vakalisa 2004:329). As a facilitator of learning, the teacher also has to create a teaching-learning environment in which learners feel free to express themselves and to learn. This is in line with the constructivist approach to learning as discussed in 2.2.3 and 2.2.5.1 and will be further investigated in chapter 4.

Teaching which imposes knowledge on learners should be replaced by teaching where negotiation takes place (Njisane 1992:28). In an educational context, negotiation should be a dialogue between the role players. Freire (2004:125-132) argues that it would be possible to move away from the so-called "banking education" through dialogue which can only occur through words. In this regard, words function in two ways, namely for reflection and for action. Freire goes on to explain that dialogue can never be an act where one person deposits ideas into another nor can it be an act where one person consumes the ideas of the other. Pang (1997:281) suggests that the dialogue should be "exciting, challenging, and thought provoking". This emphasises the important role of the teacher as mediator between the learner and the learning material. Learners should be aware of the way in which they think and learn and be able to apply new understandings to relevant situations. This can happen through assessment and, more specifically, via formative assessment.

2.3.5.1.2 The teacher as assessor

The teacher also fulfils the role of assessor. According to Killen (2010:397) as well as Potenza (2002), teachers should know how to integrate assessment into the teaching and learning process continuously and ought to understand the purposes, methods and effects of effective assessment. Dreyer (2008b:10) adds that in his/her role of assessor, the teacher has to establish whether learners are learning, the level of the learning that is taking place, whether learners understand the material studied and what learners still need to learn. Therefore, assessment must be used to identify and accommodate the diverse needs of learners (Potenza 2002). Indeed teachers should act upon these needs.

The assessment process involves teachers in various actions such as the interpretation of assessment results, giving feedback to learners and deciding upon effective follow-up actions after assessment has taken place (cf. 3.3.1 – 3.3.5). The role of the teacher as assessor forms part of the investigation that will be done in chapter 3 and 4.

2.3.5.1.3 Further roles of a teacher

Further roles of a teacher include interpreting existing learning programmes and designing their own learning programmes and learning materials. Teachers have to use their creativity to design original learning programmes and materials that will assist with the mediation of mathematics so that learners make meaning of mathematics. The teacher must furthermore fulfil the role of leader, administrator and manager. It is important that these roles should occur in a democratic manner that is supportive of learners and colleagues alike (Killen 2010:397; Potenza 2002).

The roles of being a scholar, a researcher and a lifelong learner and the role of being a learning area specialist are closely connected. According to the NCS document for mathematics, the following characteristics are envisaged in a teacher (DoE 2002b:3): "…teachers who are qualified, competent, dedicated and caring". Teachers must be knowledgeable about various aspects of their branch of learning and this includes being a content specialist, as well as having specialist knowledge of different approaches to teaching their subject appropriately in relevant contexts (Potenza 2002).

Finally, the teacher has a role to play in the community: he/she has to model citizenship and play a pastoral role. The development of an empowering learning environment (which promotes respect and responsibility towards others) forms part of the role of the teacher (Black & Wiliam 2008). This will be investigated further in 4.5.

2.3.5.2 The learner’s role

2.3.5.2.1 The learner’s role in regulating his/her own learning

One of the developmental outcomes of the NCS aims for learners to be able to “reflect on and explore a variety of strategies to learn more effectively” (DoE 2002b:1). This goes hand in hand with the critical outcome to “organise and manage themselves and their activities responsibly and effectively”. Söhnge and Moletsane (1997:271) claim that, as learners take control of their own learning process, they will learn how to prioritise activities, know the level at which to engage with activities and determine the amount of time needed for activities. Learners should increasingly accept responsibility for their own actions, investigations, thoughts and beliefs (Black et al. 2003:97).

The increased responsibility assumed by learners emphasises the importance of metacognitive skills which learners should use to regulate their own learning. From the discussions in the previous paragraph, it can be deduced that learners should become metacognitively skilled. According to De Corte, Verschaffel and Greer (1996:535), metacognition involves someone’s knowledge and beliefs about his/her own cognitive functioning (for example, beliefs about one’s own mathematical ability) and the skills and strategies required to regulate and monitor one’s own cognitive processes (for example, planning solutions when solving a mathematical problem). Troutman and Lichtenberg (1995:369) explain that metacognition refers to the intentional process of using certain thinking abilities. Simply stated it refers to “thinking about thinking” and also to pay attention to specific thought processes used (Shepard 2000a:21; Troutman & Lichtenberg 1995:116). Metacognition calls for both a judgement of the present level of understanding and a good understanding of the learning purpose and the criteria to judge whether the purpose of the exercise has been achieved. Metacognitive strategies can thus be viewed as decisions made by the learner before, during and after the process of learning (Boekaerts & Simons 1995:91).

Self-regulation forms part of metacognition. Killen (2010:28) maintains that self-regulation refers to the strategies used by a learner to direct his/her behaviour and attempts to learn. What is more, self-regulation refers to someone's knowledge of his or her own thoughts, thought processes and the ability to direct and evaluate these processes (Burger 1993:53). Zimmerman (Darr & Fisher 2004:11) indicate three cyclical phases for self-regulated learning (SRL): forethought, performance control and self-reflection. According to the authors, forethought involves analysing tasks and setting relevant goals. The actions associated with performance control are monitoring and controlling the cognitive. Learners are not just supposed to gain insight into mathematical concepts, but also to learn how to identify areas where they need assistance (Stenmark 1991:4). Accordingly, self-reflection implies that judgements should be made regarding on what has been accomplished. As a result of self-reflection, behaviour and goal orientation are adjusted appropriately. Reflection forms a non-negotiable aspect of formative assessment and will be discussed in 3.3.

2.3.5.2.2 The learner's other roles

Other roles that learners are expected to play are described in the critical outcomes. The roles of problem solver, team member and communicator are important within the context of this study. It was already discussed that NCS is in line with social constructivism. Social constructivism implies active learners and active team members. This cannot take place if learners cannot communicate effectively. Learners should gain enough confidence to solve problems and make decisions (DoE 2002b:1). When learners are confronted with mathematical problems, they should be able to make decisions using their critical and creative thinking. Learners should embrace problems and not steer away from them.

Learners also have a role to fulfil as team members. They must be willing to participate fully in group discussions or activities involving co-operative learning. All members of a group must function co-operatively, knowing that their actions influence the performance of the whole group.

The role of the learner as communicator strongly connects to the role of the learner as member of a team. Learners must communicate in an effective manner when interacting with peers as well as with the teacher. Learners should be able to communicate in both the LoLT as well as in appropriate mathematical language.

More roles of the learner as sited by James and Pedder (2006:28) include: learners should understand learning goals and actively pursue it and learners should understand how and what they should learn.

2.3.5.3 The role of the learning material

Because skills and attitudes form part of the curriculum, OBE is more than just the mere construction of knowledge, it also about acquiring skills and a value system. This implies that the learning material can no longer be restricted to textbooks only, but should come from various sources and various role players (DoE 2002c:61-62). Rich learning material is needed to compel learners to be actively engaged in the learning process. The learning material should also assist learners to monitor and assess their learning progress continuously.

The development of appropriate learning material places a heavy burden on teachers' creativity and insight into mathematics. For example, teachers could develop an interesting activity based on graphs from the media by requiring the learners to interpret the graphs. Another possibility would be for teachers to request learners to find graphs pertaining to a specific situation in the media and to analyse them carefully. Teachers should supply learners with such media if learners do not have access to it. Learners experience knowledge in everyday life in an integrated manner and therefore have to acquire the skills and a value system that will assist them to interpret the world they live in.

Teachers ought to take care when using prepared learning material designed by external sources. It is possible that it may not be appropriate for the learners that they teach. The learning material could be too difficult or too easy. It could be culturally offensive or use a context irrelevant to the learners' fields of interest. Since many learners in South Africa are taught in a language other than their home language, teachers should judge the level of language used in the learning material carefully before giving it to learners. It is vital that learning material should be relevant and appropriate for the specific group of learners (DoE 2002c:61; Killen 2010:42).

2.3.6 Co-operative learning

Spady (1994:36) includes cooperative learning in his list of what he calls "components of the outcome-based, information age paradigm", linking it with the traditional notions of teamwork and collaboration.

Fisher and Frey (2008:34) emphasise that the importance of collaborative learning is that it transfers more responsibility to learners, and at the same time provides learners with support from peers. Co-operative learning methods are based on the idea that learners should work together, taking the responsibility not only for their own learning, but also for the learning of other learners (Slavin 1996:351). Learners work together in teams or groups to achieve certain goals and the goal can only be achieved if the team as a whole is successful in the learning process. The emphasis is thus not so much on doing something as a team, but on learning something as a team. Team members learn from one another and contribute to the success of the team by improving on their own past performance (Slavin 1996:351).

Although cooperative learning may appear to be the same as ordinary group work, it is not (Van der Horst & McDonald 1997:127). It differs from group work in the sense that the important aspect of positive interdependence is not necessarily present in group work. Covey (2004:50) explains that independence is more mature than dependence, but that interdependence is the ultimate action. The reason why interdependence is far more advanced than independence is that interdependent learners can share matters deeply and meaningfully with other learners, whilst at the same time gain access to the resources and potential of the other learners.

Cooperative learning teaches learners accountability. Each learner is accountable for an aspect of the work (Fisher & Frey 2008:36). Therefore, positive interdependence refers to group work where everybody in the group becomes accountable for each other's learning and turns groups into teams. In this case, team members share the workload so that all members contribute, making the learning experience worthwhile for all. Cuseo (1992:3) indicates that assigning special tasks to each group member can increase the learners' sense of individual responsibility.

The jigsaw is a cooperative learning technique that can be effectively used in mathematics assessment. For example, in the mathematics class the jigsaw can be used when learners have to do sums for homework. The class can be divided into the number of sums given for homework (or multiples thereof). Learners from the home group can join expert groups to discuss the sums assigned to them and then return to the home groups to share their understanding. This gives learners a chance to explain their reasoning and receive immediate feedback (Shepard 2000b:10). The important dialogue mentioned in 2.3.5.1.1 is also stimulated.

Although ordinary group work does not qualify as being part of the co-operative learning technique, group work should also be included as a teaching strategy. Once again, it provides the opportunity for the important dialogue that was mentioned in 2.3.5.1.1 to take place, an opportunity that is usually lost in whole class discussion where only a few learners are involved

2.3.7 NCS and effective learning

Based on discussions in 2.3.1 – 2.3.6, it can be concluded that the NCS supports the definition of learning and principles of effective learning as displayed in table 2.1:

Table 2.1: The NCS supports effective learning

Aspect of learning	**NCS**
Constructive	Theoretical framework is social constructivism. Transformational perspective on curriculum. Learner-centredness emphasises active learners. Learners must demonstrate outcomes.
Cumulative	Social constructivism is the underlying learning theory – implies that new knowledge should be integrated into existing knowledge.
Self-regulated	The role of the learners is to take control of their own learning, use metacognition to analyse and regulate own learning.
Goal-orientated	Principle of clarity of focus. Principle of design down.
Situated	Outcomes are demonstrations in context; real life situations according to Spady's definition (cf. 2.3.3). Critical outcomes indicate life roles for learners to fulfil.
Collaborative	Co-operative learning, group work
Individually different	Assumption that every learner can be successful, but not in the same time and in the same way. Principle of expanded opportunities. Principle of high expectations.

2.4 OUTCOMES-BASED ASSESSMENT (OBA)

Kellough and Kellough (1999:419) state that the importance of "good" assessment and a good assessment programme cannot be overemphasised. According to these writers, learners should have answers to basic questions such as: "Where am I going? Where am I now? How do I get where I am going? How will I know when I get there? Am I on the right track for getting there?" in order for a learning experience to be successful. For this reason, assessment in an outcomes-based environment is essential (Richardson 2005:xiv). Outcomes-based assessment will be described in general in the next section.

2.4.1 Defining OBA

If learning is viewed as a personal construction of meaning as was debated in 2.2.3, assessment should be viewed in a more holistic and integrated manner. Seen in this way, assessment becomes a monitoring as well as a developmental process and provides an opportunity for learners to show competence in various authentic activities, with the purpose of guiding further instruction (Vandeyar & Killen 2006:32).

The root of the word "assessment" comes from the Latin verb "assidere" meaning "to sit beside" (Reddy 2004:32). Shasha (2004:28) gives a rather narrow description of assessment by describing it merely as a "process of identifying and gathering information that will indicate a learner's achievement when measured against clear outcomes". If this definition is compared to that of McMillan (2007:8), it lacks the very important angle that assessment should also "… use information to help teachers make decisions that improve student learning". This assigns the assessment process a more purposeful role and also adds a developmental side rather than only judging whether a learner has achieved an outcome or not as Sasha suggests.

Rowntree (1997:108) indicates that assessment is not just about finding out what a person knows, but also what the person understands and thinks. McMillan (2007:2) expands Rowntree's observations and describes assessment as a process. This process should support and enhance learners' learning and should not only be intended to find out what a learner knows, but what he/she can do and understand. McMillan's description makes assessment part of the teaching and learning process as expected from adherents to the founding principles of an outcomes-based curriculum. By stating that assessment merely gives an indication of what learners know, can do, understand and think is to emphasise but one important part of assessment. As McMillan rightfully states (2007:2) "teaching and assessment coexist in dynamic interaction, each feeding and influencing the other".

The DoE (2007b:1) describes assessment as "a process of collecting, synthesising and interpreting information to assist teachers, parents and other stakeholders in making decisions about the progress of learners. It involves gathering and organising information (evidence of learning), in order to review what learners have achieved. It informs decision making with respect to teaching, and helps teachers to establish whether learners are making progress towards the required levels of performance (or standards), as outlined in the Assessment Standards of the NCS."

In other words, assessment in the outcomes-based paradigm is an all-inclusive term for the full range of procedures that cannot only be used to gain information about the state of the learners' progress, but which should be acted upon to better the teaching and learning process.

2.4.2 The role of assessment in the outcomes-based classroom

Assessment should provide teachers with continuous and constructive information that specifies the progress of the learning process. It should also provide information to be considered when teachers plan learning experiences that will cater for a learner’s individual needs (Shasha 2004:29).

Biggs (s.a.:1) suggests that the components of teaching (namely outcomes, teaching methods and assessment tasks) should all be aligned (cf. 2.2.6, 2.3.4.1). Alignment will be discussed further in 4.6.2.1.

An outstanding feature of OBA is that it is continuous. According to Pahad (1999:249), teachers use this assessment mostly in a formative and also developmental manner, but Kotzé (1999:33) describes it as a culmination of all formative and summative assessment tasks (cf. 2.4.5.2, 2.4.5.3).

2.4.3 Distinguishing between assessment, measurement and evaluation

According to McMillan (2007:9), measurement implies “a systematic process of assigning numbers to behaviour or performance”. More than one technique (such as tests, observations and also interviews) can be used for measurement - but tests are usually seen as the tools of measurement. McMillan (2007:10) extends this definition of measurement and indicates that once information has been gathered by means of some form of measurement, a value must be placed on the resulting numbers. McMillan calls this process of placing a value on the numbers, evaluation.

Assessment differs from evaluation in the sense that it (assessment) is thus not just about tests, examinations and assignments, but also about a variety of ways to collect information which is used to give feedback to learners about their progress (Siebörger & Macintosh 2004:5). Assessment is thus more than making a judgement of whether a learner has passed or failed: it is about ongoing growth (Janse van Rensburg 1998:84).

In accordance with these observations, the researcher will continue to use the word "assessment" as an important aspect of OBE that should contribute to improved learning (Killen 2010:378) with the main purpose of supporting and promoting learning (Wilmot 2003:313). Therefore, the broader concept of assessment encompasses both the assessment of learning processes and its products (AMESA 2001:7). In this sense, assessment can be either developmental or judgemental. It is developmental if the purpose is to improve the learning process. "Judgemental" implies that a decision will be made such as whether the learning process has been successful or not. The researcher will use the word "evaluation" as the term for assessment when referring to the traditional curriculum. This is in line with De Corte's (2004:300) view of evaluation. De Corte describes this traditional evaluation as static and product orientated.

2.4.4 Criterion-referenced assessment versus norm-referenced assessment

Norm-referenced assessment implies that a learner's performance is being compared to the performance of other learners in a specific grouping (Harris & Bell 1994:101; Popham 1999:99). All learners are measured against a predetermined norm guaranteeing a number of failures and distinctions. This is not in line with the assumptions of OBE (cf. 2.3.2) that prefers to focus on learners' success.

Criterion-referenced assessment (associated with OBE), on the other hand, implies that the performance of a learner should be measured by clearly defined criteria or set standards (or outcomes – cf. 2.3.3) (Harris & Bell 1994:101; Popham 1999:99; Van der Horst & McDonald 1997:12). This can help learners to feel more secure in the mathematics class because it eliminates any unnecessary competition that may lead to negative feelings (such as anxiety) (Geldenhuys 2000:24). In order to achieve this, each learner ought to know exactly what is required of him or her in order to achieve the standard for any particular task (Popham 1999:99) (cf. 4.6.2.3.1). When using criterion-referenced assessment, there is no restriction on the number of successful learners and this approach is thus in line with the philosophy of OBE (Macmillan 2005:1; Spady 1994:14).

Yet norm-referenced assessment has not been totally abolished in OBE in South Africa. According to the DoE (2007b:2), systemic assessment will be done to monitor the education system. In this instance learners' performances will be compared to national indicators of learners' achievement. These indicators are, in fact, norm-referenced since the standardised tests written by learners are set at a level that can be expected from learners of a certain age. For the GET band, systemic assessment is performed at the end of Grades 3, 6 and 9 and has been done in these grades in mathematics, languages and natural science. In chapter 1 (cf. 1.3.2) the results of this assessment were mentioned; however, the use of this form of assessment is beyond the scope of this research.

2.4.5 The types of OBA

The purpose of assessment is closely linked to the type of assessment (DoE 2007b:2; Killen 2010:369).

2.4.5.1 Baseline assessment

Some authors refer to this form of assessment as placement assessment, sizing-up assessment or recognition of prior-learning. The literature explains that this form of assessment is used at the beginning of the learning process with the aim of determining what learners already know. Learning programmes, work schedules and activities can then be planned, based on the results of this type of assessment (Maree 2004:251; DoE 2007b:2).

The work of Piaget (which was discussed in 2.2.2.1) maintains that if learners' existing knowledge is not well organised or is incorrect, new information cannot be understood. This demonstrates the importance of cumulative knowledge as explained in De Corte's definition of learning (cf. 2.2.5.2). This emphasises that new learning must be connected or build upon existing or prior knowledge.

2.4.5.2 Formative assessment

Irons (2008:9) describes formative assessment as any task done that provides formative feedback. The author also describes formative assessment and formative feedback as "powerful and potentially constructive learning tools" (Irons 2008:7).

Formative assessment is developmental (DoE 2007b:2). In it, the well-defined boundaries between assessment and the teaching-and-learning situation become blurred (Elliott & Morris 2001:158). Both Reddy (2004:34) and Smit et al. (2000:28) believe that formative assessment is integral to learning. In fact, formative assessment takes place during learning.

Resources also refer to formative assessment as "assessment for learning" (DoE 2007b:2; Dreyer 2008b:12). Assessment for learning or formative assessment involves both teacher and learner in a process of continual reflection and self-assessment. It is also interactive since the teacher and learner should enter into a dialogue to discuss aspects of learner's success and failures. Formative assessment can take place in a variety of ways. It can be done through informal and spontaneous observation, but also in formal and structured ways, such as tests.

As discussed earlier, baseline assessment should be done to determine learners' knowledge at the beginning of every learning experience. This information will be used to shape the consequent learning process. Since this action also supports the idea of improving the learning process, baseline assessment can be regarded as part of formative assessment. Accordingly, the researcher proposes that baseline assessment is not another type of assessment, but in fact an important part of formative assessment (cf. 3.2.3, 3.4).

Formative assessment in mathematics is the focus of this research and will be investigated further in chapter 3.

2.4.5.3 Summative assessment

Summative assessment can be described as a summary of a learner's achievement at a specific point in time (Harlen 2006b:104; James 1998:27; Mitchell & Koshy 1995:5; Reddy 2004:33; Redfield, Roeber & Stiggins 2008:2; Shasha 2004:34). It is usually more formal and more structured than formative assessment. Usually, a judgement of a learner's performance is made through summative assessment, for example by means of the National Senior Certificate (NSC) examination at the end or grade 12. Summative assessment is also referred to as an "assessment of learning".

The outcomes of summative assessment are important to many stakeholders in education, such as parents, the business community and the general public (Harlen 2006b:104; Reddy 2004:33). Reddy (2004:33) also notes that statistics and data from this summative assessment can be used to classify and rate schools and so it is perceived to reflect the effectiveness of a specific school. The forms or strategies of assessment mostly associated with summative assessment are more formal and are normally in the form of tests and examinations. In chapter 3, summative assessment will be used as a benchmark for formative assessment so that a clear distinction may be made between formative and summative assessment.

2.4.5.4 Diagnostic assessment

OBA should aim to diagnose a learner's weaknesses in time to rectify problems so that learners can achieve the required standard (outcomes). One of the assumptions of OBE is that all learners can be successful (cf. 2.3.2), but that this does not happen at the same time for all learners. Only through well-planned, diagnostic assessment tasks can learners' problems be identified and addressed.

Different views on diagnostic assessment are found in the literature. For the purposes of this research, diagnostic assessment is done as part of formative assessment where the intention is to diagnose learners' strengths and weaknesses; but it can also form part of summative assessment for the same reasons.

2.4.5.5 Continuous assessment

In 2.4.2 the preferred form of assessment in an outcomes-based paradigm was identified as continuous assessment. The following diagram is based on a similar diagram found in Dreyer (2008b:16).

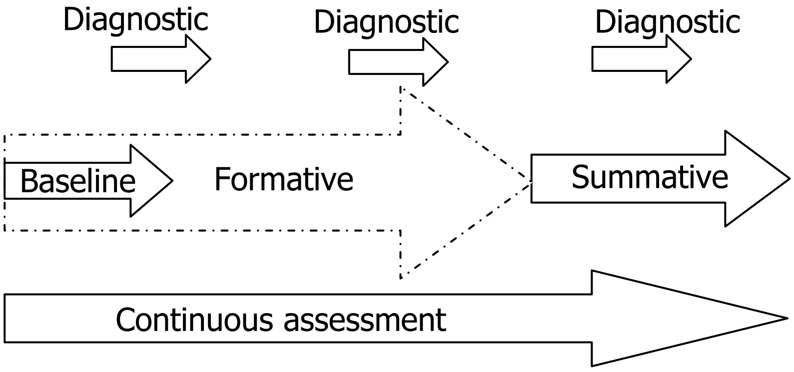


Figure 2.5: Continuous assessment (adapted from Dreyer (2008b:16))

The relationship between all types of outcomes-based assessment that were discussed in 2.4.5.1 – 2.4.5.4 is depicted. It must, however, be noted that

the researcher regards baseline assessment as part of formative assessment and hence baseline assessment is included in formative assessment.
Baseline, formative and summative assessment form part of continuous assessment. Diagnostic assessment takes place throughout continuous assessment.

2.5 SUMMARY

In this chapter, learning was discussed in terms of the behaviourist and cognitive paradigms. In addition learning from a social constructivist paradigm with reference to mathematics as the learning area was viewed. The former South African curriculum (before 1998) was mentioned as an example of a curriculum based mostly on behaviourist tenets, while the current NCS with OBE was introduced as a curriculum supported by social constructivism.

In the figure that follows, learning in a behaviourist paradigm is contrasted with learning in an outcomes-based paradigm that was in line with the definition of learning. The role of assessment in each of these paradigms is shown. The figure shows that learning in the behaviourist paradigm is something imposed upon a passive learner with assessment being the final product. Learners are compared with one another and are in competition with one another. When the explanation of behaviourist learning is compared to an explanation of social constructivist learning in the figure behaviourist learning appears narrower than the more expansive social constructivist learning (expanded opportunities).

On the right-hand side of the figure, learning in the social constructivist paradigm is explained. In this part of the figure it is clear that learning is an action done by the active learner. The multifaceted way in which learning take place is evident. All aspects in the social constructivist paradigm are directed towards outcomes (clarity of focus, designing down, a goal orientated approach) and thus towards success for all learners. Learners as well as teachers are actively involved in the learning process while the teacher acts the parts of facilitator, mediator and assessor. The teacher oversees the whole learning process (therefore is placed on top of the learning process), but also provides a safety net (hence is also shown at the bottom) to assist, learners when things go wrong in the learning process (honouring the principles of OBE and believing in the assumptions of OBE). The role of the teacher to assist learners to construct knowledge actively encapsulates the whole teaching, learning and assessment process. This explains that the role of the teacher indicated at the bottom of the sketch includes all aspects of learning. The role of the teacher to oversee the process, as shown at the top of the sketch, is of equal importance, but here teachers should realise the potential of learners and therefore step back so that continuous growth can take place.

Through metacognition as part of self-regulation, learners answer questions about their learning, while the teacher uses various form of assessment to assist learners to achieve the outcomes. Assessment in the constructivist paradigm is indicated by the arrows. These arrows point upwards to show that learning and assessment are lifelong processes that are continuous. Although summative assessment is shown at the end of the combined arrows, this is only an indication that summative assessment will be done at certain times to determine the progress of learners; but in no way does it indicate the end of the process of learning. In the constructivist paradigm assessment should always start from the learners’ current knowledge level and then be taken further. The red line above the role of the teacher shows the starting point as baseline assessment after which the teacher may build cumulatively on what learners already know.

Formative assessment and its designated application to improve teaching and learning in the mathematics classroom will be investigated in chapter 3.

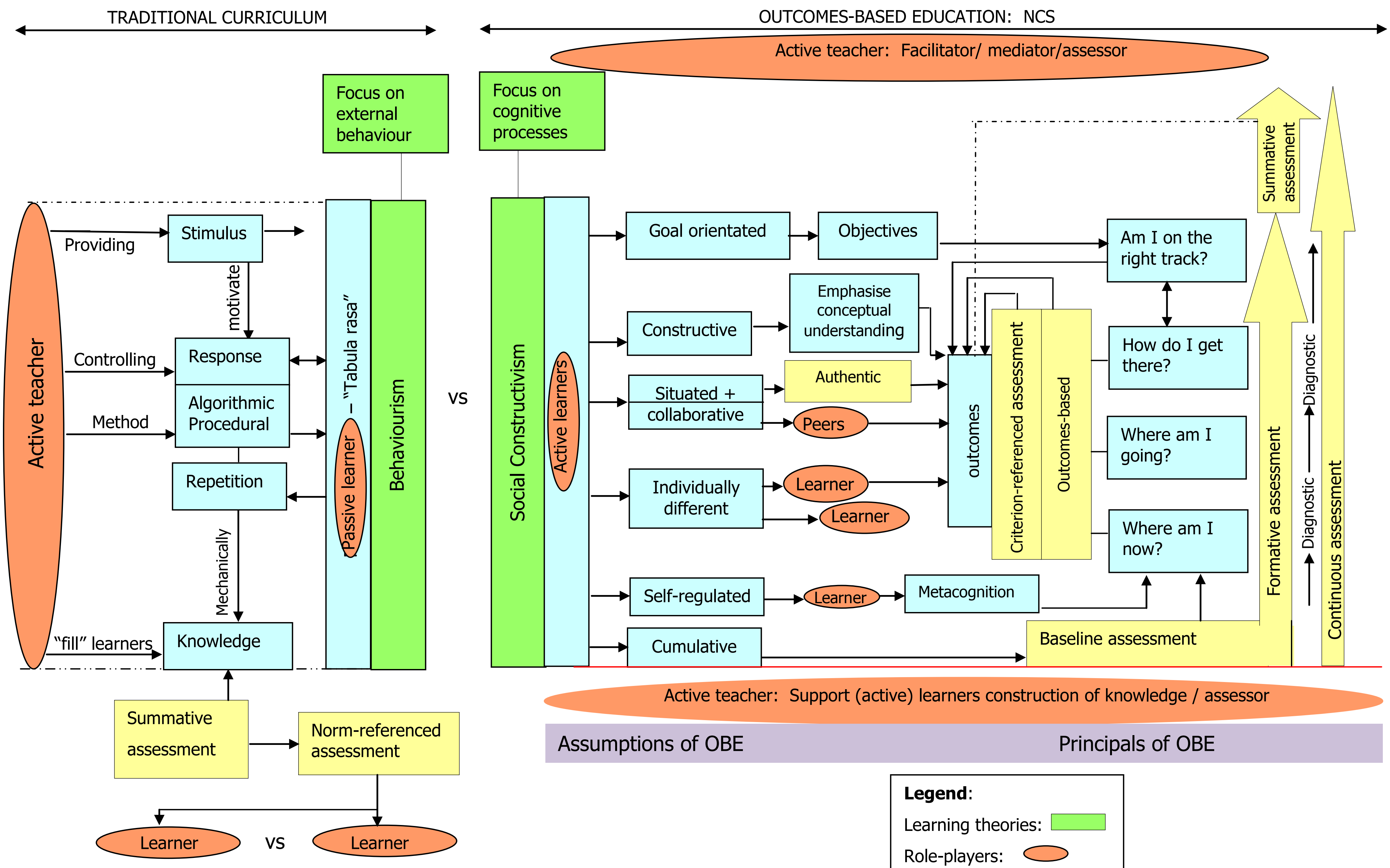


Figure 2.6: Summary of chapter 2

Legend:
Learning theories: 🟩
Role-players: ●
Assessment: 🟨
Learning: ▭
OBE: 🟪

CHAPTER 3

FORMATIVE ASSESSMENT IN MATHEMATICS

3.1 INTRODUCTION

It has been argued in Chapters 1 and 2 that the traditional ways of assessment are insufficient when applied in an outcomes-based environment. One of the reasons offered for this is that the traditional form of assessment plays no particular role in enhancing effective learning. In contrast, formative assessment (cf. 2.4.5.2) - as part of OBA - strives to address this deficit. Stiggins (2007:22) emphasises that formative assessment can assist all learners to succeed and turn all of them into winners, instead of just classifying them as either winners or losers.

In this chapter, formative assessment in mathematics will be investigated. A definition of formative assessment will be sought and its attributes identified, where after the focus of the investigation will consider how the attributes of formative assessment should be applied in the mathematics classroom.

3.2 UNDERSTANDING FORMATIVE ASSESSMENT

In Chapter 2, formative assessment and summative assessment were introduced as different types of OBA (cf. 2.4.5.2 and 2.4.5.3).

While different writers offer different definitions of formative assessment, Torrance and Prior (2002:8) indicate that these definitions usually revolve around differences in function (purpose) and timing. The function and timing of formative assessment are always stated in relationship to summative assessment. This is because summative assessment is the better known of the two, having dominated assessment in the traditional curriculum (in which it was known as evaluation – cf. 2.4.3). Contrasting formative assessment with summative assessment will thus clarify the role of formative assessment.

3.2.1 Differences between formative and summative assessment

Chappuis and Stiggins (2008) offer an analogy which can be used to explain the difference between formative and summative assessment. They suggest that summative assessment can be compared to taking snapshots of learners' achievements at specific points in time; while formative assessment could be compared to a stream of information on video about learners' achievements because it supplies continuous information about learners' progress. For this reason Chappuis and Chappuis (2008:15) argue that formative assessment delivers information while instruction is taking place, but before summative assessment is done. Whereas some sort of judgment is usually made from the results of summative assessment, formative assessment seeks to replace assessment done purely for critical purposes and offers exchange and cooperation in its place (Brookhart, Moss & Long 2008:53). This does not imply that no judgment will be made when doing formative assessment, but that an action will follow that is developmental in nature, based on the judgment made.

When contrasting formative assessment with summative assessment the following differences are evident:

- The intention of formative assessment is to promote learning. In contrast, summative assessment aims rather to monitor learning (James 1998:185; Stiggins 2007:22).

- Formative assessment provides helpful diagnostic information about the learning process. Summative assessment summarises the learning that has taken place during the learning process (James 1998:185; Stiggins 2007:22).

- Formative assessment is not intended for the purpose of accountability, but rather aims to provide corrective feedback and guidance to both teachers and learners (which makes it developmental in nature) (Harlen 2006b:104; Redfield, Roeber & Stiggins 2008:2). Summative assessment is largely used for the purpose of accountability (and is thus judgmental in nature) (Irons 2008:8).

- Formative assessment is more about the assessment of a product during its development. It is intended to assist with the shaping of the product's final form (Kotzé 1999:32). Summative assessment is about the assessment of the final product.

Formative and summative assessment should be used in conjunction with each other, to ensure that one complements the other. Both are important in the teaching and learning process.

3.2.2 A definition of formative assessment

To find a single definition of formative assessment proved to be no easy task. As a starting point, the National Policy on Assessment and Qualifications for Schools in the GET for the NCS was consulted (DoE 2007a:4,5). It was, however, established that the words "formative" and "summative" assessment do not appear in the policy. Fortunately, both do appear in the guideline document that aims to assist with the implementation of this assessment policy in mathematics classrooms (DoE 2007b:2). In this document, formative assessment is described as "developmental and is used to inform teachers and learners about their progress. It improves teaching and learning by giving teachers direction and enabling them to adapt to learners' needs. Formative assessment or 'assessment for learning' involves both teacher and learner in a process of continual reflection and self-assessment. Formative assessment is interactive in that the teacher uses thought provoking questions to stimulate learner thinking and discussion" (DoE 2007b:2). Although this definition of formative assessment seems to be sufficient, there should be concern not to over-emphasise questioning as the only interactive formative procedure. Black and Wiliam (2008), who share a similar line of thought in their original investigations of formative assessment, agree that it is naïve to consider only questioning to collect evidence of learning that has taken place during class discussions.

Heritage (2007:141) defines formative assessment in a way similar to the description that was found in the guideline document for the implementation of the assessment policy: "Formative assessment is a systematic process to continuously gather evidence about learning. The data are used to identify a student's current level of learning and to adapt lessons to help the student reach the desired learning goal. In formative assessment, students are active participants with their teachers, sharing learning goals and understanding how their learning is progressing, what next steps they need to take, and how to take them. Formative assessment involves a variety of strategies for evidence gathering."

In the following table, definitions of formative assessment of the GET Assessment Guideline document and that of Heritage are aligned with the contrasting statements of formative and summative assessment (cf. 3.2.1). The purpose of this table is to indicate how each definition supports the statements pertaining to formative assessment. The contrasting summative assessment statements give the opposite view so that the meaning of formative assessment becomes clear and unambiguous.

Table 3.1: Aligning definitions of formative assessment with contrasting formative and summative assessment statements

Definitions for Formative assessment		Contrasting statements	
DoE - Guideline document	**Heritage**	**Formative assessment**	**Summative assessment**
Gives teachers direction to enable them to adapt to learners' needs.	Identifies learners' current levels of learning to adapt lessons to help learners reach desired learning goals.	Promotes learning.	Monitors learning.
Develops and informs teachers and learners about their progress.	Learners understand how their learning is progressing, what next steps to take and how to take them.	Provides helpful diagnostic information.	Summarises what learning took place.
Involves both teachers and learners in a process of continual reflection and self-assessment.	Learners are active participants with their teachers; learners understand how their learning is progressing (because of feedback given).	Provides corrective feedback/ guidance to both learners and teachers.	Is largely used for the purpose of accountability.
Is interactive; aims to improve teaching and learning; teacher uses thought-provoking questions to stimulate learners' thinking and discussion.	Continuously gathers evidence about learning; involves both teachers and learners; shares learning goals, involves the use of a variety of assessment strategies to gather evidence.	Assessment of product while in the process of being developed and final form shaped.	Assessment of final product.

From table 3.1 it can be deduced that the value of formative assessment tasks in mathematics is comprehensive: it allows the teacher to understand the learners' thoughts and of the ways in which they reason, to observe the strategies used by the learner, to become aware of the learners' disposition and attitude towards learning and also towards mathematics (Hall & Burke 2003:13). All of the valuable information can be used constructively if it is effectively interpreted and used by the teacher to assist with the effective planning of strategies to improve learners' learning and, by implication, their performance. Formative assessment without any instructional changes taking place is not formative assessment (McMillan 2007:118). Formative assessment can take place informally or formally, in fleeting incidents or as well-organized events (Brooks 2002:1) (cf. 3.9).

The researcher concludes that the best way to understand formative assessment is to summarise its attributes on the basis of the definitions discussed.

3.2.3 Attributes of formative assessment

Consistent with the definitions and discussions in 3.2.2, the following attributes of formative assessment can be deduced:

- ❑ Attribute 1: Formative assessment is a systematic, planned, continuous process. Results of formative assessment should inform further planning.

- ❑ Attribute 2: The learner's current level of learning, including knowledge and understanding should be determined. Teachers should continuously search for this level and direct teaching to this level. In so doing they will enable learners to link new information with existing knowledge structures. This can be done through what is known as baseline assessment (cf. 2.4.5.1, 2.4.5.2 and 2.4.5.5).

- ❑ Attribute 3: Teachers should continuously diagnose learners' problems and act accordingly to remedy them. This is known as diagnostic assessment (cf. 2.4.5.4).

- Attribute 4: Learners are active participants in formative assessment. Formative assessment is an interactive process.

- Attribute 5: Formative assessment is developmental. Continual reflection and self-assessment of both the teacher and the learner should result in feedback that can be used to support the teaching and learning processes. Learners should be involved in self-assessment, peer assessment and group assessment. In this way learners can be informed about their progress.

- Attribute 6: The setting of learning goals in formative assessment should be emphasised. Learners should know how to progress towards learning goals and be in a position to monitor their progress.

- Attribute 7: Formative assessment takes place through a variety of strategies. This can be achieved by using different forms of assessment tasks or by using different assessors. It is essential that authentic tasks in real life settings be included.

These attributes of formative assessment are accommodated in the framework of OBA and they also relate to the principles of effective learning as discussed in chapter 2 (cf. 2.2.5, 2.2.5.1 – 2.2.5.6, 2.2.7). This relationship is portrayed in table 3.2.

Table 3.2: The relationship between the definition of learning and the attributes of formative assessment

	Implication for learning	Attributes of formative assessment
Constructive	Learners must engage actively with the learning material and construct their own meaning of what is to be learned.	Attribute 4: Learners are active participants in formative assessment.
	Constructivism implies that links must be created between new information and existing knowledge and understanding.	Attribute 2: Learner's current level of learning should be determined and teaching and learning should be directed to that level.
	The teacher should guide the learner to make meaning and emphasise understanding.	Attribute 4: Learners are active participants in formative assessment and formative assessment is interactive.
	The teacher should constantly monitor that learners do not construct incorrect knowledge.	Attribute 3: Teachers should continuously diagnose learners' problems and act to remedy the problems.
Cumulative	Prior-knowledge should always be determined and new knowledge connected with existing knowledge. Incorrect prior-knowledge should be corrected.	Attribute 2: The current level of learning and understanding should always be the starting point.

Self-regulated	Learners can manage and monitor their own learning guided by metacognition, using self-regulation.	Attribute 4: Learners are active participants in formative assessment. Attribute 5: Continual reflection and self-assessment of learners should take place throughout formative assessment. Learners should react to feedback given by teacher.
Goal-orientated	Learners should set goals in line with the outcomes to be reached and work towards the goals.	Attribute 6: The setting of learning goals in formative assessment should be emphasised. Attribute 1: Formative assessment is a planned process – both teachers and learners must know exactly why they do formative assessment.
Situated	Authentic real life situations should be used for learning and assessment.	Attribute 7: Formative assessment takes place through a variety of strategies as often as possible in authentic contexts that relate learning to real-life experiences.
Collaborative	Learners must work together in groups or pairs. Learners should discuss learning material with peers and explain their understanding of the topic to each other.	Attribute 4: Learners are active participants in formative assessment – learners can do formative assessment in groups. Attribute 5: Learners should be involved in self-assessment and as peers involved in peer assessment and group assessment.

Individually different	Learners do not learn in the same way and at the same pace. Learners have different learning styles.	Attribute 1: Formative assessment must be planned to optimise learning for all learners. It should address individual learner's needs. Attribute 3: Teachers should diagnose individual problems and act to remedy problems. Differentiation should take place. Attribute 7: Use a variety of assessment strategies to accommodate needs of individual learners.

From the table it is evident that the attributes should not be seen in isolation, but that they overlap in an integrated manner to form a coherent whole. Each of these attributes of formative assessment and how it is applied in the mathematics classroom will be elaborated on in the paragraphs that follow.

3.3 ATTRIBUTE 1: FORMATIVE ASSESSMENT IS A SYSTEMATIC, PLANNED, CONTINUOUS PROCESS

In order to benefit the learning process in mathematics, formative assessment cannot take place haphazardly. Driscoll (1996:17) proposes that efforts should be systematic in order to ensure that integrated assessment serves its intended purpose. Driscoll (1996:15) identifies planning assessment, gathering evidence through assessment, analyse results and interpret the evidence of assessment and finally use the evidence of formative assessment as steps in the formative assessment process.

Formative assessment can never be a successful process without continual reflection taking place. Reflection refers to an act of consciously analysing one's actions for the purpose of improving actions that have already been performed. The South African Concise Oxford Dictionary defines the verb "to reflect" as "thinking deeply or carefully about" and reflection as "serious thought or consideration" (Dictionary Unit for South African English 2002:982). This indicates that reflection is an act that should be done consciously, carefully and seriously. Chappuis (2005:38) proposes that both teachers and learners together should generate accurate information about the learners' progress by means of assessment and then use the information effectively to promote more learning. The systematic, continuous steps in conducting formative assessment can therefore be depicted diagrammatically as follows:

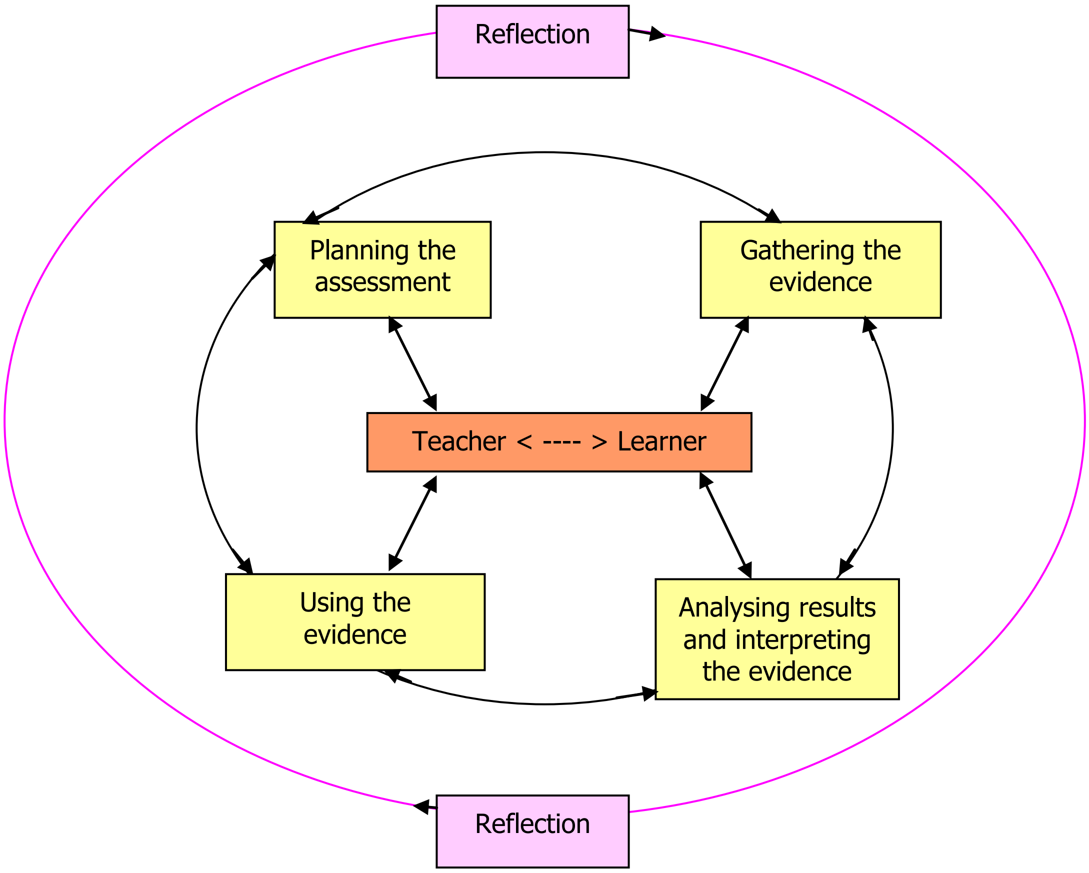


Figure 3.1 The formative assessment process

In the figure, the formative assessment process is presented as a dynamic, cyclic process where teachers and learners can move backward and forward and where reflection takes place continuously. Both teachers and learners make decisions and react to their decisions constantly in order to improve the teaching and learning process.

In the discussion of attribute 1 of formative assessment that follows, more attributes will be mentioned as they appear in the formative assessment process since the process involves all actions associated with formative assessment. This does not imply that one attribute is found within another attribute; rather that the discussion will indicate where every attribute is evident in the formative assessment process.

3.3.1 Planning formative assessment

According to the guidelines documented for the implementation of the GET assessment policy in mathematics (DoE 2007b:7), lesson plans should incorporate informal assessment such as: "reflection, observation, short assessment tasks [that are] completed during the lesson by individuals, pairs or groups or homework exercises and so on". As all of these are actions associated with formative assessment, it can be concluded that the document supports academic claims that emphasise the importance of planning formative assessment. Brooks (2002:24) suggests the lesson plans of teachers should be scrutinised to see whether they are serious about assessment or not. Authors such as Brooks (2002:27,28) acknowledge that planning for formative assessment is not easy and concede that it can be "as complex and cognitively demanding as the practice of medicine, law or architecture".

Formative assessment should be planned in such a way that it will give appropriate results so that the teacher can identify strengths and weaknesses of learners and give them proper feedback regarding the progress of their studies (Siebörger & Macintosch 2004:9). Should tasks not be well planned, teachers will find it very difficult to give feedback (cf. 3.7.6) to learners (Black et al. 2003:58). Formative assessment should also be planned in line with the lesson outcomes. The need for an alignment of outcomes, teaching and assessment has already been discussed (cf. 2.3.4.1, 2.4.2). When planning formative assessment, alignment can assist to refine lesson outcomes in order to ensure that these outcomes are clear and realistic (Killen 2010:89).

The planning of formative assessment also requires that teachers plan for the unexpected. If formative assessment reveals that learners find concepts more difficult than what the teacher had anticipated, the teacher should adapt the lesson to accommodate the circumstances. Brooks (2002:36), as well as Hall and Burke (2003:16), proposes that teachers should anticipate questions that learners might ask during the lesson and be prepared to answer them appropriately.

From the argument in the previous paragraph it can be deduced that lesson plans should be flexible and teachers ought to be able to adapt these to the real classroom situation as the need arises. Rigid lesson plans limit opportunities for feedback; yet lesson plans that are too loose run the risk of becoming ineffective (Brooks 2002:28).

More aspects to consider when planning formative assessment are: who the assessor will be (the learner himself or herself, peers or the teacher); and, how the formative assessment task will be executed. James (1998:182) argues that teachers themselves are the most appropriate people to set formative assessment tasks for learners (rather than external developers). Teachers know their learners; their strengths and weaknesses and also use differentiated assessment tasks when necessary (cf. 3.5.1.).

Teachers should reflect on the lesson plan both after it has been compiled as well as after it has been delivered. When reflecting on the lesson plan before the lesson has taken place, the teacher ought to visualise how the lesson will unfold to make sure that the actions follow each other logically. After presenting the lesson, the teacher ought to reflect on the plan once again to identify both the shortcomings and the aspects that have gone well. The teacher should decide whether the formative assessment tasks given to learners have served their intended purpose and, if necessary, take corrective action (cf. 3.5.3).

3.3.2 Gathering the evidence

Evidence should be gathered not only of learners' current and prior-knowledge of mathematics, but also of their understanding of the subject matter under discussion. This verification can be gathered by using a variety of formative assessment strategies (cf. 3.9).

After reflection teachers should decide what data are useful and what not. It is important that learners also reflect upon the evidence gathered and decide what aspect of the work was easy to understand; specify where they experienced problems; and also identify the aspects that were challenging while the evidence was being gathered. This can be done by writing journals (cf. 3.9.3) or reflective notes.

3.3.3 Analysing results and interpreting evidence

Drummond (2003:66) explains that after the evidence has been collected, it should be used in a meaningful way. Evidence can only be used meaningfully if it has been analysed properly and interpreted knowledgeably. When analysing and interpreting evidence teachers should be able to identify learners' level of knowledge, analyse the strategies they use to solve problems, find recurring errors and establish the sources of these errors.

Driscoll (1996:16) advises teachers who fear that bias could influence their interpretation of evidence to ask for a colleague's assistance because his/her opinion may sometimes be more objective or offer a new perspective.

The following scenario is an example of the analysis of results and the interpretation of evidence in mathematics: A grade 9 mathematics teacher presents a lesson on the laws of exponents, starting with the first law which states that a^x x a^y = a^{x+y}. The teacher wants learners to calculate 2^3 and then 2^4. After this, he wants learners to determine the answer if 2^3 is multiplied by 2^4 (i.e. 2^3 x 2^4). The correct response would be that 2^3 equals 8 (in other words: 2 x 2 x 2 = 8) and 2^4 = 16 (in other words: 2 x 2 x 2 x 2 = 16). However, some learners might claim that 2^3 x 2^4 is 6 x 8. Thus they give 48 as the final answer and cannot deduce the exponential law.

An analysis of the investigation reveals that certain learners think that 2^3 = 6, meaning that these learners have multiplied 2 by 3. Learners with conceptual problems will do the same in the case of 2^4 getting 2 x 4 = 8 as the answer. After the analysis, the teacher interprets the evidence and concludes that these learners do not know how to raise a number to a power. Their prior knowledge is therefore either insufficient or ineffective.

Reflection by teachers and learners should follow after data have been collected and analysed. The teacher must reflect on his/her planning to establish whether the data collected were what the teacher wanted. Moreover, the teacher must decide what ought to be done with the results of the analysis of the assessment, how it should be shared with learners and what corrective measures to take.

Learners' reflection on the analysis and interpretation are equally important. Learners must carefully study the analysis and acquaint themselves with the positive and negative aspects of the assessment task they have completed and establish what they knew and understood. The interpretation of the evidence collected is equally important as the learner should also strive to know what he/she should do to improve on what was found to be inadequate during formative assessment.

3.3.4 Using the evidence

The results of the interpreted evidence must be put to good use and feedback provided to learners. When formative evidence has been collected the results should be interpreted and an action that is based on the analysis and interpretation of the evidence) planned. Using the evidence implies that both the teacher and the learner have to make decisions. Feedback should be given from learners to teachers and from teachers to learners (cf. 3.7.6.2, 3.7.6.3). Teachers then use feedback to plan further lessons.

3.3.5 Reflection

In each of the steps of the formative assessment process reflection has been discussed. Killen (2010:112) describes two types of reflection: reflection-on-action and reflection-in-action.

Reflection-in-action refers to the decisions that teachers and learners make during the lesson. For example if there are questions that learners cannot answer the teacher can deviate from the lesson plan and attend to the problems identified through formative questioning. The learner can also reflect on the lesson while it is taking place. The learner should make notes or ask the teacher questions when he/she cannot answer a question that has been answered correctly by another learner.

Reflection-on-action takes place after the lesson. The teacher reflects on the lesson and considers whether the lesson has proceeded as planned. The teacher should also reflect on the information collected during the lesson through formative assessment to decide on the next step to be taken in teaching and learning. For example this may involve moving on to a new concept; working more on the current concept or approaching the concept on hand in a different manner if the method used in the lesson has been unsuccessful.

Similarly, learners should reflect on their actions after the lesson and, in their own time, review the formative assessment tasks done. They must ensure that they have understood all the tasks that have been performed and, if more questions arise, they should be willing to go back to the teacher or a more capable peer for assistance.

3.4 ATTRIBUTE 2: DETERMINE LEARNERS' CURRENT LEVEL OF KNOWLEDGE AND UNDERSTANDING

The importance of linking new knowledge with learners' existing knowledge, was proposed by both Piaget and Vygotsky, and has been emphasised frequently in this research report (cf. 2.2.2.1, 2.2.2.2, 2.2.5.2, 2.4.5.1). Building on existing knowledge points to a characteristic of learning that was captured in De Corte's definition of learning viz. that it is cumulative (cf. 2.2.5.2). According to the constructivist learning theory (cf. 2.2.3.1), learners create links between this existing knowledge and understanding and the new information they have to master.

It can be said that the knowledge and skills that learners acquire in the lower grades provide the building blocks for subsequent knowledge and skills that follow (Spinelli 2002:376). This implies that certain topics get more complicated as learners progress through the Senior Phase. An example of this in mathematics is factorisation: First, learners must know how to find the factors of a whole number. After this they learn how to find the factors of algebraic expressions.

The proposal that knowledge is cumulative also has another dimension in that some topics in mathematics provide information for subsequent topics. An example of this can be found when teachers teach the drawing of graphs on the Cartesian plane. It is impossible to draw graphs if the learners do not know how to plot coordinates on the Cartesian plane. Prior knowledge in this case will be the plotting of x- and y- coordinates on the Cartesian plane and learners should engage in these sorts of activities before they learn how to plot graphs.

Although descriptions of baseline assessment in 2.4.5.1 mentioned that assessment for this purpose must be done at the beginning of a learning experience, it can be deduced from the foregoing arguments that baseline assessment should be done continuously throughout learning experience with the particular aim of identifying prior-knowledge.

3.5 ATTRIBUTE 3: CONTINUOUS DIAGNOSES OF LEARNERS' PROBLEMS AND TAKING ACTION

Diagnosis of learners' problems may have two aims: to correct prior-knowledge (after baseline assessment has been done); or to correct new knowledge as teaching takes place. Careful analysis of what learners already know should thus be done and, if it is found to be insufficient, prior-knowledge must first be corrected. According to cognitive theory, these misconceptions can only be erased if learners are forced to confront their misconceptions by some form of cognitive conflict (Brooks 2002:13). Sometimes it will be possible merely to correct knowledge. An example of this would be a situation where the teacher asks learners to give the prime-factors of 24 and one of the learners gives the answer as 1, 2 and 3. The teacher asks the learner a follow-up question: Is one a prime number? If the learner answers "no" and corrects the answer to 2 and 3, knowledge has been corrected. If the learner answers "yes", the teacher needs to diagnose whether the learner understands the concept of a prime number. The close link between baseline assessment and diagnostic assessment are illustrated in the following figure:

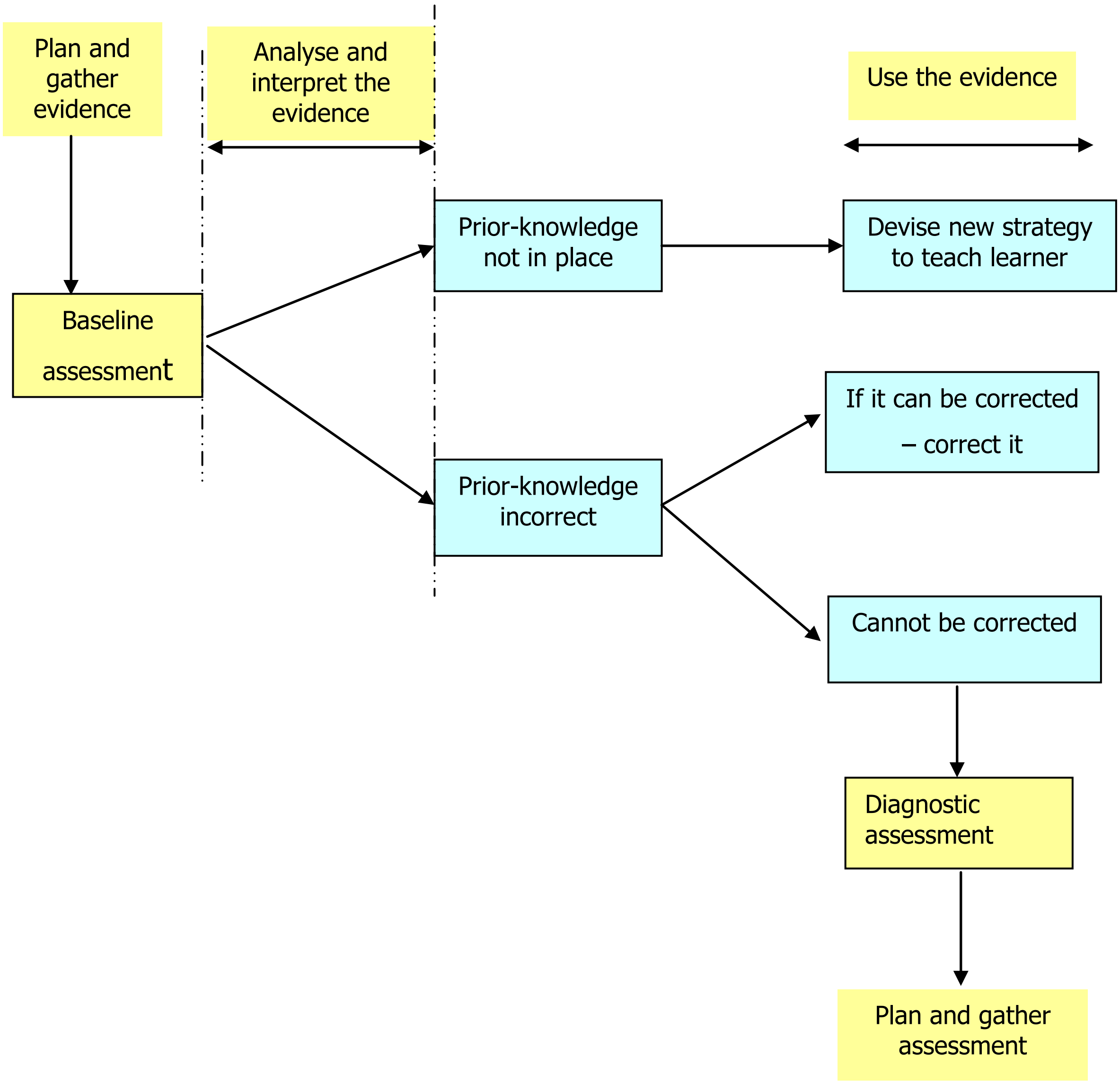


Figure 3.2: Linking baseline and diagnostic assessment

The second aim of diagnostic assessment is to diagnose problems while teaching mathematical knowledge and skills. Teachers should not assume that what they teach is what learners actually learn (Brooks 2002:13). In 2.2.5.6 it was discussed that not every learner learns in the same way. Differentiation of tasks can assist a teacher to diagnose problems as they arise.

3.5.1 Differentiation

Instead of only setting assessment tasks pitched at the level of the average learner provision can be made for learners with different abilities in different ways. Tomlinson (2008b:27) indicates that differentiation is very important in order to maximise learners' learning in a way that is in line with the principles of expanded opportunities and the high expectation of OBE (cf. 2.3.4.2 and 2.3.4.3). Differentiation implies that teachers must know their learners and their learners' abilities very well. Teachers should know about their learners' interests, readiness, how they prefer to learn (referred to as learning styles) and also what motivates them (Tomlinson 2008b:27).

Brooks (2002:34) suggests that there are different ways in which teachers can differentiate by means of assessment tasks, namely differentiation by task, differentiation by resource, differentiation by pace and differentiation by support. A discussion of each follows.

3.5.1.1 Differentiation by task

The following is an example of a basic assessment task for grade 8 learners:
For less competent learners, the teacher can set an assignment for a group of learners where the instruction is to collect data and record the data in a tally table. The data that must be collected is as follows: the learners determine what the favourite television programme of the learners in their class is. Finally this data must be represented on a bar graph.

For another group of learners that are more competent and skilled the following investigation can be given: Pose a question related to conservation and use relevant sources to collect data about the topic. Use a method of your choice to organise the data and display the data.

In the second task learners must decide what data will be collected, how they will be organised and how it will be displayed. It is the same content and skills as in the previous question, but the learner must make decisions about various aspects. This puts the question at a higher level for learners who have already acquired the basic skills.

3.5.1.2 Differentiation by resource

The same examples as explained in differentiation by task can also be used here. In the first case the resources are immediately available: it is the learners in the class that will be sampled. This task will be suitable for learners who do not have access to a variety of resources.

However, the second task allows for many resources to be used; such as books, newspapers or any other source with relevant information. The resources should be available to the learners who attempt this task.

3.5.1.3 Differentiation by pace

As the teacher monitors the learners' progress in the tasks mentioned in 3.5.1.1 and 3.5.1.2, the pace at which the learners work will become evident. By restricting the learners to certain time frames the teacher can differentiate between the learners by pace and set different due dates for different tasks.

3.5.1.4 Differentiation by support

In both the examples mentioned in 3.5.1.1, the teacher can decide about the level of support that the learners can have when completing the tasks. In 2.2.2.2 it was mentioned that some learners need more scaffolds when learning than others. There is however, also a negative aspect of support that the mathematics teacher must consider. This refers to situations in which the learners do not get the correct support from their parents, other teachers or more capable peers; and instead of receiving the correct form of assistance, they merely copy the answers to the problems without attempting at all to solve the problem themselves. For this reason it is important that the teacher must manage the completion of the assessment task carefully so that the learners receive the desired level of support. If learners are active agents in their own learning and are able to regulate their own learning, they will be committed to doing the formative assessment tasks with the intended level of support.

3.5.2 Diagnosing learners' problems

The fact that the teacher has to diagnose the learners' difficulties with mathematics implies that areas of weaknesses as well as misconceptions should be determined when learners do mathematics. It also implies that the teachers should identify the specific errors that learners frequently make (Troutman & Lichtenberg 1995:568). Strydom (1995:3) indicates the importance of trying to identify a pattern of errors in mathematics. She explains that broadly speaking the errors made by learners in mathematics are either careless errors or conceptual errors. Careless errors are mistakes that learners do not make consistently while conceptual errors are made consistently (Strydom 1995:4). The following can serve as an example:

A learner is asked to draw a graph on the Cartesian plane, setting a table and plotting it point by point. The learner plots the first point, but puts the y-coordinate on the x-axis and the x-coordinate on the y-axis. Other points are plotted correctly. This is an example of a careless error. If the learner plotted all the points swapping the x- and y-coordinates around, it would have been a conceptual error.

Errors that learners make are only symptoms and teachers should be skilled enough to be able to diagnose the underlying cause of these symptoms (Troutman & Lichtenberg 1995:568). According to Ball, Bass and Hill

(2004:51), it is not easy to diagnose learners' problems and it requires exceptional skill and knowledge from teachers. This knowledge needed by mathematics teachers when teaching and assessing mathematics is known as pedagogical content knowledge (PCK). Black et al. (2003:92) remark that formative assessment does indeed make considerable demands on a teachers' subject (content) knowledge, but advises teachers not to fear this demand. Teachers should rather explore ideas together with their learners.

3.5.3 Taking action

3.5.3.1 Problems experienced by the whole class

Once problems have been diagnosed through assessment the teacher must take appropriate action. If it is found that the whole class or the majority of the class is having problems with a specific topic, re-teaching should take place (Killen 2010:369). However, re-teaching is more than just teaching the topic again. The teacher has to use other strategies to teach the topic. The following example illustrates this point:

The teacher wants to do an introductory lesson on the theorem of Pythagoras. He or she decides to use direct instruction for the lesson and models the correct behaviour when doing calculations. During the lesson the teacher tells the learners about Pythagoras, gives background information about him and ends the explanation by writing the theorem on the board. After this the teacher does an example on the board explaining to learners that the rule is a given, and that the learners merely have to substitute the new figures and calculate the length of the unknown side of the triangle. The teacher then gives the learners several exercises to do as assignments.

Assessment of the assignment reveals to the teacher that some learners substituted values for the symbols in the formula incorrectly. Furthermore some learners do not work with the squares, but only with the length of the sides. The teacher decides to re-teach the lesson.

In order to reteach this lesson, the teacher uses an investigative approach rather than the method of direct instruction attempted above. According to the new teaching method being applied, learners are asked to draw a rectangular triangle with side lengths of 3 cm, 4 cm and 5 cm respectively, where the 3 cm and 4 cm lines form a right angle (90^0) and the 5 cm line is the hypotenuse. The learners then construct a square on each of the side lengths. This implies that on the side length of length 3 cm, a 3 cm x 3 cm square will be constructed. Similarly, 4 cm x 4 cm and 5 cm x 5 cm construction of squares will follow. After this, the teacher allows learners to cut out the 3 cm x 3 cm square as well as the 4 cm x 4 cm square and fit these to squares on the 5 cm x 5 cm square. More cutting of the squares will be necessary to fit them exactly onto the 5 cm x 5 cm square. Finally, the learners conclude that the 3 cm x 3 cm square added to the 4 cm x 4 cm square will be equal to the 5 cm x 5 cm square. The learners have seen and experienced that they worked with squares, they added and subtracted the squares physically and should now have a better chance to understand and apply the theorem of Pythagoras.

Re-teaching has thus taken place involving the use of a different teaching strategy. In the light of this example it can be mentioned that all mathematics teachers should be well versed in different teaching strategies.

3.5.3.2 Problems experienced by individual learners or small groups of learners

In line with the one of the assumptions made by OBE namely that every learner can succeed in their own way and in their own time (cf. 2.3.2) and in line with the principle of high expectations (cf. 2.3.4.3), it is important that individual learners be assisted when they have problems. Brooks (2002:13-

14) advises that teachers ought to identify misconceptions by asking probing questions to individual learners and by carefully observing these learners while they are active in the classroom. In cases where only some learners are struggling, the teacher will have to deal with problems individually. This can either take place during teaching time or thereafter. During school hours the teacher can give the competent learners additional or challenging exercises to do while continuing to assist other learners individually. Alternatively, the teacher can assist the learners individually after school hours. Depending on the seriousness of the problem, the parents can also be consulted and made aware of learners' problems. Parents can then take action such as arranging for additional tutoring for their children.

A full awareness of all the errors that learners may make when solving mathematical problems; all sources of error together with the knowledge of the actions required to remedy these problems, is a vast study on its own and beyond the scope of this research.

3.6 ATTRIBUTE 4: LEARNERS ARE ACTIVE PARTICIPANTS IN FORMATIVE ASSESSMENT

3.6.1 Active learners

Heritage (2007:141) advises that learners should actively co-operate with their teachers. Stiggins (2007:23) goes further and explains the role of the learner as a partner in the assessment and learning processes. In so doing, learners have the opportunity to control their own learning (Baumfield & Mroz 2002:137) (cf. 2.2.5.3, 2.3.5.2.1).

3.6.2 Effective interaction

According to Brookhart, Moss and Long (2008:52), the power of formative assessment lies in the communication between learner and teacher (also learner and learner). In 2.3.6 the role of co-operative learning in the constructivist classroom was illuminated. Muijs and Reynolds (2001:17) also identify a positive link between increased interaction and learners' improved performance.

Interactive teaching implies that communication cannot take place in one direction only. Cobb (1988:88) explains that knowledge is not simply absorbed by the learner, but is "constructed by reflectively abstracting from and reorganizing sensorimotor and conceptual activity". As teachers and learners both construct their own meaning, they miscommunicate if this meaning is not the same. Consistent with this observation are Cobb's (1988:88) remarks that ensuring that successful communication takes place is a true problem for the constructivist teacher. In 2.3.5.1.1 the importance of dialogue and Freire's work regarding effective dialogue were discussed.

3.7 ATTRIBUTE FIVE: FORMATIVE ASSESSMENT IS DEVELOPMENTAL

3.7.1 The importance of involving learners in formative assessment

Research shows that learners learn best when they are involved in the assessment of their own work (Spinelli 2002:49). Formative assessment has proved to contribute more to learners' taking ownership of their learning than other classroom-based approaches (Brookhart, Moss & Long 2008:54).

Unless learners are involved in formative assessment so that they clearly understand their strengths and weaknesses, appropriate progress will not be made (Hall & Burke 2003:78). Active and involved learners forming part of the assessment process are more motivated to learn (Siebörger & Macintosch 2004:8).

3.7.2 Metacognition

Metacognition and self-regulation were discussed in 2.3.5.2.1 and were identified as being - at least partially - the learners' responsibilities in the constructivist classroom. Learners who use metacognitive strategies can monitor their own progress and, when necessary, make changes to ensure progress (Burger 1993:53). Metacognition involves (amongst other factors) self-monitoring; self-assessment; management and control of learners' own thinking.

3.7.3 Self-assessment

Black and Wiliam (1998) refer to self-assessment as a determining part of formative assessment. Both teachers and learners should assess their performances themselves and reflect on the outcomes of assessment (Archer et al. 1999:120; Wiliam 2000:19).

It was mentioned in 2.2.5.4 that learning should be goal orientated. Black et al. (2004) draw attention to the fact that learners can only achieve a goal if they know and understand what the goal is. The importance of self-assessment is that learners should understand the purpose of their learning and consequently understand what they must achieve (Black and Wiliam 1998). It is important that learners aim to understand the learning and performance goals and that they should be honest with themselves when doing self-assessment (Hall & Burke 2003:81).

Self-assessment can also assist learners to feel more confident about their performance in mathematics. This can happen in more than one way. As learners begin to understand and experience self-improvement, they start to realise that success is within their reach (Stiggins 2007:23). In mathematics, for example, marking their own homework and classwork assists learners by indicating their errors to them so that remedial action can be planned. This can however only happen if learners do calculations in full and do not only write answers. Learners will further realise that not all the errors they make are serious; and that the mistakes can easily be rectified by themselves when they know what and where their errors are. Finally the realisation that not all they do is wrong assists learners to grow in confidence.

Some learners have a natural ability for self-assessment while others do not have this aptitude. However, it is true that the skill of self-assessment can be developed in learners if they are carefully trained to do so (Archer et al. 1999:120, Csongor 1996:58). In addition, Hart (1994:60) indicates that self-assessment assists to promote a sense of ownership of their own learning processes for learners. Self-assessment should inform learners about their own learning so that they can focus their own learning energies in an effective manner (Stiggins & Chappuis 2008).

3.7.4 Strategies to promote ownership of learning

As learners become more confident and competent in mathematics, teachers can gradually transfer the responsibility for learning to their learners. Fisher and Frey (2008:32) call for the support of the teacher at all times. Yet, this is no simple task and teachers need to employ strategies to promote ownership of learning, such as those delineated below (Fisher & Frey 2008:34):

- The purpose for doing an activity should be clear and be in line with the intended outcomes (cf. 2.2.5.4, 2.3.4.1, 3.8). If learners perceive an assessment task to be unnecessary and irrelevant, they will have no incentive to do the task and will not assume responsibility for it.

- Learners should have opportunities to work with peers. This collaborative learning assists in transferring responsibility to the shoulders of the learners with peer support as a scaffold (cf. 2.3.6).

3.7.5 Peer assessment

Black et al. (2003:50) describe peer assessment as an important complement to self-assessment. Peers assess each other's work so that learners can benefit from sharing other learners' ideas and insights.

Peer-assessment is favoured for several reasons (Black et al. 2003:50). One of these reasons is that communication amongst peers is usually in a language that learners would naturally use. Peer assessment also gives learners an opportunity to "speak mathematics" and explain their thoughts. Many teachers make the mistake of asking learners to explain only faulty answers, but in fact all answers, whether right or wrong, can be explained (Greenwood 1996:19). Learners do sometimes get correct answers as a result of inefficient or incorrect methods.

Both Archer et al. (1999:119) and Shasha (2004:42) argue that learners are more willing to express themselves in the presence of peers because it is less threatening. Learners are also usually more willing to interrupt a peer learner when they do not understand than they would interrupt a teacher (Black et al. 2004). Van de Walle (2004:33) explains that while learners are critiquing other learners, they are forced to revisit their mental schemas and to assimilate what has been said into existing mental schemas (cf. 2.2.2.1.2(c)).

3.7.6 Feedback

3.7.6.1 Description of feedback

Feedback in education refers to "information about the gap between actual performance and desired performance (the standard) in a given domain which can be used to close the gap in some way" (James 1998:96). Dreyer (2008b:19) indicates that feedback is the "most important opportunity to influence, shape, direct and improve the learning process".

Some resources like Irons (2008:7) do not only refer to "feedback", but also to "feedforward". Feedforward refers to information that will assist learners to amend activities in future (Irons 2008:7).

3.7.6.2 Feedback to the teacher

Formative assessment tasks must be carefully planned to ensure that quality feedback can be given (cf. 3.3.1) (Black & Wiliam 1998). Lesson planning involves, amongst other things, planning for formative assessment. Teachers should reflect on lessons (cf. 3.3.5) to decide whether the lesson has been successful or not and to plan the next learning experience. However, Brooks (2002:37) warns that reflection should not merely recount what happened during the lesson: it should rather truly judge the efficacy of the lesson.

3.7.6.3 Feedback to learners

Feedback to the learners should focus on the particular qualities of work that has been done and should contain advice on how the learner can improve (Black & Wiliam 1998). Feedback should, however, not only focus learners' errors, but also on their positive achievements. When success "feeds a growing sense of confidence" (Stiggins & Popham 2008), it is in line with the underlying assumption of OBE that "success breeds success" (cf. 2.3.2).

Two types of feedback to learners can be identified: firstly, feedback involving the learner's self-concept and self-esteem; and secondly, feedback that focuses on the task (James 1998:97). Examples of feedback involving the learner's self-concept and self-esteem in mathematics are remarks such as "Well done, this is good work!" or, "You did not do your best this time, work harder next time!" The use of reward and punishment also fall into this category. In mathematics, an example of feedback focusing on the task is:

"You make errors when you take out the common factor when factorising – do extra examples …."

Learners should receive feedback throughout the formative assessment so that they can learn from the errors they have made and reconsider possible misconceptions (Dekker 2007:56) (cf. Figure 3.1). This implies that for feedback to be effective, it should encourage the learner to think and act on their performance (Black et al. 2004).

To ensure that feedback enhances the learning process, the time when feedback is given, and the kind of feedback given should be considered. The following table indicates the difference between productive feedback and counterproductive feedback.

Table 3.3: Productive feedback versus counterproductive feedback

Productive	**Counterproductive**
Timing the feedback: Feedback should be prompt, preferably immediate. Feedback must be frequent. Learners must implement feedback before their summative assessment.	*Timing the feedback:* If feedback is delayed, it will be ignored once learners have moved on to a new topic.
Focus on the process: Give feedback over a number of events.	*Focus on product:* Give feedback about isolated events.
Format of feedback: Written comments should provide a clear indication of what should be done to be successful and improve future performance. Feedback should be descriptive.	*Format of feedback:* When using marks and grades it encourages "complacency in the able and despondency in the less able" (Dreyer 2008b:20)

Kind of feedback: Feedback should focus on knowledge, skills and concepts that are needed to accomplish the task: it should involve tasks. Learners must know what corrective measures to take to improve on the task.	*Kind of feedback:* Feedback that focuses on the learners, and compares their performance to those of other learners.
Strengths and weaknesses should be identified in a balanced manner – the one should not be emphasised more than the other.	*Strengths and weaknesses* emphasised without acknowledging the other dimension

(Dreyer 2008b:20; Irons 2008:72, 74; James 1998:98; McMillan 2007:139 – 141; Stiggins 2007:22; Tomlinson 2008a:12).

Productive feedback (cf. Table 3.3) has a critical influence on a learner's academic progress (Elliott & Morris 2001:158). This is also true for the teaching and learning of mathematics. Learners who cannot find a solution to a mathematical problem must be assisted to find an alternative solution, especially if the repetition of the same process keeps leading to failure. Instead of just supplying answers, teachers should rather ask stimulating questions or give an alternative task that will assist the learner to steer his thoughts in the right direction.

3.8 ATTRIBUTE 6: EMPHASISING THE IMPORTANCE OF GOALS

In 2.2.5.4 it was explained that learning is goal orientated and - since teaching, learning and assessment are intertwined - assessment should be done to assist learners to monitor their progress towards achieving their goals. Jacobs, Vakalisa and Nqabomzi (2004:30) indicate that "outcomes instil a sense of purpose in both teachers and learners". Teachers should facilitate the process and together with learners, goals should be determined (De Corte 1995:41). Referring to the work of Brandt (1998), Killen (2010:5) indicates that learners who accept challenging yet achievable goals learn more. Harlen (2006a:65) adds to this that learners should understand goals.

By breaking the broader goals into more manageable smaller, short-term objectives, the teacher provides the means to learners to experience success and provides more effective teaching in so doing.

3.9 ATTRIBUTE 7: USING A VARIETY OF FORMATIVE ASSESSMENT STRATEGIES

In order for formative assessment to inform teachers about which mathematical skills and knowledge learners have or lack, a variety of strategies can be used by teachers to collect formative information. An assessment strategy refers to the way or method in which information about the learner's learning is collected. Badger (1996:42,76) indicates that mathematical knowledge is too complex to be assessed using the same instrument always.

3.9.1 Questions and answers

3.9.1.1. When to use questions and answers

Questions can be asked or answered either orally or in writing. Questions can be used for various purposes during the lesson, but are also effective at the beginning of a lesson to establish the level of prior learning (cf. 2.2.2.1, 2.2.3.1, and 2.4.5.1) (Muijs & Reynolds 2001:19). Ultimately the idea behind the use of the question-answer technique to teach mathematics is not simply to get the correct answer, but also to elicit more information about a learner's thought processes and the way they conceptualise mathematics.

When learners struggle with mathematics in class, the teacher's probing questions can help them to conceptualise the topic in mathematics. At the same time, while answering these questions, teachers can identify any misconceptions learners might have. Learners must also learn to ask themselves similar questions so that when they get stuck with a mathematical problem, they will be able to get themselves "unstuck" and "on track" again (Greenwood 1996:19). Mathematics teachers often believe that they would spend class time better if they used the more traditional forms of teaching and assessment such as giving learners direct answers to questions related to solving mathematical problems. According to Greenwood (1996:19), this can hinder a learner's ability to learn how to do mathematics.

An alternative to questioning is to use statements instead of questions. An example of such a statement in mathematics might be "All rectangles are parallelograms". Learners must react to the statement, indicating whether it is correct or incorrect. Making these statements can, in fact, increase the level of discussions in a classroom (Wiliam 1999:18).

Brooks (2002:57) advises teachers to refrain from answering their own questions. Learners ought to be given the opportunity to think for themselves and work out answers either mentally or in writing. By the same token, teachers should plan their lessons so that there is enough thinking time for learners.

3.9.1.2 The use of open-ended questions

Authors such as Killen (2010:261) use the terminology "open-ended questions" while others refer to "open questions" (Brooks 2002:53; Muijs & Reynolds 2001:20). Open-ended questions require observation of the learners and the consequent drawing of conclusions. These are examples of a productive style of questioning that teachers can use. However, open-ended questions (also referred to as "diverging questions") can demand more from teachers than ordinary closed questions (also referred to as "convergent questions").

Per definition, open-ended problems have more than one answer and/or can be solved in a variety of ways. The "openness" of the problems, allows for more perspectives. They can also assist to stimulate fruitful communication of mathematical ideas (Badger 1996:44; Moon & Schulman 1995:25). Open-ended questions should often be used in mathematics because they challenge learners to think. Moreover, open-ended questions can reveal learners' thoughts, opinions, views and conceptions and misconceptions (Burrill 2007; Chapman & King 2005:91). Muijs and Reynolds (2001:191) maintain that the advantage of doing this is that misconceptions can be observed as they occur. Open-ended questions can be put to better use diagnostically since they cover a wider area than closed questions. Learners who are not used to answering open-ended questions often find this call for higher-order thinking very difficult and do not always perform optimally (Hart 1994:95).

An example of an open-ended question in mathematics could be: A graph (such as a bar graph, pie chart or straight-line graph) is given to learners who are then asked to study the given graph and write an appropriate story that would be applicable to the graph. To support the story the learner could provide a heading for the graph and label, the x-axis and y-axis and supply a scale (adapted from Burril 2007).

More examples of open-ended questions in mathematics would be: "Design your own house and make a scale drawing of the house" or "Set up a monthly budget that you think will reflect the income and expenses of a young adult who just started his first job". Teachers should know the content of the mathematics syllabus very well and how it is applied in authentic situations to be able to judge whether an answer is pertinent (Heddens & Speer 1997:32).

3.9.1.3 Handling responses

Wrong responses can be used as a learning resource (Brooks 2002:36). Teachers should deal with mistakes in such a way that learners are not ridiculed – this will make them withhold future responses (Muijs & Reynolds 2001:19). A teacher's reaction to an answer is very important because it can motivate or demotivate learners to respond to questions. Teachers should create a healthy atmosphere in the teaching-learning environment (this will be addressed in chapter 4) in which learners feel free to participate (Van Niekerk 1997:313).

3.9.1.4 Waiting time

Teachers must allow learners to formulate a response and refrain from answering questions on behalf of learners. If the interval between questions is too short (less than one second), learners have insufficient time to think and formulate an answer (Black et al. 2003:32).

Should the waiting time be increased, learners' answers become longer, there is a decrease in failure to respond, more confident responses are forthcoming, learners improve on answers of other learners or even challenge them and alternative explanations are offered (Black et al. 2003:33). There is also a negative side to this. Although an increase in waiting time can encourage more learners to participate in the answering of questions, it can also lead to learners becoming restless.

3.9.2 Observation

There are two ways of doing observation: by observing learners while working and/or answering questions in the mathematics classroom (when teaching) or by means of more structured interviews or conferences (Airasian 1991:13; Lester & Kroll 1996:4). Sometimes learners convey nonverbal messages that can assist teachers to judge the success of their explanation of a question should teachers care to observe it. McMillan (2007:60) indicates that nonverbal communication such as looks of frustration can often be more helpful than verbal feedback.

3.9.3 Journal writing

Black and Wiliam (1998) suggest that opportunities ought to be created for learners to express their understanding. In this regard, journal writing can be helpful. Journal writing implies also that learners must write down their thoughts, feelings, frustrations, how they experience the teaching-learning environment and more about the mathematics lesson that have taken place at the end of a period (Norwood & Carter 1996:82). Used in this way, journal writing forms an important part of reflection (cf. 3.3.5; Miller 1996:80). Learners can communicate with the teacher via the journal, and tell the teacher what they do not understand and ask questions (thus giving feedback to the teacher – cf. 3.7.6.2)

Teachers who use journal writing in their classrooms have realised that the journal writing reveals the thoughts and understandings of learners that typical classroom interactions do not elucidate (Norwood & Carter 1996:81).

3.9.4 Interviews and conferences

An interview or conference is a setting where teachers engage in a one-to-one communication with learners and discuss aspects of mathematics. In such an interview or conference, the teacher can get feedback from learners about what they understand and what not, and make decisions about corrective teaching (cf. 3.5.3; Stenmark 1991:28). Learners can also get feedback from teachers about their strengths and weaknesses in mathematics.

3.9.5 Assignments: Classwork/homework

Some authors clearly distinguish between classwork, homework and assignments. In the GET assessment guideline document for mathematics (DoE 2007b:32), reference is made only to daily assignments, and does not specify classwork, homework and assignments. The document indicates that the purpose for doing these daily assignments is to assess learners' knowledge and skills development formatively. Assignments (classwork/homework) include mostly routine problems or sums.

Muijs and Reynolds (2001:70) emphasise the importance of doing assignments (specifically homework). However, in order for this to be true, homework should fulfil certain conditions (Muijs & Reynolds 2001:71, 72). First of all, homework should never be used as a punishment; it should always be a learning activity. Another requirement is that homework should always be properly corrected and teachers should provide proper feedback on the homework. It is better to give less homework, which is corrected and for which feedback is given, than more homework that remains uncorrected (Muijs and Reynolds 2001:72). Homework should be challenging, but learners should be able to do it successfully.

3.9.6 Tests

Tests are probably the best-known way of assessing learners. When learners write a test, they perform individually without any assistance from the teacher or fellow learners.

3.9.7 Performance assessment tasks

Performance assessment tasks aim to assess learners' abilities to use knowledge and skills in various realistic situations and contexts (Hart 1994:40). Janse van Rensburg (1998:83, 86) describes performance assessment as a situation where learners perform live for the assessor or perform a task directly instead of doing a paper-and-pencil task. This method of assessment can be used with success to assess learners' skills as well as higher-order cognitive processes (Muijs & Reynolds 2001:192).

Projects are an example of performance assessment tasks (AMESA 2001:40). They can also be combined with other strategies of assessment such as posters, models and games. It requires learners to do independent research, and a presentation which can be done individually, in pairs or in groups.

3.9.8 Investigations

Certain assessment standards in the NCS policy document for mathematics (DoE 2002b:75, 87) require learners to undertake investigations such as:

- Learning outcome 2 (Grade 9): "Investigates, in different ways, a variety of numeric and geometric patterns and relationships by representing and generalising them, and by explaining and justifying the rules that generate them."

- Learning outcome 4 (Grade 8): "Investigates the relationship between the sides of a right-angled triangle to develop the Theorem of Pythagoras".

Through investigations, learning and formative assessment can truly take place at the same time. While the learner is actually doing the investigation, the teacher can assess formatively whether the learner is making progress and give feedback to the learner.

3.9.9 Portfolios

Although many sources refer to portfolios as a strategy to use in formative assessment (Hart 1994:23; Janse van Rensburg 1998:86; Popham 1999:181), Stiggins (1994:87) indicates that portfolios should not be seen as a separate assessment strategy, but as a means of gathering evidence of learners' achievement through the use of different assessment strategies (cf. also Heddens & Speer 1997:37). This is in line with the view of portfolios according to the National Curriculum Statement Assessment Guidelines for Schools: GET Mathematics (DoE 2007b:6).

Since 2010, portfolios have no longer been required of learners (Department of Basic Education 2010:4). The only requirement is that evidence of learners' formative assessment should be kept.

3.10 KEEPING RECORDS

Record keeping is essential to show learners' progress in terms of both formative and summative assessment. The GET assessment policy indicates that informal (formative) assessment need not be recorded (DoE 2007a:6).

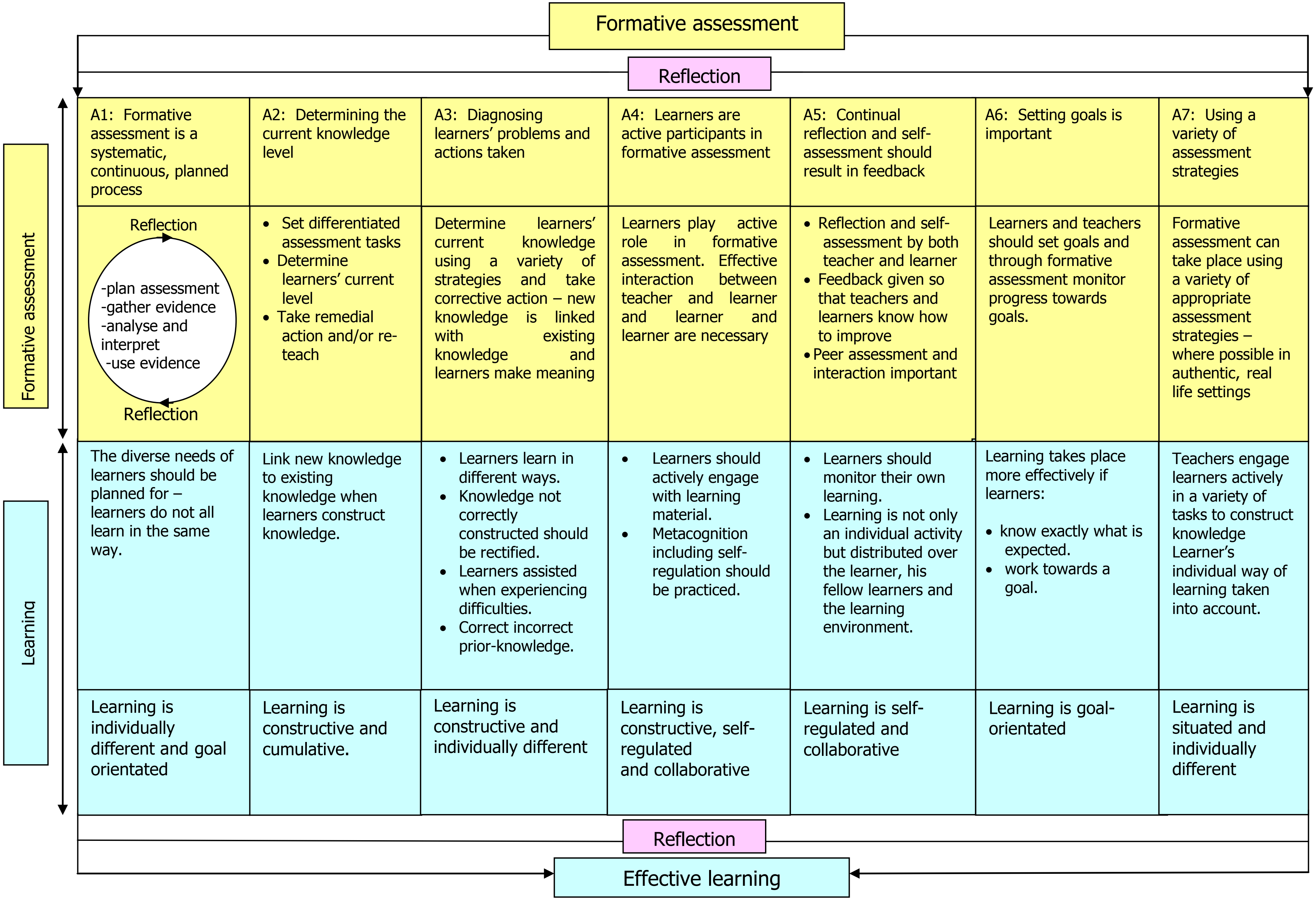
The fact that the results of formative assessment are expressed as comments to learners with corrective feedback was discussed in 3.7.6.3 (Redfield, Roeber & Stiggins 2008:2).

For the teacher, managing the analyses of the results of formative assessment is extremely demanding, in terms of time and management (Della-Piana 2008:592). The results of formative assessment aught only be used to enhance the learning process of learners, either by adjusting the teaching practices or by addressing the learner's needs.

3.11 SUMMARY

In this chapter formative assessment was defined within the outcomes-based paradigm discussed in chapter 2. Seven attributes of formative assessment were formulated that support the definition of learning (cf. 2.2.5) and effective learning (cf. 2.2.7). Each of these attributes was investigated to determine how each should take place in the mathematics classroom to enhance the teaching and learning of mathematics.

In the following figure the attributes of formative assessment and how they link with learning taking place in a constructivist mathematics classroom are summarised:



Formative assessment

Reflection

Formative assessment	A1: Formative assessment is a systematic, continuous, planned process	A2: Determining the current knowledge level	A3: Diagnosing learners' problems and actions taken	A4: Learners are active participants in formative assessment	A5: Continual reflection and self-assessment should result in feedback	A6: Setting goals is important	A7: Using a variety of assessment strategies
	Reflection -plan assessment -gather evidence -analyse and interpret -use evidence Reflection	• Set differentiated assessment tasks • Determine learners' current level • Take remedial action and/or re-teach	Determine learners' current knowledge using a variety of strategies and take corrective action – new knowledge is linked with existing knowledge and learners make meaning	Learners play active role in formative assessment. Effective interaction between teacher and learner and learner and learner are necessary	• Reflection and self-assessment by both teacher and learner • Feedback given so that teachers and learners know how to improve • Peer assessment and interaction important	Learners and teachers should set goals and through formative assessment monitor progress towards goals.	Formative assessment can take place using a variety of appropriate assessment strategies – where possible in authentic, real life settings
Learning	The diverse needs of learners should be planned for – learners do not all learn in the same way.	Link new knowledge to existing knowledge when learners construct knowledge.	• Learners learn in different ways. • Knowledge not correctly constructed should be rectified. • Learners assisted when experiencing difficulties. • Correct incorrect prior-knowledge.	• Learners should actively engage with learning material. • Metacognition including self-regulation should be practiced.	• Learners should monitor their own learning. • Learning is not only an individual activity but distributed over the learner, his fellow learners and the learning environment.	Learning takes place more effectively if learners: • know exactly what is expected. • work towards a goal.	Teachers engage learners actively in a variety of tasks to construct knowledge Learner's individual way of learning taken into account.
	Learning is individually different and goal orientated	Learning is constructive and cumulative.	Learning is constructive and individually different	Learning is constructive, self-regulated and collaborative	Learning is self-regulated and collaborative	Learning is goal-orientated	Learning is situated and individually different

Reflection

Effective learning

Figure 3.3: Summary of chapter 3

CHAPTER 4

TEACHING-LEARNING ENVIRONMENTS SUPPORTIVE TO FORMATIVE ASSESSMENT

4.1 INTRODUCTION

In Chapter 3 formative assessment was defined and its attributes identified. Furthermore, these attributes and their application in the mathematics classroom were discussed. From these discussions it became apparent that a specific teaching-learning environment is needed for formative assessment to support learning. Authors such as Keys and Golley (1996:229) agree with this and indicate that, for constructivist teaching and learning to take place (as described in 2.2.3), it is necessary for teachers to create both experiences and environments where learners can "build on their own prior cognitive structures". This argument is strengthened by contributions from De Corte (2000:40) who argues that studies of learning should be complemented with studies in the design of a powerful teaching-learning environment. Muijs and Reynolds (2001:57), as well as Dorman, Fisher and Waldrip (2006:3), refer to various studies that prove the impact of positive teaching-learning environments on improved learner achievement, both on a cognitive and an affective level.

Mathematics is a subject (learning area) that is generally disliked (Black & William 1998:1). Geldenhuys (2000:24) goes so far as to claim that learners fear mathematics. In order to address negative perceptions of mathematics, Muijs and Reynolds (2001:58) suggest that in constructivist classrooms teaching-learning environments that are warm and supportive should be created so that learners will get the opportunity to achieve the desired outcomes. Reusser (2000:17) emphasises that despite ongoing research, there is compelling evidence that "the cognitive components underlying mathematical ability not only rely on the functioning of neurocognitive systems, but are also heavily sensitive to instructional and environmental factors".

This chapter will investigate the teaching-learning environment that should prevail in mathematics classrooms for the successful integration of formative assessment into teaching and learning of mathematics.

4.2 EXPLAINING TEACHING-LEARNING ENVIRONMENT

Various authors agree that the teaching-learning environment plays a very important role in quality teaching. However, their understanding of the "teaching-learning environment" differs from the researcher's concept of the meaning of this designation. Muijs and Reynolds (2001:57) refer to a "classroom climate" which denotes the environment or the mood created by the teacher in the classroom; whereas Geldenhuys (2000:28) uses the words "learning climate" to refer to the same concept. In line with this, Black and Wiliam (2004), Feldman and McPhee (2008:154), Irons (2008:8) and Killen (2010:25) all refer to a "learning environment", while authors such as Kruger and van Schalkwyk (1997:75;86) use both "classroom environment" and "classroom climate" as separate, but complementary concepts.

The researcher chooses to use the term "teaching-learning environment" as proposed by De Corte (2000:40) who connects the idea of a "teaching-learning environment" to his definition of learning (cf. 2.2.5). The researcher accepted De Corte's definition of learning (as it supports ideas of social constructivism) and identified the attributes of formative assessment that support this definition of learning (cf. 2.2.5 and 3.2.3). In addition, as argued in 2.3.7, the NCS supports De Corte's definition of learning.

The term "teaching-learning environment" is also used by Reusser (2000:18) who emphasises that while the prevailing learning theory is constructivism, the creation of an effective teaching-learning environment is fundamental.

The word "teaching-learning" is preferred to the word "classroom" since "teaching-learning" is what should happen in educational spaces such as schools. The use of the word "teaching-learning" shifts the emphasis to the actions of both learning and teaching that take place inside or outside the classroom. This links up with the line of reasoning in Chapter 3 where it was proposed that teaching and learning in the constructivist classroom is integrated and interdependent.

The word "environment" has been chosen since, per definition, it refers to "the surroundings or conditions in which a person operates" (Dictionary Unit for South African English 2002:386-387). In this case, the persons are the teacher and the learner with the learner at the centre. Killen (2010:5) states clearly that the total environment (including the psychological, social and physical aspects) in the classroom influences learning. According to Dorman, Fisher and Waldrip (2006:2), when applied to the educational context, the concept "environment" includes "the atmosphere, ambience, tone or climate that pervades the particular setting". Thus, the word "environment" is deemed to be the most suitable. It is important to mention that, as one of the seven roles of a teacher (cf. 2.3.5.1), the teachers' role as mediator includes to create "learning environments that are appropriately contextualised and inspirational" (Killen 2010:396). Current policy documents in South Africa thus also emphasise the importance of an appropriate teaching-learning environment.

The assumptions of OBE emphasise the importance played by the school in terms of creating a suitable environment for learning to take place (cf. 2.3.2). In other words, schools are obliged to provide an environment in which learners can be successful and in which greater success can be fostered. The teaching-learning environment in a mathematics classroom must be such that it maximises the learners' opportunities to learn and reach their full potential. Chapter 3 discussed how formative assessment contributes to learning in the mathematics class. It can thus be argued that a teaching-learning environment that supports formative assessment will also maximise the learning opportunities in mathematics.

4.3 FACTORS THAT INFLUENCE THE TEACHING-LEARNING ENVIRONMENT

Reusser (2000:18) mentions the following aspects that affect the design of effective teaching-learning environments as comprising "domain-specific knowledge and skill, the orientation toward understanding, problem solving and social interaction …"

4.3.1 Domain-specific knowledge

Teachers need mathematical knowledge and skills if they really want to reveal the world of mathematics to learners. For teachers to diagnose learners' problems in mathematics, they need a thorough knowledge of the content of the mathematics syllabus (Ball, Bass & Hill 2004:51-54; Strydom 1995:3). This knowledge is different from the expertise needed by a mathematician.

The literature describes the understanding required of a mathematics teacher to teach mathematics as pedagogical content knowledge (PCK) (cf. 3.5.2). Ball, Bass and Hill (2004:54) refer to "pedagogical content knowledge" as "a special kind of teacher knowledge that links content and pedagogy". This kind of knowledge integrates mathematical content knowledge with aspects of mathematical teaching and learning. Shulman (1986:14) avers that this is an integral form of content knowledge. Knowledge of this kind empowers teachers to present mathematics in such a way that learners are able to understand it. There is no single, powerful presentation with which to do this. Thus, according to Shulman (1986:11-14), teachers need to use various forms of presentation that are based on research or that originates in "the wisdom of practice". PCK is the kind of knowledge that contributes to the professionalisation of teaching as a profession.

4.3.2 Orientation toward understanding, problem solving and social interaction

Teachers' orientation towards understanding, problem solving and social interaction depends on how they view the learning process. If teachers value learners' understanding rather than rote memorisation, they will emphasise this and design activities to promote it and will value problem solving as a teaching method. Social interaction should take place between teachers and learners and among learners so that dialogue (cf. 2.3.5.1.1) can be enhanced. In order for them to achieve this, teachers need to value social interaction and should view it as a valuable opportunity for learning to take place.

4.4 DESIGN PRINCIPLES FOR A TEACHING-LEARNING ENVIRONMENT

De Corte (1995:40, 2000:40) proposes that, when a teaching-learning environment is created, it must be done in such a way as to support features of effective learning. According to de Corte (2004:40), the design-principles for a powerful teaching-learning environment in the mathematics classroom are as follows:

- Teaching-learning environments must be such that they support acquisition processes that are active and constructive in nature.

- This active construction of learners' knowledge should preferably take place in authentic real life situations as far as possible.

- The development of self-regulation strategies for learners should be strived for in powerful teaching-learning environments. Learners themselves should become responsible for their own learning.

- Powerful teaching-learning environments should provide opportunities for the acquisition of general learning and thinking skills embedded in mathematics.

- An appropriate teaching-learning environment should provide opportunities for learners to reflect on their learning activities and their problem-solving strategies specifically. Learning should be strengthened through the use of metacognitive strategies, reflective practices and dialogue that take place in small groups with peers.

4.5 THE REQUIREMENTS OF A SUITABLE TEACHING-LEARNING ENVIRONMENT IN MATHEMATICS

All the design principles of a powerful teaching-learning environment discussed in the previous paragraph refer to the active role that learners should play in the learning of mathematics (cf. 2.3.5.2). Subsections 3.3, 3.6.1 and 3.7.1 discussed the value of keeping all learners active in all steps of the formative assessment process.

Tomlinson (2008b:27) emphasises that learners should take charge of their own learning and that the aim of schooling should be that each learner should achieve his or her full potential. In order for this to happen Tomlinson (2008b:28-30) recommends the following requirements for teaching-learning environments in mathematics: building a relationship of trust; ensuring fit (ensuring suitable assessment tasks); strengthening the learner's voice; and developing awareness. De Corte, Verschaffel and Masui (2004:368-369) also refer to the active involvement of learners when a powerful teaching-learning environment is designed.

In the investigation of appropriate teaching-learning environments the researcher subscribes to the requirements specified by Tomlinson (2008b:28), but wants to include the involvement of learners.

4.6 INVESTIGATING TEACHING-LEARNING ENVIRONMENTS

Smith (s.a:1) argues that learners behave in accordance with "their subjective perception of the environment". This implies that the way in which learners perceive an environment has a direct influence on the teaching-learning environment in the mathematics classroom. The literature makes it apparent that certain indicators are instrumental in the creation of a beneficial teaching-learning environment. Each of these indicators will be investigated in turn to determine how each contributes positively to the teaching-learning environment.

4.6.1 A relationship of trust

Various relationships are present in the mathematics classroom: the relationship between the teacher and learners; and the relationship among the learners themselves. These relationships should be built on mutual trust.

4.6.1.1 The relationship between the teacher and the learners

According to Tomlinson (2008b:29) "trust begins when students believe that the teacher is on their side". She continues by describing how learners who truly believe this will be open to suggestions and accept necessary criticism from their teacher in order to achieve better learning.

Khine and Lourdusamy (2006:31) refer to several studies that investigate how particular learner-teacher relationships can affect learners' achievements and attitudes. The authors conclude that there are three factors that play a decisive role when the relationship between teachers and learners is considered. Each of these factors will subsequently be discussed.

4.6.1.1.1 A caring attitude towards learners

Learners should be made aware that their mathematics teacher cares about them. Muijs and Reynolds (2001:59) explain the value of something as basic as knowing learners' names: in this way learners realise that the teacher values them as individuals. It is also important that mathematics teachers should know their learners' backgrounds and what is important to each learner (AAMT 2006). Remarks like "Well done on Saturday, Sarah!" or, "Sorry about your accident, John!" when learners walk into the mathematics classroom show them that the teacher is interested in them. This can have a greater effect if the teacher uses events in learners' lives when setting mathematical investigations as formative assessment tasks (cf. 3.9.8). The following is an example of this: Sarah won the 100 m breaststroke on Saturday when competing in the school gala. Since the time in seconds is known, learners can work out Sarah's speed (in $m.s^{-1}$) and compare it to other known speeds such as the speed of a car travelling in an urban area at 60 $km.h^{-1}$.

When formative assessment is being conducted, learners ought to feel sure that whatever task the mathematics teacher sets for them will be in their best interests. According to Tomlinson (2008b:28), this implies that learners should realise that the mathematics teacher is there to support their growth and development. In a caring teaching-learning environment, learners should not fear assessment tasks or regard it as a waste of time. Learners will look forward to doing formative assessment tasks in mathematics when they know that the tasks are being set for their growth and benefit. This means that teachers should consider their learners as active role players (as described in 3.6.1) when doing formative assessment. Teachers should explain the importance of formative assessment tasks to learners and how the tasks will assist their progress in mathematics. Transparency is thus not negotiable in formative assessment. This will be investigated in 4.6.2.3.1.

Furthermore, learners must be comfortable and feel “at home” in the mathematics classroom. If mathematics teachers can inspire learners to be excited about new learning opportunities and the challenges they bring, learners will look forward to accepting new challenges in mathematics (Muijs & Reynolds 2001:60). A caring disposition should thus aim to turn learners into eager learners. In this regard, Muijs and Reynolds (2001:71) and also Geldenhuys (2000:27) advise that assessment tasks should never be used as punishment. The authors point out that this leads to resentment of the assessment tasks and also gives learners the idea that the teacher does not really value these tasks as learning activities. As a result learners will not be motivated to complete assessment tasks and this will thus influence the teaching-learning environment negatively.

To care for learners also means that teachers should respect learners and value their opinions (Tomlinson 2008b:28). Cangelosi (2008:90) maintains that respect should be disassociated from achievement. This implies that teachers must love and respect their learners whether they are successful or not. When learners answer questions, teachers should listen attentively to their answers (Tomlinson 2008b:28). Van de Walle (2004:33) proposes that listening to learners’ answers requires that they believe in the learners’ ideas.

4.6.1.1.2 Teachers should believe that learners have the ability to be successful

a) All learners can be successful

One of the assumptions of OBE is that all learners can study or be taught successfully (cf. 2.3.2). This assumption does not imply that everything that the learner does will be correct: it is more about the teachers’ and the learners' states of mind. In an outcomes-based environment teachers must believe in their learners' potential to be successful. Learners must also believe in themselves.

The first assumption of OBE that states that all learners can make a success of their learning has further implications: not all learners achieve success simultaneously and neither do they achieve it in the same way. Some learners need more learning opportunities than others - and accordingly, more formative assessment opportunities - for success in mathematics. Mathematics teachers who believe that their learners can be successful do not give up on them. They continue to support learners by providing expanded opportunities (2.3.4.2) by means of formative assessment tasks to support learners' growth and learning.

Teachers can set differentiated assessment tasks (cf. 3.5.1) to assist learners to perform at a level comfortable to them and/or to accommodate their special needs (Tomlinson 2008b:27). This can have a double effect: since the teacher provides for the learner's special needs, learners feel comfortable when doing the task; and learners feel taken care of, since they perceive that the teacher has their special needs at heart. Teachers must, however, be very subtle, and not label learners as, for example, "more clever learners" and "less clever learners", when they assign differentiated formative assessment tasks to learners.

b) Teachers should have high expectations of learners

Besides believing that learners can be successful, mathematics teachers should also have high expectations of the learners (cf. 2.3.4.3). The admonition that teachers should have "high expectations" of learners does not imply that all learners will achieve all outcomes in the same way. Killen (2010:26) explains that teachers should expect all learners to achieve "significant outcomes" to "appropriate standards". Teachers' expectations can play a determining role in learners' performances. Research has proved that learners whom teachers expect to do well, tend to do even better than expected. Yet the opposite is also true: when teachers expect little of learners, the learners fulfil the teachers' prophecy and under-perform (Muijs & Reynolds 2001:63). In this regard Muijs and Reynolds (2001:108) remark that having high expectations of learners is one of the main factors that contribute to the improvement of learners' self-concept.

The second OBE assumption (cf. 2.3.2) states that success stimulates more success. May and Fray (2010:16) quote Burton (2004) who says: "Success in mathematics breeds confidence. Confidence in mathematics breeds success." Stiggins and Chappuis (2005:1) argue that achievement comes first and confidence will follow.

According to Wood (1998:233), research indicates that learning in mathematics is driven by success. This implies that the learners who see that their attempts yield positive results start to believe that they can do the mathematics required of them instead of claiming, "I know I cannot do it". If learners do make this claim, the teacher can respond by saying, "Here you were able to do the work, so you can do this". As the learners grow in confidence in their mathematical abilities, the teachers gradually increase the level of difficulty of the tasks accordingly.

Teachers must always value learners' attempts (Killen 2010:257) and never "put them down", be sarcastic or make fun of them (Feldman & McPhee 2008:165). Statements such as "You asked a good question today and it led to fruitful discussions – thank you" can make a learner feel that he or she has added value to the class and make them more eager to participate in future (Feldman & McPhee 2008:167).

c) Motivating learners

Teachers have the important task to motivate learners to keep on trying to master the various topics in mathematics and make a success of their learning (Stiggins 2007:23). Chappuis and Stiggins (2008) observe that teachers who understand the relationship between assessment and motivation set formative assessment tasks that maximise motivation.

Both social and emotional factors affect the learning experiences of learners in some way. Every learner has beliefs about their own ability to learn mathematics that have been shaped by previous experiences. Brooks (2002:21) warns that these beliefs can result in either positive or negative motivation for the learner, resulting in poor or high self-esteem. Learners with positive self-esteem are more motivated to learn, prepared to take intellectual risks and do not hesitate to tackle difficult tasks. Learners with low self-esteem reject taking risks and do not like to be challenged (Brooks 2002:44). These learners try to avoid failure and are reluctant to seek help, as they fear their weakness will be exposed to both teacher and other learners.

Motivation can either be internal or external – this is also known as intrinsic and extrinsic motivation (Olivier 1999:7). When teachers believe in learners and learners believe in themselves, this positive attitude can motivate a learner intrinsically. In contrast, extrinsic motivation is driven by factors outside the learner, such as a reward or good marks which give the learner satisfaction that the work itself fails to provide. Extrinsic motivation is often driven by fear (e.g. of failure) or by a dominating teacher (who applies coercion). Thus it is clear that intrinsic motivation is more favourable to constructivist learning than motivation from an external source. However, Harlen (2006a:63) warns that to regard all intrinsic motivation as good, and all extrinsic motivation as bad "ignores the reality of the variety of learning, of learning contexts and goals as learning".

Another important aspect to consider when motivating learners is academic efficacy. Dorman, Fisher and Waldrip (2006:5) describe academic efficacy as referring to the personal judgments that learners make about how they perceive their competence to do certain activities. Should learners be positive about their academic efficacy, there are enough research studies to prove that they will be positively motivated (Dorman, Fisher & Waldrip 2006:6) and persevere with more difficult tasks. Harlen (2006a:67) indicates the importance of assessment to help build a learner's efficacy. Finally, it must be noted that there is a link between goals and motivation. Learners who attach value to goals related to academic achievement are likely to be motivated by them (Harlen 2006a:65).

d) A disciplined relationship

Although a relaxed environment is the ideal, this does not imply that the teaching-learning environment is undisciplined. Teachers must stay in control of the constructivist classroom: they need to intervene when necessary, clarify ideas, elicit higher-order thinking, stimulate discussion, arbitrate the discussions, resolve conflict and encourage participation by all learners (Muijs & Reynolds 2001:62). This implies that teachers should neither be overly authoritarian nor undisciplined. As a matter of fact, Muijs and Reynolds (2001:61) found that there is a positive correlation between disciplined classrooms and a positive classroom climate.

Cangelosi (2008:58) refers to a businesslike atmosphere and explains it as "a learning environment in which students and the teacher conduct themselves in ways suggesting that achieving specified learning goals takes priority over other concerns". Although the teaching-learning environment thus should be relaxed, learners must know that teachers mean business when they come into the classroom.

4.6.1.1.3 A harmonious relationship between teacher and learners

That teachers should have a caring disposition towards learners, that they should believe in their learners and have high expectations were discussed in the previous paragraphs. In so doing, the teacher will create a harmonious relationship between him/herself and the learners. Harmonious relationships are implicitly free of conflict (Dictionary unit for South African English 2002:528). If there is a harmonious relationship between the teacher and the learners, the learners will have the courage to give their own opinions and solve problems in the mathematics classroom – even if they do not find the correct solution to a mathematical problem. Learners will see this as a learning opportunity (Glasgow & Hicks 2003:98; Van de Walle 2004:32). Learners should not be afraid to answer teacher's questions in the mathematics classroom and they should be willing to enter into a dialogue with the teacher (cf. 3.6.2) and explain why they thought to solve a problem or do exercises in a specific way (Dorman, Fisher & Waldrip 2006:5; Muijs & Reynolds 2001:62). The teacher's guidance of the learner to the correct solution by means of dialogue involves the learners' full co-operation.

Harmonious relationships between teacher and learners result in a relaxed teaching-learning environment. Learners should be comfortable enough to tell teachers the cause of their fears and anxieties. Learners can open-up to teachers that they trust and, in this way, personal stumbling blocks that hamper learners' growth in mathematics can be removed. Keeping a mathematics journal (cf. 3.9.3) can be especially helpful in this regard (Norwood & Carter 1996:82).

4.6.1.2 The relationship of learners among themselves

In 2.2.2.2 it was discussed that Vygotsky valued the importance of social interaction in, amongst others, the mathematics classroom. This implies that the relationship among learners in the mathematics classroom contributes greatly to the teaching-learning environment. Learners should trust fellow learners and feel safe when they participate in formative assessment. If learners feel that they will be exposed as ignorant, ridiculed, embarrassed or harmed in any way, they will not display on-task, engaged and pro-social behaviour (Cangelosi 2008:87).

Teachers should handle formative assessment in such a manner that learners learn to respect each other (Van de Walle 2004:32). All human beings fear humiliation. Mathematics teachers should foster an environment in their classrooms that ensures that this does not happen. Teachers must teach learners to respect each other so that everybody feels safe and secure in the mathematics classroom. The teacher should always lead by example, and model the correct behaviour to learners, both inside and outside the classroom (Muijs & Reynolds 2005:133).

4.6.2 Ensuring suitable assessment tasks ("fit")

In order to be able to provide information about learning, formative assessment tasks must be carefully set. Tomlinson (2008b:28) explains that "fit" implies that the mathematics teacher will set formative assessment tasks that are suitable for every learner's mathematical needs: they must "fit" the learner's current level of competence (cf. 3.4). Should assessment tasks be consistently beyond a learner's reach, Tomlinson (2008b:28) maintains that "students become more occupied with escaping possible danger or humiliation than with learning". In this regard academic efficacy is important. Ensuring that formative assessment tasks are suitable for all learners according to the principle of high expectation can assist learners' academic efficacy to grow. In this way "fit" can assist learners to be positive about their academic efficacy.

Van de Walle (2004:32) proposes that suitable mathematical tasks engage learners in the concepts that the curriculum envisages for them. This is why formative assessment tasks should adhere to certain prescriptions in order to contribute to a positive teaching-learning environment. Tasks should be such that they support the learning process and facilitate learners' success in mathematics.

4.6.2.1 Alignment

Alignment was already discussed in 2.3.4.1, 2.3.4.4, 2.4.1 and 3.3.1. McMillan (2007:82) argues that it makes sense that what is taught should be the same as what is assessed. When teachers formulate outcomes, and design formative assessment activities that are directed towards the outcomes, alignment will happen naturally. Alignment will ensure that the teacher assesses what ought to be assessed and, in so doing, contributes to the relationship of trust between learners and teachers.

Yet, alignment goes further than merely aligning goals, learning and assessment. Constructivism implies that learners should construct their own meaning of concepts (cf. 2.2.3.1). There is a real danger that the meaning of concepts (as constructed by the learners) is not aligned with the correct meaning of the concept (Driscoll 1996:14). In order to identify such misalignment, teachers should encourage learners to communicate their understanding of the concept either orally or in writing. Learners will render this information if the teaching-learning environment is built on trust between teacher and learner. If not, they will withhold the information or refuse to share it (Muijs & Reynolds 2001:58).

Should the teacher be able to identify any misalignment of the learners' interpretation of a concept with the true meaning of the concept through formative assessment, appropriate action can be taken to remedy the problem.

From the previous discussion it can be deduced that if teachers ensure that outcomes are aligned with assessment as well as with the formation of concepts, learners will learn what they ought to learn. If there is misalignment, learners will learn how to answer assessment tasks without real understanding of the content.

4.6.2.2 Considering learners' level of competence

Presenting learners with formative assessment tasks suitable for their level of competence was discussed in 4.6.2. According to Piaget's developmental stages (cf. 2.2.2.1.1), learners who are in the Senior Phase (12 years of age and above) should be either in the formal operational stage or entering this stage. However, Mwamwenda (2004:96) refers to research studies done in the United States of America (USA) that indicate that most adolescents (who are the Senior Phase learners in SA) do not function at this level and posits that there is no evidence to suggest otherwise about South African adolescents. According to this view, Senior Phase teachers in South Africa can assume that many of their learners (if not most) are on the concrete operational level. When planning assessment tasks, this should influence mathematics teachers' construction of the tasks. Teachers who realise that their learners have not yet reached the formal operational stage should consider including tangible tasks to assist learners and to promote transition to the formal operational stage.

4.6.2.3 High quality of formative assessment tasks

In order to ensure that formative assessment tasks are of good quality, the following characteristics can guide teachers: authenticity, variety, volume, validity and reliability (accuracy) (Swearingen 2002:4). Authors such as Van Rooyen and Prinsloo (2002:34,36) and Siebörger and Macintosh (2004:11) contribute the virtues of transparency, practicability and fairness to the list above. The assessment policy for the General Education and Training Band

(DoE 2007a:5) add the qualities of objectiveness and impartiality, a sensitivity to race, gender and cultural backgrounds. Each characteristic will be investigated and discussed in the subsections that follow.

4.6.2.3.1 Transparency

When doing a formative assessment task in mathematics, learners should know exactly what is expected of them. This links up with De Corte's definition that "learning is goal orientated" of (cf. 2.2.5.4). In other words, learners should know what is expected of them and work towards that goal.

4.6.2.3.2 Practicability

When a teacher plans formative assessment tasks, the available resources should be taken into consideration (Van Rooyen & Prinsloo 2002:36). The following can serve as examples: if the teacher wants learners to draw angles, they must have protractors to do the measurements themselves. If the teacher wants learners to take measurements, measuring instruments such as scales, measuring cylinders and measuring tapes should be available. Not having the necessary instruments available or not having enough instruments can lead to the disruption of an otherwise constructive teaching-learning environment. Furthermore, in 2.2.2.1.2 (b) it was discussed that, according to Piaget, one of the factors influencing learning is physical experience. As was stated in 4.6.2.2, because most learners in the Senior Phase are expected to be still in the concrete operational stage (cf. 2.2.2.1.1), physical experiences become non-negotiable when teaching mathematics. Resources also include mathematics textbooks, models of 3-D solids and graph paper.

If no mathematics textbooks and other resources are available, learners might think that they are certainly failures and not worthy of the expenditure of buying textbooks. It will result in poor learner participation and can influence the teaching-learning environment negatively.

4.6.2.3.3 Authenticity

Learners live in a world beyond the school premises and this larger environment influences both learners' interests and their attitudes. The fact that learning is situated was described in 2.2.5.5; and the importance of applying acquired knowledge and skills in real life situations was emphasised.

As has already been mentioned (in 4.4), one of the design principles of a powerful teaching-learning environment is that the active construction of learners' knowledge should preferably take place using authentic real life situations as far as possible. This is even more valuable when these real-life situations have personal meaning for learners. Hart (1994:9) argues that authentic assessment tasks require learners to use higher-order thinking skills (cf. also Kotze 2002:80) and also coordinate a broad range of knowledge. Seen like this, authenticity is something that should be explored in a wide range of formative assessment tasks. In the same vein, Kotzé (2002:79) rightfully points out that authentic assessment is not a specific assessment strategy or instrument, but could be reflected in various formative assessment strategies (cf. 3.9).

4.6.2.3.4 Variety

To prevent boredom and keep learners interested in mathematics, the teacher should use various formative assessment strategies (cf. 3.9). Besides the fact that variety can make the mathematics class more interesting, teachers can also give learners with different abilities a chance to show their strengths and weaknesses (cf. 3.5.1) as provided for in the principle of expanded opportunities (2.3.4.2).

4.6.2.3.5 Quantity of work

Teachers should assess the learners in such a way that both teachers and learners will be able to handle the quantity of work (in other words, it must be sustainable).

Swearingen (2002:5) makes the point that assessment can really take its toll on teachers if they have to set and evaluate many assessment tasks. If the teachers do not perceive teaching, learning and assessment as integrated, but rather regard assessment as an "add on", they become frustrated. Such teachers portray negative measures to learners through their body language, and this influences the teaching-learning environment negatively (Feldman & McPhee 2008:165).

4.6.2.3.6 Validity

An assessment is valid when it assesses what it claims to assess (Van Rooyen & Prinsloo 2002:35). For OBE, validity implies that the stated outcomes must be assessed. If teachers ensure that outcomes, teaching and assessment are aligned (as suggested in 4.6.2.1), validity will be a given and thus be easier to attain in OBE.

Formative assessment should result in an improvement. Anything that hinders this improvement threatens the validity of the assessment task (Stobart 2006:136). For example, this can be:

- ☐ The learning context: different cultural and also social factors can have an effect on the classroom situation (Stobart 2006:136).

- ☐ External factors: Stobart (2006:137) also mentions that these can influence the classroom situation. Aspects such as what society values, the curriculum, inadequate training, resources and the culture of schooling falls in this category of external factors. All of these can influence effective formative assessment.

- Factors within the classroom: these include factors such as learning contexts and feedback. The classroom context should be supportive and productive feedback should be given (Stobart 2006:138).

- It has already been debated in 4.6.1.1.1 that learners have to trust teachers and that whatever tasks they are required to do will be for their own benefit, and hence valid.

4.6.2.3.7 Reliability

Reliability refers to the quality of the assessment procedure itself. For summative assessment in which scoring is very important, reliability refers to the consistency and dependability of learner's scores (McMillan 2007:69; Popham 1999:23). James (1998:185) as well as Black and Wiliam (2006:129), indicate that reliability is not as important for formative assessment as it is in the case of summative assessment, because the results of formative assessment are used to inform learners and teachers about the learning that has taken place. Instead, formative assessment should be judged on the basis of the extent to which it provides for successful action to take place after the formative assessment has been done (Black & Wiliam 2006:130).

4.6.2.3.8 Fairness

More contemporary forms of assessment are perceived to be fairer to learners since learners know exactly what is expected of them. These forms of assessment also accommodate individual differences in the pace of their work (Hart 1994:94).

Learners who believe that mathematics teachers do not treat them fairly can become negative about mathematics. This can influence the teaching-learning environment negatively.

4.6.2.3.9 Non-discriminating

As "the Constitution of the Republic of South Africa provides the basis for curriculum transformation and development in contemporary South Africa" (DoE 2002a:15), the values of non-discrimination, no discrimination on the base of sex or race should be upheld in the mathematics classroom.

Assessment tasks should also be set and executed in a manner to honour these values. Teachers should be sensitive to race, gender and cultural backgrounds of learners (DoE 2007a:5). As an example, Muijs and Reynolds (2001:65) mention that teachers must be aware of how many times they ask boys or girls or learners of different cultural groups to answers questions in the class.

4.6.2.4 Time considerations

When learners are given a formative assessment task in mathematics, teachers should allow them enough time to complete the assessment task. Learners should have the time to be able to wrestle with the tasks, individually or in groups. Learners need enough time to construct knowledge and teachers should allow learners this time (Zmuda 2008:42). Restricting the time allocated to learners interferes with the learners' curiosity and behaviour that will lead to an in depth exploration of the problem (Geldenhuys 2000:27).

4.6.3 Strengthening the learner's voice

Tomlinson (2008b:29) states: "Voice, the third element, is an extension and refinement of thought that gives students power over their own destinies as learners". Tomlinson continues by quoting Parker Palmer (1998): "Learning doesn't happen when students are unable to express their ideas, emotions, confusion, ignorance, and prejudices. In fact, only when people can speak their minds does education have a chance to happen". The teaching-learning environment in the mathematics classroom should be such that learners should feel free to ask questions, to experiment, to explore their own methods, to explain their ideas and, above all, to make mistakes (Black et al. 2004). This must take place in such a manner that learners will not fear embarrassment or ridicule.

4.6.3.1 Allowing learners to work in cooperative learning groups

In classes where co-operative learning groups are used (cf. 2.3.6) and learners get a chance to express themselves, learners will learn valuable social skills. Some learners are only willing to contribute to small groups, as this is less threatening than presenting solutions in front of the whole class. The same is true about questioning. If learners do not feel comfortable enough to ask questions in the mathematics class, they may be more comfortable when they work in small groups (Van de Walle 2004:33).

4.6.3.2 Allow learners to assess themselves

The teaching-learning environment in the mathematics classroom must be one that encourages learners to not only do formative assessment tasks, but also to assess their own performances (cf. 3.7.3). Janse van Rensburg (1998:88) posits that self-assessment increases the motivation and commitment of learners. When learners are motivated and committed, the teaching-learning environment is influenced positively.

4.6.4 Developing awareness

4.6.4.1 Reasons for doing formative assessment

According to Thomlinson (2008b:30), developing awareness when doing formative assessment implies first of all that learners must know exactly what they are expected to learn. Thereafter, they must know why they are doing formative assessment tasks and how these tasks contribute to their learning.

4.6.4.2 Learners must be aware of their own performance

Developing awareness also involves the learners' awareness of their performance in mathematical formative assessment tasks. This can be done through formative feedback (cf. 3.7.6). Irons (2008:8) states that formative feedback in mathematics can be given effectively in a teaching-learning environment that is open, constructive and supportive. The important impact of motivation in the teaching-learning environment has already been discussed. In addition, McMillan (2007:12) indicates that research on motivation suggests a positive correlation between teachers' constantly assessing learners and providing informative feedback and motivation. McMillan (2007:12) goes on to explain that by providing specific and meaningful feedback learners are encouraged to regulate their own learning and enhance their sense of self-efficacy and self-confidence besides. This contributes all to a positive teaching-learning environment (De Corte 1995:41).

4.6.5 Involving learners in the setting of tasks

Dorman, Fisher and Waldrip (2006:3) suggest that learners should be involved when decisions are made concerning which assessment tasks in mathematics are suitable for them. Stiggins and Chappuis (2008) emphasise that teachers must realise that learners are also decision makers when it comes to formative assessment and that their need for information about their learning should also be met by formative assessment tasks. Learners can also be requested to set assessment tasks (Feldman & McPhee 2008:169). An example of this can be to involve learners in a quiz where groups set questions and then compete against each other.

Ownership of learning means that learners "have a sense of belonging to something they have helped create" (Feldman & McPhee 2008:163). A sense of ownership can assist in creating a positive teaching-learning environment. Instead of letting learners set formative assessment tasks, teachers can fully involve the learners in setting tasks. Teachers can ask learners how they feel about doing a task (is it interesting?); whether they want to do the task (will it contribute to their learning?); whether it should be an assignment, a project or an investigation. They may also decide whether to do the task individually or in groups. Learners can help the teacher to choose a context and suggest questions in this specific context or help identify a specific field of interest (e.g. becoming an entrepreneur). Teachers can combine all the learners' ideas, add his/her own ideas and then construct the formative assessment task.

When teachers involve learners in the setting of formative assessment tasks the formative assessment process is "opened" to learners and can contribute to a teaching-learning environment that is inviting.

4.6.6 Perspectives on the teaching-learning environment

In a positive teaching-learning environment, mathematics teachers should not only believe that their learners can be successful, they should also believe that learners can control and manage their own learning. Consequently, they should fully engage learners in the teaching-learning-assessment process. By releasing responsibility to learners, allowing learners to assess themselves regularly and also keep track of their own learning, learners will become more confident in themselves as students of mathematics. They will be more motivated to learn, and the success they experience will breed more success (Stiggins & Chappuis 2008).

4.7 THE PHYSICAL APPEARANCE OF THE MATHEMATICS CLASSROOM

Although much has been said about the emotional and psychological aspects that have an influence on the teaching-learning environment, it is also worthwhile to mention the effect of the physical appearance of the mathematics classroom. This corresponds with Feldman and McPhee's (2008:154) definition of learning environment. The authors indicate that the physical setting and emotional climate both contribute to the teaching-learning environment.

Muijs and Reynolds (2001:60) suggest colourful and attractive mathematics displays to brighten the classroom. The authors explain that this has the added advantage that peripheral learning can occur. These displays or posters can, in fact, be the formative assessment tasks that have been done by learners. Learners can, for example, be given the task of making a poster where a mathematical topic is depicted (such as the number system). Teachers can also request learners to construct 3-D solids using cardboard. These can be arranged as a decorative feature and displayed in the mathematics classroom. Learners feel important and respected if their artworks are displayed and this can contribute to the learners' confidence.

4.8 THE HIDDEN CURRICULUM

The paragraphs above discussed that various messages go out to learners regarding teaching, learning and assessment of mathematics. Many of these takes place unintentionally. This can be referred to as the hidden curriculum.

The hidden curriculum refers to unplanned experiences of learners and teachers at school that are not prescribed in the official departmental policy (Jacobs, Vakalisa & Nqabomzi 2004:53). Glatthorn, Boschee and Whitehead (2006:22) define the hidden curriculum as "those aspects of schooling, other than the intentional curriculum, that seem to produce changes in student values, perceptions, and behaviours". Therefore the hidden curriculum does influence the teaching-learning environment in a negative or a positive way.

As teachers do assessment, they send out messages to learners (AMESA 2001:9; Feldman & McPhee 2008:23). Teachers must be careful that their body language does not give a different message from their verbal messages. Learners interpret these messages and act upon them. Negative messages influence the teaching-learning environment negatively. Muijs and Reynolds (2001:60) on the other hand mention how the teacher's enthusiasm can influence the teaching-learning environment positively. In addition, Feldman and McPhee (2008:170) indicate that if teachers are excited about topics and introduce real life experiences in a passionate way, the teaching-learning environment will be influenced in a positive manner.

4.9 SUMMARY

This chapter discussed how mathematics teachers can create a supportive teaching-learning environment that will be appropriate for learners to achieve the desired outcomes. This teaching-learning environment should also support formative assessment, as was discussed in chapter 3. Such a teaching-learning environment will be supportive, engaging, inviting, respectful, caring comfortable, non-discriminating and motivating.

It was found that the assumptions of OBE and the principles of outcomes-based if evident in the five factors, support the creation of a positive teaching-learning environment. A diagrammatic representation of chapter 4 is presented in Figure 4.1.

The diagram helps to summarise chapter 4. In a teaching-learning environment the teacher should focus on the relationships and interactions for formative assessment to take place effectively. The assumptions and principles of OBE should be practiced by teachers. This would assist with the creation of a positive teaching-learning environment.

Harmonious relationships between teacher and learners and among learners themselves should be established. These relationships should be built on trust and respect. Learners will become motivated, active learners and be able to take charge of their own learning through formative feedback. This will assist learners to achieve the outcomes.

Formative assessment tasks set by the teacher should be of high quality. There should be enough resources available for all learners to use when doing formative assessment tasks. The classroom should also be physically attractive to learners. The hidden curriculum also influences the teaching-learning environment.

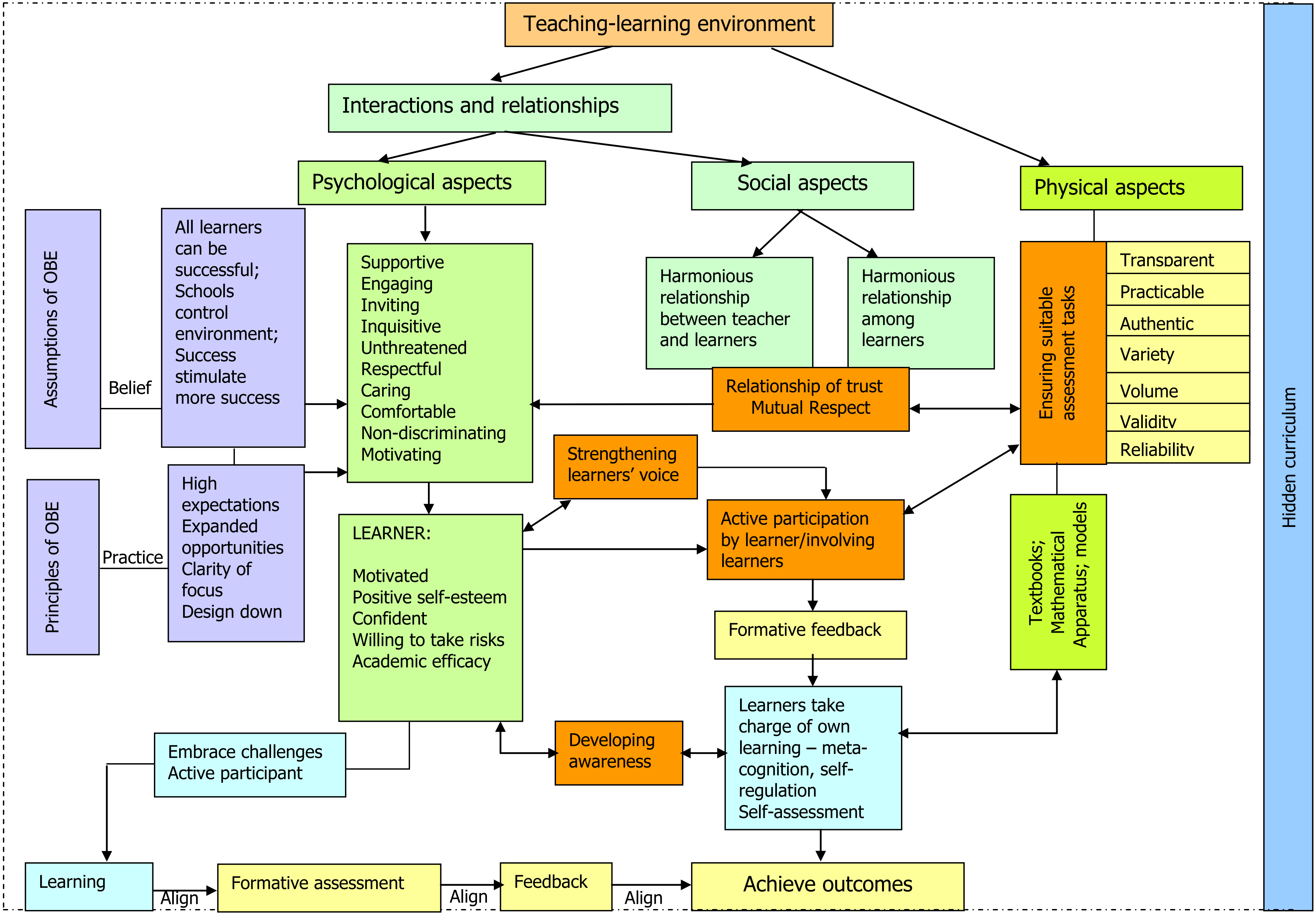


Figure 4.1: Summary of Chapter 4

CHAPTER 5

RESEARCH DESIGN

5.1 INTRODUCTION

In Chapters 2 – 4 a literature study was undertaken in order to understand formative assessment in mathematics in an outcomes-based teaching-learning environment. Chapters 2 and 3 dealt with effective learning and how it takes place within the outcomes-based paradigm, how formative assessment contributes to effective learning and how it should be applied in the mathematics classroom. This was followed (in Chapter 4) by an investigation of the relevant teaching-learning environment that is needed to support the use of effective formative assessment in mathematics classrooms.

To address research questions 4 and 5 (cf. 1.3.7), an empirical research design will be used to investigate how formative assessment takes place in Senior Phase mathematics classrooms in the Motheo district, and also to consider the nature of a teaching-learning environment in Senior Phase mathematics classrooms. This empirical research design will be described in this chapter.

5.2 A MIXED METHODS RESEARCH DESIGN

Although empirical research can be done by using either the quantitative or the qualitative research methods, it is also possible to use both methods in the same research study (Johnson & Christensen 2004:48). Johnson and Christensen (2004:410) refer to this as “mixed method” research. Authors such as Mackenzie and Knipe (2006) as well as Creswell and Plano Clark (2007:9) refer to “mixed methods” research. Johnson and Christensen (2004:410) indicate that “mixed method research" and "mixed methods research" can be treated as synonyms. In this research report the term "mixed methods research" will be used.

5.2.1 Triangulation design

Ivankova, Cresswell and Plano Clark (2007:261) define mixed methods research as follows: "Mixed methods research is defined as a procedure for collecting analysing and "mixing" both quantitative and qualitative data at some stage of the research process…" Cresswell and Plano Clark (2007:59) identify four designs for a mixed methods approach to research. One of these, the triangulation design, and more specifically the convergence model, was chosen for this research project as it would potentially result in well-substantiated conclusions. The triangulation design allows for the strengths and weaknesses of qualitative and quantitative methods and accommodates them. One research method complements the other and, in so doing, provides stronger and more comprehensive evidence for the study of the research problem (Creswell & Plano Clark 2007:9,62, 64-67; Gorard & Taylor 2004:7, 43). The convergence model has the advantage that qualitative and quantitative data can be analysed separately using techniques associated with each of these data types. During interpretation, results are compared and validated (Creswell & Plano Clark 2007:66). The convergence model of the triangulation design can be represented graphically as follows:

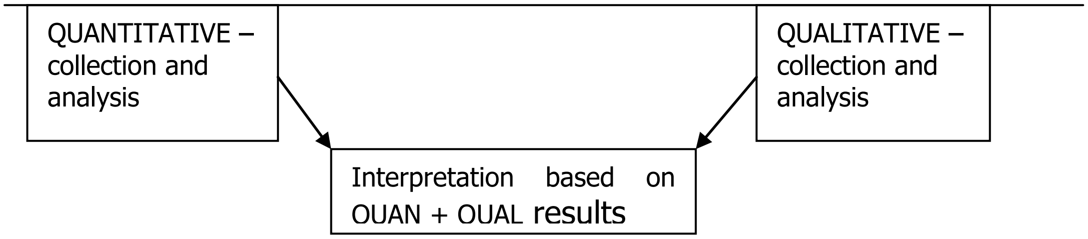


Figure 5.1: Triangulation Design: Convergence model (adapted from Creswell & Plano Clark 2007:63).

5.2.2 Philosophical assumptions

Before completing the description of the research design, it is necessary to understand the philosophical assumptions that provide the foundation for this research.

Creswell and Plano Clark (2007:20) claim that every researcher makes assumptions about reality (ontology), the acquisition of knowledge (epistemology) and the methods used to obtain this knowledge (methodology). This implies that every researcher works in accordance with a worldview or paradigm that influences how he or she approaches the study undertaken. Although these worldviews or philosophies have common elements, each takes a different stance on, amongst others, epistemology (Creswell & Plano Clark 2007:20).

Gray (2004:16), as well as Creswell and Plano Clark (2007:23), indicates that the epistemological stance of a researcher influences his or her theoretical perspective; and consequently influences the research methodology. Constructivism provides the framework wherein learners can construct their own knowledge and thus constructivism in the case of this research project typifies the epistemology. Interpretivism is the theoretical perspective associated with a constructivist epistemology (Creswell & Plano Clark 2007:25). Mackenzie and Knipe (2006) explain that the theoretical perspective can also be referred to as the paradigm for the research. This research will be conducted within an interpretivist paradigm.

A study conducted within the mentioned paradigm lends itself to various numbers of interpretations (King 2005:13). However, Lourens (2004:5) maintains that the best research is always an approximate version of the truth. According to this view, the interpretations of the qualitative data in this research study are limited because one researcher conducted the research only. For this reason, the researcher complemented the qualitative study with a quantitative study. Quantitative data were not used merely to support the qualitative data but also to expand on it and explain it as suggested by Mackenzie and Knipe (2006). As both qualitative and quantitative research methods were used, both post-positivist as well as positivist paradigms are relevant to this research.

5.2.3 The qualitative study

The qualitative part of the study will be described first followed by the quantitative part in 5.2.4.

5.2.3.1 Using multiple case studies

In the qualitative study, the researcher used the method of multiple case studies. According to Ary, Jacobs and Sorenson (2010:454), "a case-study focuses on a single unit to produce an in-depth description that is rich and holistic". In this case of this research, the "unit" is actually a process, namely the process of formative assessment. Formative assessment was investigated in depth, focusing on teachers of mathematics in various schools. The researcher attempted not merely to record teachers' and learners' behaviour but also tried to describe, analyse and interpret events that took place. The case studies conducted can therefore be described as descriptive or intrinsic case studies (Fouché and Schurink 2011:321).

One of the advantages of using case studies is that the researcher investigates all aspects of a case, in the totality of the environment (Ary, Jacobs & Sorenson 2010:455). Furthermore, in multiple case studies, the researcher does not concentrate on just a single case, but rather studies multiple units so that maximum illumination of the process studied can occur. In total the researcher chose eight teachers in eight different schools for this study.

According to Fouché and Schurink (2011:321), the case-study researcher only enters the field where the research is to be done after a thorough literature study of the phenomenon under investigation. In chapters 2 – 4 of this research project, the literature study done was reported. This was completed before the researcher entered the research field.

5.2.3.2 Data collection strategies

Three data collection strategies, namely interviews, observation and document analyses were used. Each procedure has its own strengths and weaknesses; but by using all these data collection procedures, the strength of one procedure compensates for the weakness of another (Strydom & Delport 2005a:314).

The data collection strategies were employed in a specific order: firstly, classroom observations were done in all selected schools. The next step was to do document analysis; and finally the interviews were conducted. Because they were done in this order, the results collected from one collection strategy informed the results collected by the strategies that followed. Biographical details of teachers were collected with the help of a short questionnaire (cf. Appendix D). This included the following: gender, home language, language of learning and teaching, teaching experience, experience teaching mathematics in GET, highest qualification, highest qualification in mathematics, NCS training in GET, self enrichment towards mathematics teaching and learning, as well as formal study in an education-related direction.

5.2.3.2.1 Observation

Observation can be described as "the systematic process of recording the behavioural patterns of participants, objects and occurrences without necessarily questioning or communicating with them" (Niewenhuis 2007b:83).

Observation allows the researcher to collect data from spontaneous, unplanned and unintended events (Thomas 2003:62). What is more, observation stimulates the use of both the senses and intuition to collect fragments of data. Observation assists the researcher to gain a better understanding and deeper insight into the (human) phenomenon under scrutiny. Nevertheless, this technique is not without risk: the very nature of observation is to be selective and subjective. For this reason, researchers should be aware of their own biases and how to deal with them (Niewenhuis 2007b:84). As a data-collection technique, observation has the advantage of allowing the researcher to observe the objects of their research in their daily natural surroundings (Van der Burgh 1988:67). It was essential for this research study to observe how formative assessment takes place in mathematics classroom situations through the actions of the teachers.

It is important that the researcher should become part of the situation without changing the situation (Strydom 2005:275). Inevitably it is impossible to this achieve in full. Suter (2006:169) refers to what is known as the "Hawthorne effect" to explain that participants' behaviour changes because they are aware that they are involved in a research study. According to this effect, the mere presence of the observer changes the situation. For example, in this research project it could have happened that teachers prepared mathematics lessons that they thought the researcher wanted to observe; or tried to impress the researcher by teaching in a way that they did not use under normal circumstances. Another possibility is that the learners could have been coached before the researcher entered the classroom.

Different writers refer to observation in different ways. They do, however, all refer to a situation where the researcher makes qualitative analyses of a social setting by being in or around that setting. Four types of observation are identified: complete observer, observer as participant, participant as observer and complete participant (Niewenhuis 2007b:85). Strydom (2005:274,275), as well as Henning, Van Rensburg and Smit (2004:85), refers to a continuum with complete involvement on the one end, and complete observer on the other.

In the case of this research, the researcher used the "observer as participant" type of observation. This implied that although the researcher was involved in the situation, she focused mainly on her role as observer. Niewenhuis (2007b:85) indicates that the researcher should establish patterns of behaviour through observation in order to understand the values and beliefs of participants, but should remain uninvolved and not attempt to influence the dynamics of the setting. This is why the researcher observed the teachers for a minimum of twelve periods on different days, except for the two farm schools where it would be best to describe the observation period in hours. In these two schools observations were done for an average of seven hours.

Observations can be recorded in a number of ways such as anecdotal records, running records and structured observation (Niewenhuis 2007b:85). However, it is important that the observer should only record as much information as can be attended to in an effective manner (Borg 1987:11). In the case of this research, an observation schedule (see Appendix A) was designed for classroom observation. It was informed by the literature study.

Two dimensions of observation were captured (Niewenhuis 2007b:85):

- First of all, the researcher described what was observed and what actually took place. No value judgments were included here – the researcher merely completed the observation schedule.

- Secondly, the researcher reflected on what had happened during the observation. This is where the researcher interpreted what had been observed, and formulated her thoughts or ideas on what had transpired. It was done soon after the observation to retrieve maximum information from memory.

The following characteristics of participant observation as mentioned by Strydom (2005:276) are applicable to this research:

- The researcher focused on the everyday experiences of teachers inside their mathematics classrooms. For this reason the researcher observed teachers in their own classrooms during a normal school day.

- As the researcher visits teachers in all kinds of schools in her daily work, she is aware of customs, lifestyles and cultural contexts of teacher and is sensitive to special circumstances in different schools.

- Because the researcher managed to observe teachers in normal circumstances, the results can be considered to be accurate. In addition, the researcher already had a good relationship with the participants prior to the start of the research project and this enhanced the quality of data collected through observation.

The classroom observations gave the researcher a new insight into assessing mathematics in line with outcomes-based assessment and specifically formative assessment.

5.2.3.2.2 Document study and analyses

Niewenhuis (2007b:82) indicates that all types of written communication that shed light on the phenomenon under investigation can be used in the data gathering process. Unpublished sources gathered directly from participants or organisations by the researcher are described as primary sources.

During this research, the documents generated by both teachers and learners were analysed. This can all be considered as primary sources. Teachers' planning, recording sheets and all evidence of formative assessment were scrutinised in their files. In the case of learners, the researcher requested to view files and/or workbooks in order to determine whether formative assessment done by teachers was evident in written work of learners. In the cases of both teachers and learners, these were official documents that were required from teachers by the Department of Education.

These documents were analysed to determine in the first place whether formative assessment had been planned. Brooks (2002:24) indicates that studying the teacher's lesson plans will reveal his or her level of commitment to formative assessment. Secondly the researcher wanted to establish whether teachers kept any records (either in the form of marks or notes) about what the learners had gained through formative assessment. In the third instance, learners should have had evidence of both formative and summative assessment tasks done. Evidence of whether teachers used a variety of formative assessment strategies, gave written feedback and the learners' involvement in self-assessment, should appear in the learners' collections of formative assessment tasks.

Mouton (1988:30) remarks that the availability of documents constitutes the most serious threat to validity when using personal documents for investigative purposes. Researchers should always ask themselves whether there is a significant reason for the presence or absence of material. If material is not available, the researcher should establish whether or not the material exists, or whether the material just not available for any reason. In the current research, the researcher requested in advance that the required documents should be available on the day of her visit. It may be mentioned that availability of documents was not a problem since the Department of Education requires that these documents should be available at all times. In cases where the documents were not found, teachers confirmed that the documents did not exist.

In the case of document analyses, it is essential that the authenticity or validity and reliability of the documents studied be verified (Strydom & Delport 2005a:317). As the researcher had visited all the teachers involved in the study in the past on several occasions as part of her duties as learning facilitator, she could refer to past experiences when considering the authenticity of documents. Daily work experience assisted the researcher to judge the authenticity, validity and reliability of the learners' evidence. The researcher chose a sample of the documents randomly from among those of all the learners taught by the specific teacher. The researcher studied at least 30% of learners' documents. If the teacher taught both grade 8 and 9, the researcher divided the 30% proportionally between the two grades.

The researcher used a pre-designed instrument (see Appendix B) to observe the documents and also made notes about what was observed during the analysis of documents for clarity during the interviews.

5.2.3.2.3 Interviews

Niewenhuis (2007b:87) describes the interview as a data-collecting instrument in the form of a two-way conversation. As the interview allows for immediate feedback, the researcher gets an opportunity to follow up leads that arise during the interview. This allows the researcher to obtain more data and also gain greater clarity. Formative assessment can be described as using "old" or "traditional" concepts in a "new" way. It was thus essential that the researcher should interrogate the interviewee to find out the meaning that he or she would give to a specific concept.

In the current study, the researcher used semi-structured interviews. This implied not only that a predetermined set of questions were used but also that the researcher remained attentive to all answers in order to identify, explore and probe emerging lines of inquiry related to the phenomenon being studied (Niewenhuis 2007b:87).

The questions guided the interview schedule, but never dictated it (Greeff 2005:296). As advised by Creswell (2008:225), the questions asked were open-ended. The following questions were asked during the interviews:

- How do you do assessment in your mathematics classroom?
- How do you see the role of the learner in assessment?
- What role does feedback play when you are doing assessment in mathematics?

It is essential that the interviewees' responses should be accurately captured when interviews are documented (Henning, Van Rensburg & Smit 2004:67). All interviewees agreed to the recording of the interviews by means of the researcher's digital recorder. Interviews were downloaded directly onto the hard drive of the researcher's computer to be kept safely. A backup of the recording was also made for safekeeping. All interviews were transcribed and the researcher can make transcriptions (as well as recordings) available on request.

5.2.3.3 Responsibility of the researcher in qualitative research

When doing qualitative research, the researcher's ability to make sense and interpret what is observed is critical to the understanding of the social phenomenon being studied (Leedy & Ormrod 2001:147). The researcher should enter into a partnership with respondents in order to collect data, with the principal aim of creating understanding. In this study the researcher knew the teachers, all of whom participated with the knowledge that the researcher was there to understand how formative assessment was being done in their mathematics classrooms. During all the observations the researcher simply observed the teachers.

Richards (2005:23) cautions the qualitative researcher that the researcher will learn things from the data collected during the research and that this will require the researcher to adapt his or her enquiry. In the case at hand, as the researcher moved among the different schools, she became aware of aspects pertaining to certain mathematics classes that were not observed in mathematics classes at other schools. The researcher could then explore these findings at the other schools to see whether they existed or not.

The researcher should always respect the site where research is taking place (Creswell 2008:12). This means that the researcher should have permission to do the research (cf. 5.2.3.7), and that he or she should limit any disturbances as far as possible.

5.2.3.4 The population for this study

This study involved teachers at all the schools in the Motheo district that offered grade 8 and 9 Mathematics in the Senior Phase. Traditionally grades 8 and 9 attend school at high schools, and grade 7 at primary schools. This means that the whole Senior Phase is not found at one school (except for intermediate and combined schools).

The researcher chose this population because her occupation as learning facilitator (subject advisor) for mathematics involves servicing high schools in the Senior Phase in this district which means that she interacts with grade 8 and 9 mathematics teachers daily. The researcher had also assisted with the training of grade 8 and 9 teachers for the implementation of NCS and specifically for outcomes-based assessment.

5.2.3.5 Selection of the sample

In the general, the process of selecting subjects for study is known as sampling. In a qualitative study, sampling is usually based on non-probability and purposive sampling, rather than on probability or random sampling (Niewenhuis 2007b:79, Strydom & Delport 2005b:328). When the selection of participants is based on some defining characteristics, the sample selection is purposive. There are no specific rules for the size of the sample when it comes to qualitative inquiry, but the sample size will depend on what the researcher wants to know and also on the purpose of the research inquiry (Strydom & Delport 2005b:328).

In order to ensure that the results of this study would be applicable to the South African setting, the researcher decided to consider the school situation in South Africa with care. Because schools in South Africa were racially segregated until 1994, the shadow of apartheid still falls on the resources, the demographics of the each school and the language of learning and teaching (LoLT). The researcher defined the following categories of schools based on her own experience while working in them. Consequently these categories are the researcher's personal grouping and do not indicate any classification of the Department of Education:

Category A: These schools are situated in cities (in the case of the Motheo district, the city is Bloemfontein). They are usually well resourced and were known in the previous political dispensation as "Model C" schools. Learners of all races attend these schools, especially if the language of learning and teaching (LoLT) of the school is English. If the LoLT is Afrikaans, more white children than black and coloured learners attend these schools. Most of the mathematics teachers at these schools are white (especially in the Afrikaans-medium schools), but teachers of other races are also involved. The symbols AA and AE will be used to refer to category A schools.

Category B: These schools are situated in the townships surrounding the cities: in the case of the Motheo district, these schools are the Mangaung and Heidedal townships of the city of Bloemfontein. Some sources refer to these schools as "previously disadvantaged schools" - but the researcher knows from her experience that the majority of these schools are still not well resourced and that learners attending them are still from disadvantaged communities. Learners in these schools usually come from the surrounding townships and consequently most are black learners, but coloured learners also attend these schools. In this case the LoLT is usually either English or Afrikaans. As a rule there are no white learners enrolled at these schools. In areas that were traditionally black, the

LoLT of the schools is English. The majority of the mathematics teachers in these schools are black, but there are white, coloured and Indian teachers at these schools as well.

Category C: These schools are found in small towns. In the case of the Motheo district, these towns are Thaba Nchu, Botshabelo, Tweespruit, Excelsior, Ladybrand, Dewetsdorp, Wepener and Van Stadensrus. Some of these schools are well equipped with resources, while others are not. In general these schools are not as well endowed as the schools in category A. Learners of all races attend these schools - but the majority are black. Teachers of all races teach mathematics at these schools. The LoLT at these schools is usually English but some schools are double medium, offering both Afrikaans and English as LoLT. Because of the declining number of white learners attending these schools, there are no longer any Afrikaans-only schools in the small towns in the Motheo district.

Category D: These schools are on remote areas or farms and are known as public schools on private property, or as farm schools. Each school is far away from any neighbouring school. Most of the learners (if not all, in the Motheo district) at these schools are black and the majority of mathematics teachers are also black. The LoLT in all these schools is English.

The schools chosen for the research were functional, accessible and some were a reasonable distance away from Bloemfontein (where the researcher lives). For category A, the two schools selected were both in Bloemfontein. One school was selected where the LoLT is Afrikaans and one where the LoLT is English. For logistical reasons, the researcher chose two schools that were not too far from each other to minimise travelling time so that observations could be made in both schools on the same day.

For category B, two schools in the Mangaung township were selected: as before, one school had Afrikaans as the LoLT and the other had English as the LoLT. The same was done for category C, with the selection of one school with the LoLT being Afrikaans and the other with the LoLT being English - except that in this case, the school where Afrikaans was the LoLT was a double-medium school. This means that Afrikaans- and English-speaking learners were taught mathematics together in the same classes. The researcher decided to include the class containing both Afrikaans- and English-speaking learners in the study. For category D, both schools selected used English as the LoLT. As explained earlier, there are no schools in Motheo in category D that have Afrikaans as the LoLT. The researcher still decided to choose two schools from category D - but chose one school relatively close to Bloemfontein, and the other school in a totally remote area.

The symbols AA, AE, BA, BE, CA and CE are used to refer to schools, teachers and learners participating at the relevant schools. The first letter refers to the category and the second letter to the LoLT (A for Afrikaans and E for English). For the two farm schools, D1 and D2 will be used since in both cases the LoLT is English. D1 is the farm school close to Bloemfontein while D2 is the farm school further away from the city.

In every selected school one teacher volunteered to participate in the study: this means that eight teachers in total participated in the study.

5.2.3.6 Quality of qualitative research

Different authors have different opinions about how the quality of qualitative research can be ensured (Maxwell 2002:38). Maree and Van der Westhuizen (2007:38) as well as De Vos (2005:346) agree that issues of credibility, transferability, dependability and conformability will be detrimental to the quality of qualitative research.

5.2.3.6.1 Credibility

By placing adequate parameters or boundaries around the study, its credibility will be assured (De Vos 2005:346). In this study, the researcher clearly demarcated the research population. The researcher then identified the categories of schools and chose a sample of two schools from each of these categories so that it would be representative of the population.

5.2.3.6.2 Transferability

By being able to transfer the study to another context, the transferability of the study can be established (De Vos 2005:346). In this case, the researcher delineated schools into categories that represented the differences between schools to be found in the Motheo district. These categories are also representative of schools found in the whole of South Africa. This being so, this research could be repeated in any other district using the same sampling categories to make the results transferable. All the instruments used in this study are attached to this research report as appendices and could be used to duplicate the study.

Triangulation - also known as crystallization of multiple data sources - can enhance transferability of the study (De Vos 2005:346; Maree & van der Westhuizen 2007:40).

5.2.3.6.3 Dependability

The researcher should attempt to account for any changing conditions in the chosen field of study as well as changes in the research design that may happen because of an increasingly refined understanding of the problems and the context (De Vos 2005:346). As the researcher gained a greater understanding of the research problem, she started to focus on issues as they arose. The order in which the research instruments were used, also contributed to this. Aspects detected during classroom observation were clarified when analysing the documents; and both the classroom observation and the insights gained from analysing the documents informed the interviews. Accordingly, besides the fact that the findings in all schools enlightened the researcher so that she could project her new insights onto another school, the findings from one research instrument assisted the researcher to adapt as the research process evolved.

Dependability can also be established if the researcher keeps an audit trail of materials (such as raw data) documenting the study (Ary, Jacobs & Razavieh 1990:449). Interviews were recorded digitally and they were kept safely on electronic storage devices. During classroom observations, the observation instrument was completed and kept for the record. The researcher made a detailed summary of what was observed during the class visits every day so that aspects, which were not captured on the observation tool, could be recorded in case they proved to be of use later. Finally, the instruments for analysing the documents were completed. All of these have been kept for quality control purposes.

5.2.3.6.4 Confirmability

The question that arises is whether any other researcher doing such a study can confirm the findings of the study (De Vos 2005:346). The researcher ensured that all steps followed in the research are well-documented in the research report. This will enable any researcher to follow the research done to confirm the findings of the study.

5.2.3.7 Obtaining permission for study

Before the actual process of collecting data could begin, the researcher had to obtain permission from the Free State Department of Education to undertake the research project. Application forms were obtained from the website of the Free State Department of Education (**www.fsdoe.gov.za**). A lengthy application form was completed and all questions to be used in interviews as well as the instruments for observation and document analysis were submitted for approval. The questionnaire used for the quantitative study (cf. Appendix C) was also included, together with a letter that would be used to obtain permission from principals to conduct research in their schools. The letter of permission from the Free State Department of Education is attached as Appendix E to this research report.

After permission for the study had been obtained from the Free State Department of Education, the researcher approached the principals and mathematics teachers at the identified schools. The rationale for the study was explained and the letter of approval from the Free State Department of Education was submitted. All the principals of the chosen schools were very supportive and in favour of the study.

5.2.3.8 Ethical issues

The researcher has a responsibility to adhere to ethical standards (Mouton 2001:28). In any research study "informed consent" will be the determining factor regarding the ethicality of the research study (Leedy & Ormrod 2001:158).

In the case of this research, the researcher informed the principals of the sample schools about all aspects of the research study. Teachers volunteered to participate in the research study after the researcher explained all details of what will be expected of them. The researcher also explained the purpose of the research and how the research will be conducted.

The biographical details of teachers were collected using a short questionnaire (see Appendix D). Furthermore, great care was taken to ensure that participants were not inconvenienced in any way, both during the interviews as well as during the classroom observations. Appointments were made beforehand to suit the participants' work schedules and school timetables.

To ensure confidentiality and anonymity of respondents and the schools involved, they were given designations such as AA, AE, and Teacher AA and Teacher AE. All personal and identifiable information as well as the data that were provided by the participants will be protected.

Learners answered the learners' questionnaire anonymously. It was clearly stated on the learners' questionnaire that learners should not write their names on the questionnaire. Learners were also given the assurance that the questionnaires were for the use of the researcher only.

The researcher strove to maintain objectivity and avoid bias in the analysis and interpretation of the data. Furthermore, the researcher endeavored to maintain honesty in all scientific communications.

5.2.3.9 The pilot study

In qualitative research a pilot study is a requirement; but it can be done informally (Strydom & Delport 2005b:331). The researcher chose to pilot the study at a school in Bloemfontein other than those that formed part of the sample. Two teachers were involved in the pilot study, one of whom was more versed in outcomes-based assessment than the other. The researcher chose both teachers to ensure that research methods would be valid for both cases. Both teachers had been involved in the teaching of mathematics to grades 8 and 9 since the implementation of the NCS.

Soon after permission had been obtained for the study at the Motheo schools, the researcher approached the principal of the pilot school for permission to do the pilot study. Permission was granted and the researcher started with observations in teachers' classrooms.

The researcher struggled at first to do the classroom observation. Completing the observation schedule and writing notes distracted the researcher from what was happening in the classroom. One of the teachers used for the pilot study talked and worked at a very fast pace, making the observation even more difficult. The researcher amended the observation schedule after the first observations and returned to observe the teachers again. It remained difficult to complete the observation schedule and write notes, but as the researcher became more skilled, the situation improved. The researcher also noticed that the teacher who spoke and worked very fast, slowed down. The researcher assumed that the teacher was getting used to the observation and had become more relaxed. The researcher had to amend the observation schedule as new situations arose that had to be captured. The process of observation and amending the observation schedule was repeated observing the two teachers until the researcher was satisfied that there were no more new emerging situations that had to be accommodated.

The document analyses did not pose any problem as the researcher was used to scrutinising documents. The schedule used for document analysis proved to be sufficient.

The pilot interview was conducted in the afternoon after school. This took place after classroom observations and document analyses were completed. As with the observations, the pilot interview posed challenges to the researcher. The researcher found it difficult to write notes, ask questions and listen attentively to what the interviewee was saying. The researcher also had to run a few test runs to use the digital recorder, making sure that both the researcher and the interviewee were audible on the recording. The researcher decided to not take any notes during the interview and to have a list of probing questions at hand during the interview. The second interview went much better and the researcher became more confident asking the searching questions. Opie (2004:115) advises researchers to use the pilot study also to obtain an indication of the length of the interview and the time taken for the analyses of the documents. This was very helpful for the planning of future visits to teachers.

5.2.3.10 Analysis of qualitative data

For a qualitative research study, common statistical research procedures to assist with the display and analysis of data cannot be used (Mauch & Park 2003:18). A researcher strives to understand the phenomenon studied in qualitative research (Mauch & Park 2003:18). In qualitative research the processes of collecting, processing, analysing and finally reporting the data are intertwined. This does not suggest that these steps take place successively but that the researcher moves forward and backward freely between the processes (Niewenhuis 2007b:100). This may mean that the researcher has to go back to participants to collect additional information or request feedback or clarity from participants in order to enrich certain information.

De Vos (2005:335) describes the data analysis process as a twofold approach. While the researcher is collecting data at the research site, analysis is already taking place. This is the first aspect of data analysis. The second takes place after the researcher has left the site where data were collected.

During the research process, the researcher made notes continually. In some cases this was done as the data were collected - in other cases the researcher reflected afterwards on what had happened during the collection of data and made notes. In the process, judgments had to be made of what information would be used, and what not. Walliman (2001:50) indicates that these judgments depend on the researcher's existing knowledge about the subject as well as on the nature of the research problem. The literature study empowered the researcher with knowledge about the subject. When analysing qualitative data, the central task was to search for common themes (Leedy & Ormrod 2001:153) in the teachers' descriptions of their experiences related to formative assessment.

The researcher drew up three data matrices after the data had been coded and, one for each of the data collection strategies. The matrices were analysed to look for patterns involving similarities or points of contrast (Nadin & Cassel 2005:273).

The first matrix was used to identify general trends in classroom observations as well as points of contrast. The matrix was compared with the interviews to establish what teachers had to say about aspects observed by the researcher (triangulation). The second matrix was used to identify general trends as well as for points of contrast during document analyses. Once again, this matrix was compared with the interviews (triangulation). Finally, a matrix was drawn up for the interviews. All aspects arising from the interviews that had not been previously captured in one of the other two matrices were captured here.

5.2.4 The quantitative study

In line with the mixed methods approach followed in this study, the researcher conducted a quantitative study in addition to the qualitative study described above. Only learners were involved in the quantitative study. The reason for this was, as stated rightfully by Muijs and Reynolds (2001:59), that teachers often have a perception of doing something positively only to find out that learners have not experienced it in the same way. The researcher wanted to find out how learners experienced both formative assessment and the teaching-learning environment. Since the researcher wanted to involve as many learners taught by a teacher as possible, a questionnaire was used to collect information.

5.2.4.1 Sample

The sample schools chosen for the qualitative study was the same sample that was used in the quantitative study. In the case of the qualitative study the sample included all the grade 8 and 9 learners taught by the teacher involved in the qualitative study. A questionnaire (Appendix C) was set (cf. 5.2.4.2) to gather information. Teachers administered the questionnaire on suitable days. The percentage of learners that completed the questionnaires was 89,6% (cf. table 6.4). Absenteeism was the reason for non-completion of the questionnaires.

5.2.4.2 Construction of the questionnaire

The researcher based the questionnaire for this study on one by Stiggens and Popham (2008), published in one of their articles. In it the authors discussed how to establish learners' affect pertaining to formative assessment. They constructed a questionnaire with eight statements. For every positive statement there was a negative statement. The idea was that truthful learners would answer one question positively and another negatively. Stiggens and Popham (2008) report that this method of positive-and-negative phrasing results in an accurate indication of the learners' true sentiments. The researcher took the ideas for questions from this article which clearly states that these "inventories" are part of the public-domain and that questions can be added or subtracted to suit the needs of the researcher.

In line with this go-ahead and in order to tailor the questionnaire for this research, the researcher added several statements to the questionnaire referred to above: in each case one was positively stated and one negatively stated. Statements regarding formative assessment and teaching-learning environment were included. These statements explored more than just learners' affect towards mathematics. The formulation of the statements was based on the findings of the literature study in chapters 3 and 4 and strove to explore learners' view of formative assessment and teaching-learning environment. The questionnaire started with instructions to the learners and consisted of two sections:

- Section A: obtained the general and biographic information of learners. The following were included: gender, current grade, home language, LoLT and performance in mathematics for the term ending before the questionnaire was answered.

- Section B: concerned formative assessment (part 1) and teaching-learning environment (part 2).

The researcher decided to use the term “classroom environment” in the questionnaire rather than “teaching-learning environment” because both teachers and learners would be more familiar with the term “classroom environment” than “teaching-learning environment”. Therefore, the researcher will use these two terms interchangeably.

In part 1 of section B, the learners had to consider 32 statements pertaining to formative assessment: 16 positive statements and 16 negative statements. The positive statements were based on the study of formative assessment described in the literature and discussed in chapter 3. The negative statements were formulated so that the meaning was the opposite of that of the positive statements and in line with the traditional approach to assessment. The researcher used the characteristics of learning as discussed in the literature in chapter 2 (cf. 2.2.5) as a frame of reference. In part 2 of section B the learners were asked to consider statements pertaining to the teaching-learning environment. Again, the researcher set 32 statements of which 16 were positively stated and 16 negatively stated.

Table 5.1: Formative assessment: Part 1 of Section B

Definition of learning	**Implication for assessment**	**Positive statement**	**No.**	**Negative statement**	**No.**
Learning is constructive (6 statements)	Teacher should check frequently that learners are constructing the correct concepts.	The mathematics teacher checks several times during a lesson to see if I understand the mathematics that we are doing.	1	The teacher does not check during the lesson whether I understand the mathematics that we are doing.	19
	Learners should be given an opportunity to make meaning themselves.	I prefer to do a sum myself before the teacher explains it.	17	I prefer the teacher to do many examples so that I know exactly how to do the sums.	22
	Teachers monitor learners' constructions through formative assessment	While I am struggling with a sum on my own, the teacher assists me several times during the period.	8	When I am struggling with a sum alone, the teacher does not usually offer me any assistance.	27
Learning is cumulative (2 statements)	Baseline assessment-determine learners' prior-knowledge	The mathematics teacher always tries to find out what I know about a topic before he/she starts explaining new work.	3	The mathematics teacher often talks about things in the mathematics class that I do not have any idea about.	15

Learning is self-regulated (8 statements)	Learners should keep track of their own learning and progress	The classwork and homework that we do in mathematics help me to know if I can do the mathematics.	4	The classwork and homework that we do in mathematics do not help me to know whether I can do the mathematics.	18
	Learners should be committed to self-assessment	I like to assess myself in mathematics so that I know exactly what I do right and what I do wrong.	23	I do not like to assess myself in the mathematics class.	5
	Learners who can apply metacognitive skills effectively usually have a good idea whether their answers are correct or not.	I know when my answers are correct in mathematics even if the teacher has not yet given the answer.	6	I am not always sure whether I am doing the mathematics right or wrong.	20
	Learners should be committed to doing mathematics, even if it is not counting marks.	I do my mathematics homework regularly.	30	I don’t do my mathematics homework regularly.	7

Learning is goal-orientated (2 statements)	Learners should set goals for themselves.	I do set goals for myself in mathematics.	25	I do not set goals for myself in mathematics.	14
Learning is situated (2 statements)	Learners should know the need to solve real-life problems.	I think it is necessary to solve real-life problems in mathematics.	10	I do not think it is necessary to solve real-life problems in mathematics.	26
Learning is collaborative (6 statements)	All learners should contribute when assessment tasks are done collaboratively	When we are doing mathematics in groups, everybody in the group works together to find the answers.	11	When we are assessed in groups in the mathematics class, some learners do all the work, while others relax.	32
	Learners should benefit from assessment in groups.	I find that I can learn mathematics from discussions in groups with my peers.	9	I cannot learn mathematics from other learners.	21
	The teacher must monitor group work	While we are doing group work, the teacher often assists us by asking leading questions.	16	When we are doing group work, we usually work alone; the teacher does not assist us.	28
Learning is individually different (6 statements)	Teacher should give feedback to individuals about their performance	The teacher usually gives enough information so that I know exactly what I do wrong in mathematics.	13	I often do not have a clear idea about what I am supposed to be learning in the mathematics class.	29

	Teachers should show individuals exactly what to do to improve.	The teacher shows exactly what I should do to improve in mathematics.	24	The teacher does not inform me what I do wrong in mathematics.	31
	The teacher should assist individual learners by giving them additional formative assessment tasks.	I feel like I am special in the mathematics class because the teacher always attends to my problems.	12	I don’t think the mathematics teacher knows what my problems in mathematics are.	2

Table 5.2 Teaching-learning environment: Part 2 of section B

Element of teaching-learning environment	**Contribution to assessment**	**Positive statement**	**No.**	**Negative statement**	**No.**
A relationship of trust (12 statements)	A caring disposition towards learners.	I feel at home in the mathematics class.	1	I do not feel at home in the mathematics class.	14
		I am really excited about learning new things in the mathematics class.	20	Usually I do not look forward to learning new things in the mathematics class.	2
		The teacher listens attentively to my answers in the mathematics class.	31	The teacher does not listen attentively to my answers in the mathematics classroom.	16
	No unrealistic expectations.	I look forward to being assessed in mathematics.	4	I do not look forward to be assessed in mathematics.	18
	Harmonious relationship: teacher and learner.	I like to answer the teacher's questions in the mathematics class.	9	I am too shy to answer the teacher's questions in the mathematics class.	21

	Harmonious relations: Learner and learner.	I have the courage to try to solve problems in the mathematics class.	6	I do not have the courage to solve problems in the mathematics class.	26
Teachers should ensure fit (8 statements)	Academic efficacy	When I have to learn new things in the mathematics class, I know I can learn them even if they are difficult.	29	Even with help and plenty of time, I am going to have difficulty learning new things in the mathematics class.	11
	Considering the level of the learner.	Many of my answers are correct in the mathematics class.	15	My answers are mostly wrong in the mathematics class.	30
	Authentic tasks	The teacher always gives us interesting real-life mathematics problems to do so that we can really use mathematics in our everyday lives.	25	The real-life mathematics problems that we do are boring most of the time.	5
	Considering time	The teacher allows enough time in the mathematics class for me to think when I have to answer questions.	27	The mathematics teacher does not allow enough time for me to think when I have to answer a question.	3

Strengthening the learners' voice (4 statements)	Learners must feel free to ask questions in the mathematics class.	I like to ask questions in the mathematics class.	8	I don't like to ask questions in the mathematics class.	28
	Learners must be free to use their own methods.	The teacher encourages us to use our own methods to solve problems in mathematics.	7	The teacher wants us to use his/her methods when we solve problems in mathematics.	24
Developing awareness (6 statements)	Reasons for doing formative assessment tasks must be clear.	I usually understand what is expected from me to learn in the mathematics class.	13	I often do not have a clear idea in the mathematics class about what I am supposed to be learning.	23
		The mathematics teacher always explains why it is important do mathematics classwork and homework.	10	I am not sure why we have to do homework and classwork in mathematics.	22

	Learners must be aware of own performances.	I believe that mathematics problems can be solved in several ways.	12	I believe that mathematics problems have one correct solution.	19
Involving learners (2 statements)	Learners should be involved in setting of formative assessment tasks.	The teacher involves us learners in the setting of mathematics assessment tasks.	17	The teacher never involves learners in the setting of mathematics assessment tasks.	32

Learners’ responses were marked on a scaled response as was suggested in the article of Stiggins and Popham (2008). This scaled response uses an agree-disagree continuum (Suter 2006:95). The researcher used a 5-point scale namely: strongly disagree (SD), disagree (D), uncertain (U), agree (A) and strongly agree (SA). This was explained to learners in the instructions on the questionnaire and an example was given. The researcher decided to include the uncertain response so that learners who were not sure what the statement meant were not forced to make a choice or make no choice at all. The questionnaire took about 30 minutes to complete.

5.2.4.3 Reliability and validity regarding the questionnaire

According to Sutter (2006:230), reliability refers “to the consistency of the outcome measure”; while validity refers to ”the accuracy of inferences that are made on the basis of the outcome measure”. This implies that a questionnaire is reliable to the extent that it measures consistently from one situation to a next situation, while validity refers to the extent to which an instrument collects appropriate data as well as how the appropriate results are interpreted.

5.2.4.3.1 Reliability

Sutter (2006:240) defines reliability as the “true score variance divided by obtained score variance”. The closer the true score variance and the obtained score variance is to each other, the more reliable the results. Cronbach formulated a formula to determine reliability that is known as Cronbach’s alpha coefficient (Sutter 2006:241).

McMillan and Schumacher (1993:230) consider the Cronbach alpha coefficient as the appropriate measure of reliability where respondents can choose from a range of possibilities for each item. The Cronbach alpha coefficient can be calculated as follows:

$$r_{\alpha} = \frac{k}{k-1}\left[1 - \frac{\sum \sigma^2}{\sigma^2}\right]$$

where r_{α} is coefficient alpha, k is the number of items, $\sum \sigma^2$ is the sum of the variances of each item and σ^2 is the variance of the total test scores. The alpha coefficient increases if the number of items increases. The values of the reliability coefficient range from .00 to .99. A high reliability coefficient (e.g. a value above .9) implies that there is little error when measuring with the questionnaire and thus that it is extremely reliable (McMillan & Schumacher 1993:231). The Cronbach alpha coefficient was used to determine the reliability coefficient of the total questionnaire as well as for part 1 and part 2 of Section B of the questionnaire for this research. The Cronbach alpha was also used to determine the reliability coefficient of the total questionnaire per school.

McMillan and Schumacher (1993:230) state that several factors should be considered when interpreting reliability coefficients. One of these is that the more heterogeneous the group of participants is, the higher the reliability will be. In the case of this research, the group of participants were heterogeneous. It included boys and girls, learners taught in their mother tongues and learners taught in a language other than their mother tongue, learners who perform differently in mathematics and learners with and without access to various resources. Furthermore, it included learners from advantaged communities and learners from disadvantaged communities, black learners (including various ethnic groups), white learners, coloured learners, Indian learners, Taiwanese and Chinese learners.

To increase the reliability further, the researcher constructed the questionnaire in such a way that for every aspect appearing in the questionnaire a positive and negative statement were formulated. An example of this is a statement such as "I do my homework regularly" versus "I don't do my homework regularly". Such positive and negative statements were not placed together in the questionnaire but were randomly mixed in the questionnaire. The positive statement would also not necessarily appear first in the questionnaire and the negative statement later. In certain cases the negative statement appeared first and the positive statement later.

5.2.4.3.2 Validity

One way to increase validity is to allow respondents to complete the questionnaire anonymously. In this case the researcher included the following statement in the instructions in bold print so that learners could clearly see it: "You answer this questionnaire completely anonymously: do not write your name on this questionnaire." The researcher further stated in the instructions that the researcher would be the only person using the questionnaire and requested participants to be honest. This guarantee of anonymity should allow learners to complete the questionnaire without feeling threatened.

In order to increase the validity of the questionnaire further, statements had to be unambiguous and clear. First of all the researcher ensured that every statement only contained a single idea. After this, the researcher did a pilot study (see 5.2.4.4) to ensure that statements were in any way unambiguous and afterwards adapted the statements that posed a problem. Furthermore, the items in the questionnaire should all be relevant to the research topic studied (McMillan & Schumacher 1993:224). In the case of this research, statements were restricted to formative assessment and the teaching-learning environment described in the literature study done in chapters 2 - 4.

Finally, validity can be increased when discussing a matter with another knowledgeable person in the field of research. In the case of this research, the questionnaire as well as the whole research design was discussed with the promoter who is himself an expert in the field. The questionnaire was also discussed with a colleague who is often in situations similar to those of the researcher, and who works with teachers in a variety of schools daily. This colleague has more experience than the researcher and consequently made a valuable contribution. The discussions with this colleague encouraged the researcher continually to reflect on what was found in the research and brainstorm possible outcomes. Valuable insights were also gained in this way.

5.2.4.4 The pilot study

Suter (2006:412) describes pilot studies as "those small-scale tryouts designed to uncover problems in methodology and instrumentations". Suter continues to explain that pilot studies are done to discover problems before full-scale implementation of the research instruments. Although Stiggins and Popham's (2008) questionnaire (on which the questionnaire used in this research is based) was piloted, the researcher decided to pilot the questionnaires again as many additional statements had been added to the original questionnaire.

The researcher piloted the questionnaire for this research using six grade 8 and 9 learners who did not form part of the sample of this study. The home language of three (one grade 8 and two grade 9) of them was English and the mother tongue of the other three (two grade 8 and one grade 9) learners was a language other than English. These learners were requested to fill in the English version of the questionnaire. The three learners whose home language was English had no trouble completing the questionnaire. They found the statements clear. However, the three learners whose home language was not English found certain statements that they did not understand. After discussions with the learners, the researcher rewrote the statements and requested learners to answer the questionnaire again.

Three Afrikaans-speaking learners were requested to fill in the Afrikaans version of the questionnaire. Although the learners were satisfied after completing the questionnaire the first time, changes to the English questionnaire implied changes to the Afrikaans questionnaire. And so, the Afrikaans-speaking learners were requested to redo the questionnaire.

5.2.4.5 Administration of questionnaires

All the grade 8 and 9 learners who were in the classes of the participating teacher were requested to complete the questionnaires. Teachers administered the questionnaires at a suitable time, allowing learners to complete questionnaires during class time. Teachers did not see this as a problem since learners were about to start their final examinations and the curriculum had already been completed in all cases. In the end, 661 learners out of 738 learners completed the questionnaires designed for the learners implying an 89,6% return.

5.2.4.6 Analysis of results

Analysis of the quantitative results was done with the help of the Information and Communication Technology Services (ICT) unit of the University of the Free State. The researcher encoded all the questionnaires before they were captured on computer. The questionnaires were analysed by the ICT services using the Statistical Package for the Social Sciences version 17.0 (SPSS). The same package was used for calculations of the Cronbach alpha, t-test and Pearson correlation coefficient.

The researcher received a report from the ICT unit. The first part of the report comprised of the following frequency tables:

- A summary of gender, grade, home language, LoLT and achievement of learners in mathematics.

- A summary of the total number of learners in all schools responding to a statement. This was followed by a summary of learners' responses per school per statement. This enabled the researcher to search for cases where learners' responses in individual school differed from that of the total over all schools.
- A summary of learners' responses per statement according to achievement level (1 – 7). The researcher used this data to determine in what cases learners of different achievement levels differed in the answering of statements.

In the second part of the report, reliability coefficients (Cronbach alpha) were reported for the formative assessment part of the questionnaire (32 items) as well as for the teaching-learning environment section (32 items) of the questionnaire. The Cronbach alpha over all 64 items of the questionnaire for all schools, as well as for each school, was also reported. This was followed by results from the t-test. The t-test was used to determine if the mean of responses to statements of the group taught in home language and the group taught in a language different from their home language differed statistically (Johnson & Christensen 2004:486). The t-test was performed for each category of formative assessment (e.g. learning is constructive is one category including statements 1, 2, 8, 17, 19, 22) and each aspect (e.g. relationship of trust) of the teaching-learning environment. The same was done over all categories of formative assessment as a whole and aspects of the teaching-learning environment as a whole.

Finally, the Pearson Correlation coefficient calculated was reported. This was done to investigate the strength and direction of the relationship between each of the categories of formative assessment and each of the aspects of the teaching-learning environment (Johnson & Christensen 2004:41). The value of correlation coefficients varies from –1 to +1. Zero implies no correlation at all. A positive value is an indication of a positive correlation and a negative value an indication of a negative correlation. The closer the value of the correlation coefficient is to –1 or +1, the stronger the correlation. In the case of a value equal to –1 or +1, there is a perfect correlation (Johnson & Christensen 2004:42).

The researcher constructed Excel spreadsheets to capture the data after the feedback report had been received from ICT services. Percentages were calculated and results for "agree" and "strongly agree" as well as for "disagree" and "strongly disagree" were combined. The researcher investigated using two methods for the calculation of overall responses.

- The first method was where equal weight was placed on every school. This implied that percentages were calculated for each school according to data from the frequency tables. All percentages were then added and the total divided by eight to get an average percentage per response. In such cases the number of learners who had participated per school did not influence the data.

- The second method was where all the responses of all schools were calculated as a percentage of the total number of learners.

After the percentages had been calculated by using both methods, the results were compared. These results were found to be similar. The researcher then chose the second method as she argues this will give an indication of learners' opinions regardless of the school and notwithstanding the teacher.

Graphs were constructed using Excel to assist with the analysis and interpretation of quantitative data. The researcher reflected throughout on both methods mentioned in the bulleted items above, searching for cases (per school) deviating from the general case (over all schools).

5.3 SUMMARY

In chapter 5, the research design to investigate the following two research questions (cf. 1.3.7) was discussed: "Does formative assessment take place in Senior Phase mathematics classrooms?" and "What is the nature of the teaching-learning environment in Senior Phase mathematics classrooms?" The researcher used a mixed-methods approach by performing both qualitative and quantitative research.

In the next chapter, the data obtained in both the qualitative and the quantitative studies will be presented, analysed and interpreted.

CHAPTER 6

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

6.1 INTRODUCTION

Chapter 5 described how the researcher had chosen a mixed methods research design to investigate the phenomenon of formative assessment in Senior Phase mathematics classrooms and considered whether the teaching-learning environment supported formative assessment. In the execution of the mixed methods research, results were generated both qualitatively and quantitatively. In this chapter, the qualitative results will be presented and analysed first and afterwards the quantitative results will be considered. When quantitative data are interpreted, they will be compared with relevant qualitative data for simultaneous interpretation. Before this is done, the biographical details of teachers who participated in this research will be discussed.

6.2 BIOGRAPHICAL DETAIL OF TEACHERS

The following abbreviations will be used throughout the presentation, analysis and interpretation of data to refer to schools, learners or teachers teaching: AA, AE, BA, BE, CE, CA, CE, D1 and D2 (cf. 5.2.3.5).

Teachers participating in the study completed a short questionnaire (cf. 5.2.3.2, 5.2.3.8) in which they provided their biographical details. The results are reflected in Table 6.1:

Table 6.1 Biographical details of participating teachers

	T AA	T AE	T BA	T BE	T CA	T CE	T D1	T D2
Gender	F	F	F	F	M	M	F	M
Home language	Afr	Afr	Afr	SS	Afr	SS	SS	SS
LoLT	Afr	Eng	Afr	Eng	Afr/Eng	Eng	Eng	Eng
Teaching experience (in years)	3	20+	2	6-10	1	20+	11-15	6-10
Experience teaching mathematics in GET (in years)	3	11-15	2	3	1	15-19	11-15	6-10
Highest qualification	B Ed Hon	HPED	B Ed Hon	HPED	MSc Math	B deg and dip	HPED	B Ed Hon
Highest level of mathematics	Math I	Math I	Math I	ACE maths	Masters	Math III	Math I	Math II
NCS training	FS DoE	FS DoE	FS DoE	FsDoE	None	FS DoE	FS DoE	FS DoE
Self-enrichment: teaching and learning of mathematics	Workshops Studying	Reading Workshops	Colleagues Policies	Workshops Studying	Other teachers	LF visits Workshops	LF visits Workshops	Reading Workshops
Last year of formal studying	2010	1979	2006	2010	2009	1976	1995	2008

The following abbreviations are used in the table: F – Female; M – Male; Afr – Afrikaans; Eng – English; SS – South Sotho; HPED – Higher Primary Education Diploma; B deg – Baccalaureus degree, dip – diploma in education B Ed Hon – honours degree in education, MSc Math – master's degree in mathematics; ACE – Advanced Certificate in Education; math – mathematics; ACE math – Advanced Certificate in Education Specialising in mathematics education; math 1 – first year level, math II – second year level; math III – third year level; FS DoE – FSDoE, LF – learning facilitator

Five female teachers and three male teachers participated in the study. Teachers AA and BA taught all their (grade 8 and 9) classes in their home language all the time (Afrikaans). All the other teachers taught all their classes or some of their classes in a language that was not their home language. The teachers' teaching experience varied from one year to more than twenty years. It can thus be said that some teachers had much more teaching experience than others. The amount of experience in teaching mathematics in GET differed also; but it must be noted that the current NCS GET curriculum was implemented in 2007 for grade 8 and 9 and is thus relatively new to all teachers teaching in GET.

All teachers had studied mathematics at a post-matric level and all teachers were appropriately qualified to teach mathematics in GET at the time of the research project. Teacher CA did not have any teacher's qualification but had a master's degree in mathematics. All teachers except CA had attended training presented by the FSDoE to implement the NCS in mathematics which included a session about assessment in OBE where formative assessment was introduced. Of interest to this study is thus that all teachers who participated in the study, except teacher CA, had been made aware of formative assessment in the past. In the case of teacher CA, it is unknown whether the teacher had heard the term before the research intervention took place.

Pertaining to self-enrichment in terms of the teaching, learning and assessment of mathematics, six teachers indicated that they learned more about the teaching, learning and assessment of mathematics by attending workshops arranged by learning facilitators. Two participants also mentioned they had been brought up to date by the support provided by the learning facilitator when he/she visits the schools. The two teachers, who indicated that they had not been updated by the learning facilitator about recent trends in mathematics teaching and learning, mentioned that they relied on other teachers for this type of information. Although reading and the use of policies were also mentioned, there is a clear indication that teachers rely on other people (such as learning facilitators) to be informed about recent trends in teaching, learning and assessment of mathematics. Only two participants indicated that they considered studying further for a formal qualification as another way to stay informed. Three of the eight participating teachers had not been involved in formal study in a direction of study related to education after 2000; while five had been involved in studies that focussed on education. At the time of the research study (done in 2010), only two teachers were enrolled for a formal study programme at a tertiary institution.

6.3 PRESENTATION OF QUALITATIVE DATA

As already explained in chapter 5, qualitative data was collected using classroom observations, document analysis and interviews - in this specific order. This was done in order to lay bare as much about the phenomenon of formative assessment and the teaching and learning environment prevailing in mathematics classrooms as possible. Data collected using one strategy confirmed or further elucidated data collected using another strategy. Triangulation thus took place within the qualitative research.

The qualitative results will be presented in the following paragraphs. Document analysis will be presented first for all schools, where after classroom observations and interviews will be presented per school.

6.3.1 Document analysis

The following table summarises the findings of the analysis of both the teachers' and the learners' documents:

Table 6.2: Analysis of teacher's documents

	AA	**AE**	**BA**	**BE**	**CA**	**CE**	**D1**	**D2**
Lesson plans	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Planning for formative assessment	Not evident	Plan exercises to be done	Not on lesson plan	Not evident	Not on lesson plan	Plan exercises to be done	Not on lesson plan	Not on lesson plan
Anticipated questions (for use during lesson)	None planned	None planned	None planned	None planned	None planned	None planned	None planned	None planned
Differentiation	No	No	No	No	No	No	No	No
Reflection	None	None	None	None	None	None	None	None
Formative assessment inform planning	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence
Strategies used for formative assessment	Classwork homework	Classwork, homework, informal tests	Classwork homework	Classwork, homework	Classwork homework	Classwork, homework	Classwork homework	Classwork, homework, informal tests
Type of questions	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed
Worked out answers to exercises given	None	None	None	None	None	None	None	None
Baseline assessment	None	None	None	None	None	None	None	None
Records of formative assessment	None	None	None	None	None	None	None	None
Involve learners in setting of tasks	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence

All teachers' files and the majority of learners' workbooks were available for document analysis. Although teachers made an effort to collect learners' documents, some were not available because of absenteeism and others had left their books at home.

All teachers had a formal lesson plan for the lessons that the researcher observed, except teacher AA and BE. Teacher AA only indicated in her textbook which examples were to be done by her and which were to be done by the learners (teacher AA told the researcher). Lesson plans in general were of a very poor quality. No detail about how the lesson would unfold in class was given. None of the teachers referred to the concept of formative assessment in their lesson plans. The researcher used her knowledge of formative assessment to interpret lesson plans. Teachers AE and CE indicated on their lesson plan what classwork and homework exercises learners were going to do. When asked about it, teachers BA, CA, D1 and D2 (also true for BE) explained that they knew what exercises they wanted learners to do but they had not indicated this in a lesson plan. None of the teachers worked out the answers of to the questions posed in the exercises.

All teachers participating in the study used the same lesson plan (and implicitly, classwork and homework exercises) for all classes of a specific grade taught (even if they did not have a written lesson plan). No evidence could be found of planning for differentiation. The same exercises and informal tests (where applicable) were given to all learners to do. None of the teachers had a list of anticipated questions to ask during lessons in their planning or anywhere else. There was no evidence of reflection on the lesson plans and no evidence that formative assessment (limited strategies were used) informed teachers' planning.

What is more, there was no evidence of written baseline assessment tasks or - if they were given verbally - no plan was available. No records of formative assessment (in this case classwork, homework and where applicable informal tests) could be found; and the only records were for formal summative assessment. Finally, there was no evidence that teachers wrote any anecdotal notes or made notes of any feedback that had been given to learners and no evidence that teachers involved learners in the setting of assessment tasks.

Table 6.3: Analysis of learners' documents

	AA	**AE**	**BA**	**BE**	**CA**	**CE**	**D1**	**D2**
Strategies (formative assessment tasks)	Classwork homework	Classwork, homework, informal tests	Classwork homework	Classwork, homework	Classwork homework	Classwork, homework	Classwork homework	Classwork, homework, informal tests
Questions	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed	Mostly closed
Teacher marking formative assessment	No evidence	Once a term teacher marks for correctness	Teacher only signs work book	Marks books once per term	No evidence	Teacher only signs work book	Marks books from time to time	Marks books once per term
Learners marking own exercises	Evidence exists	Evidence exists	Evidence exists	Evidence exists	Evidence exists	Evidence exists	Evidence exists	Evidence exists
Peer marking	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence
Task specific feedback	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence
Journal writing	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence
Writing thoughts	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence	No evidence
Reference made of where to find exercise	Evidence exists – depending on the learner	Evidence exists – depending on the learner	Evidence exists – depending on the learner	No evidence	Evidence exists – depending on the learner	No evidence	Evidence exists – depending on the learner	No evidence
Reflection	None	None	None	None	None	None	None	None

The strategies of written formative assessment used by all teachers were classwork and homework (cf. 3.9.5). There was evidence in learners' workbooks that teachers AE and D2 also used informal tests about once a term. Focusing on only the exercises given as classwork and/or homework during lessons observed, the researcher found that these exercises included mainly closed questions, with single answers. These exercises were also largely based on the examples that the teachers had done during the presentation of lessons. There was no evidence of any investigation done by learners and no argumentative responses or reasoning was requested of them. In all cases the teachers showed evidence of using real life examples, but projects where learners applied mathematical skills to solve problems in real life were not done as formative assessment tasks. Real life examples were typically applied to certain sections of the work that lends itself to it such as data collection, probability, financial mathematics and perimeter, area and volume calculations. It was concluded that the exercises done by learners in class and/or at home were routine problems or sums where they practiced mathematics done by the teachers. These exercises, that had been done by learners in class and/or at home, were thus in line with the assignments described in 3.9.5.

Except for teacher AE, BE and D2 who marked learners' workbooks once a term; and teacher D1 who marked them two to three times a term, teachers did not mark learners' workbooks. When marking by the teacher did take place, not all exercises had been marked - only the recently done exercises. Teachers BA and CE signed the books without checking whether the work had been done correctly or not. Teachers AA and CA did not mark the books and neither did they sign them

At all schools it was found that teachers expected learners to mark their own homework as either correct or incorrect and then copy the corrections of incorrect sums from the blackboard. However, it was also found during the document analysis that some exercises for some learners had not been marked. The same was true of corrections. At all schools there were always some learners without corrections for certain exercises in their workbooks. There was no evidence of peer marking or task-specific feedback. None of the teachers requested learners to write down their thoughts when doing mathematical problems and learners did not keep a mathematics journal or do any reflection (except for corrections done).

Although teachers AA, AE, BA, CA and D1 expected learners to refer specifically to where exercises done could be found, it was found that not all learners noted the page number or exercise number when doing classwork or homework as reference for later use. In the case of schools BE, CE and D2, learners never numbered their assignments nor indicated where the exercises could be found.

Although the researcher was interested in determining the volume of classwork/homework done by learners at the different schools, this posed a challenge because learners did not always write the date or the exercise number (page number) when doing classwork/homework. In this regard, it is worthwhile to mention that, just by looking at the number of written pages in the workbook the following was found: for learners in school AA, AE and CA, the frequency of doing homework/classwork exercises was the highest. Where resources were a problem, the frequency was lower, like in the cases of BA, BE, D1 and D2. In CE where the classroom situation was most challenging (cf. 6.3.2.6.1) the frequency of doing classwork/homework exercises was the lowest of all schools.

6.3.2 Classroom observations and interviews

As already described in 5.2.3.2.1, classroom observations took place over a period of ten weeks. Each teacher was observed for a minimum of 12 periods; or in the case of D1 and D2, an average of seven hours, teaching mathematics to grade 8 and/or 9 learners. Since teachers D1 and D2 were teaching in small schools, they extended mathematics periods at will without influencing the school's time-table. The researcher aligned the time-tables of different schools and would stay at a school for a minimum of three periods a day. Sometimes as many as four consecutive periods were observed. It was not possible to visit more than two schools per day for classroom observations.

During the classroom observations the researcher aimed to establish how teachers applied formative assessment during class teaching, as well as to identify aspects from the teaching-learning environment that could influence formative assessment. The researcher focussed on the efforts made by the teachers: to establish learners' prior-knowledge; to diagnose possible problems and to solve them; to involve learners in assessment; to deploy a variety of formative assessment strategies and to use different assessors when doing formative assessment mathematics and give feedback. When considering the learners, the researcher focused on learners' responsiveness and the level of engagement in actions associated with formative assessment during the lesson.

Interviews took place after school hours. An appointment was made with every teacher in order to conduct the interview when convenient to the teacher. Interviews were conducted after all classroom observations and document analyses had been completed. In the interviews the researcher could probe for explanation and clarification of events that had happened during the classroom observations or aspects observed in document analyses.

In the following paragraphs, the observations and interviews that took place will be reported. Because it would be impossible to describe all the lessons and all the events that were observed, the researcher will discuss events occurring that are representative of what happened in classrooms. The focus will be the events that are significant to formative assessment and a teaching-learning environment that supports formative assessment.

6.3.2.1 School AA

6.3.2.1.1 Classroom observations

School AA is situated in Bloemfontein. The LoLT of the school is Afrikaans. The mathematics classroom of teacher AA was well organised, with single tables standing in rows. Towards the front of the classroom the tables were closer together than at the back and it was more difficult to move between them. The classroom was beautifully decorated and the walls were painted in black and red. There were posters against the wall and on the notice boards. Some posters were related to mathematics, while others were about general knowledge. Some of the posters were humorous – in line with the teacher's youthful spirit. All learners had workbooks, textbooks, basic stationery and most had calculators with them. On average there were 30 learners in each of the grade 8 and 9 mathematics classes observed. Observations were done in three grade 9 and one grade 8 class.

All the learners of the observed classes were taught in their home language. Periods were 30 to 35 minutes long and from time to time classes had double periods. On some days, all periods were a little bit shorter to make an extra period used first thing in the morning for learners to write tests for a specific learning area. This was referred to as test week.

For all classroom observations done, the researcher was always already in the classroom when learners entered. During the first visit to each class, teacher AA explained briefly at the beginning of the period that the researcher was the lady she had told them (the learners) about and that they should act normally as if she (the researcher) was not in the classroom.

The spirit in the class was light and cheerful in all observed lessons. Both the teacher and the learners seemed comfortable with each other. The working pace of the teacher was very fast in all lessons. The teacher spoke very quickly, worked fast on the blackboard and during question-and-answer sessions, the teacher required answers from learners immediately.

During the first observed lesson, the teacher started off by reviewing the homework of the previous day, which was about exchange rates. The previous day the learners had been given an exercise from the textbook to complete. Learners had their textbooks open and followed the teacher. The teacher read the questions from the textbook and then put questions to learners while writing the answers on the blackboard. Some questions were put to the class as a whole while others were directed at specific individuals. When questions were posed to the class, learners put up their hands to indicate to the teacher that they wanted to answer the question. However, some learners gave answers without having been asked to do so. In every lesson it was remarked that the same group of learners always put up their hands to answer questions. Other learners seldom put up their hands and some never did so. Occasionally the teacher asked the unresponsive learners to answer questions. Some of these learners did not answer the question but just looked up at the teacher. If learners could not answer the questions, the teacher directed the question to another learner. It was noted that the teacher never returned to the first learner she had asked – neither to check whether the learner could answer the question after the answer had been given, nor to seek further answers. Also, the teacher did not probe learners for correct answers. In cases where teacher AA asked individual learners to answer questions, she would call out the name of the learner who had to answer immediately. The waiting time was less than one second.

In all cases where questions were asked, the teacher did not always indicate that the learner had given the correct answer. From time to time she remarked "Mooi!" or "Goed so!" (Good), but usually the learners had to make their own deductions about the correctness of their answers as the teacher moved on.

Questions asked by teacher AA were closed-questions such as: "Wat noem ons die geldeenheid van Amerika?" (What do we call the currency of America?). "Wat is die rand-doller wisselkoers?" (What is the rand-dollar exchange rate?). At one point, a learner had a different answer from that of the teacher and the teacher asked an open-ended question: "Waarom verskil ons antwoorde?" (Why do our answers differ?). When the learners hesitated for a moment before answering the question, the teacher answered it herself. At another point, one learner remarked "Ek verstaan nie, Juffrou" (I don't understand, Miss). The teacher explained by writing on the board to address the learner's problem. Afterwards the teacher asked, "Verstaan jy nou?" (Do you understand now?) The learner said, "Ja, Juffrou" (Yes, Miss). No follow-up was made by the teacher to see if this was true.

In the second part of the lesson, teacher AA changed the topic to circle diagrams (pie charts). The same lesson was also observed for other classes presented by teacher AA, with the difference being that these learners had not had any homework and the teacher started with circle diagrams directly. The teacher handed out a copied piece of paper to each learner. On it were several questions about circle diagrams. Teacher AA did not request the learners to answer the questions on the worksheet at first. She went to the board and presented a problem to the learners about their school's budget and the allocation of money on the budget. The learners had to do follow the teacher while doing this example. She did not use the real budget of the school but used imaginary percentages for categories of expenditure that she created. It appeared that she had made this up on the spot. Teacher AA started constructing the circle diagram based on the data she had given. For this she used a board ruler, board protractor and some coloured chalk. Each portion of the budget was represented by a different colour. At this stage the teacher did not request the learners to draw a circle diagram – they were just supposed to follow her explanation. Teacher AA requested the learners to use their calculators to work out the degrees for each sector of the circle. Some learners did the calculations while other learners remained inactive. Teacher AA did not ask specific learners to answer questions but, while she was explaining, put questions to the whole class. Some learners simply answered the questions while the teacher was standing with her back to the class, busy writing on the blackboard. All the time the teacher was explaining how to draw the circle diagram.

After the explanation, the teacher requested the learners to draw the circle diagram, based on the information given on the work sheet. Most learners started drawing the circle diagram. However, not all learners did so. The researcher watched one girl who cut the page of the work sheet smaller. Before doing this, the girl had marked out the borders with a pencil and a ruler. When she had finished, she applied glue to the paper and pasted it into her workbook. She took out a sharpener and sharpened her pencil. All of these actions were performed slowly so that by the time the teacher asked for feedback, she had still not started to do the exercise that learners were supposed to have completed. One boy at the back of the classroom fidgeted all the time, not attempting the exercise. Other learners close to the researcher worked very slowly on the problem, taking their time to get their drawing material, looking at the work sheet again and then slowly drawing a circle using a pair of compasses. Most learners attempted the task.

Although Teacher AA moved around, she did not offer any real assistance – instead she prompted learners to do the exercise. She stopped to give support to some learners who had asked a question or requested assistance. Support was given in the form of explanations to learners.

The teacher stopped at some point and then, without checking that all learners had finished the exercise they were doing, went to the board to start explaining the answer. This part of the lesson proceeded in the same way as the first part of the lesson described earlier on, where the teacher asked questions and learners answered questions.

When observing lessons that teacher AA presented to grade 9 learners, it was noted that the teacher started the lesson by saying, "Vandag gaan ons weer na faktorisering kyk" (Today we will look at factorization again). It appeared that factorisation was problematic so the teacher had decided to re-teach the topic. The lesson proceeded in a similar way to what has been previously described. The teacher started the lesson with examples, asking the learners questions and providing an explanation at the same time. When the teacher wanted to determine whether learners had understood, she simply asked the whole class: "Verstaan julle?" (Do you understand?)

Teacher AA had a very clear picture in her mind of how she wanted the learners to do factorisation. Although she indicated that they were going to do factorization again, she constantly referred to "steps" that she had taught learners in the past. She asked the learners to recite these steps when doing sums. The teacher made up a story to help the learners to remember the steps. She told the learners that in life, boys would always first have a girlfriend. The learners had to remember the G and the F in the word. These letters stood in Afrikaans for "gemene faktor" (common factor). The teacher then continued by saying that later in life boys would find a “vaste vrou” (permanent wife). In this case the two Vs represented “verskil van kwadrate” (difference between squares). It seemed that the learners liked these stories and that they were used to learning mathematics in this way. At a stage a learner said, “Ek verstaan nie” (I don’t understand). The teacher explained the work to the learner, referring to the steps. She also asked the learner during the explanation what the next step would be. The learner described the next step by referring to the teacher’s story.

Although the learners were never told to use the teacher’s method, there was also no attempt by the teacher to encourage learners to use their own methods. The teacher always referred to her method when questions were asked. For example learners were asked to factorise: $81p^2 - 9b^2$:

Learner: Juffrou ek het $(9p - 3b)(9p + 3b)$’ (Miss, I have ….)

Teacher: Nee, nee, jy het vergeet van die gemene faktor. Onthou jy moet altyd eers die gemene faktor uithaal. Wat het ons gesê van die girlfriend? (No, no, you forgot to take out the common factor. Remember you must always take out the common factors first. What did we say about the girl friend?)

Learner: Jammer Juffrou ek het vergeet (Sorry Miss, I forgot).

In fact, this learner was correct and could take out the common factor after factorising using the difference between squares. After doing examples, the teacher allowed learners to practice sums similar to the sum in the example. During this time, the teacher moved up and down the rows and helped the learners who put up their hands. Some learners asked questions without putting up their hands. In all cases where teacher AA was observed, she was still busy answering learners’ questions or explaining work to learners when the period ended. The teacher would continue talking although some learners had started closing their books and packing them in their suitcases, not paying real attention to what the teacher was saying. At this stage the homework for the next day was given. The teacher would write wrote the exercises to be done on the blackboard. Not all learners copied this into their workbooks.

The researcher did not observe any lesson in which this teacher used group work or co-operative learning. Learners completed exercises by themselves in all lessons and could speak to each other about mathematics if they wanted to. This was, however, rarely the case.

6.3.2.1.2 Interview with teacher AA

During the interview with teacher AA, the teacher started by saying that assessment was very important to her. She gave the reason as, "Kinders het nodig om te weet waarheen hul oppad is" (Children need to know where they are going). The teacher did not mention that assessment could also inform her about her teaching.

The teacher acknowledged that she was confused about the differences between formative and summative assessment and was not well acquainted with the terms. It is significant that this was so, despite the fact that she was still furthering her studies in education (cf. Table 6.1). The teacher also acknowledged that she could not assist all learners when they were doing classwork: "Tydens daai laaste 10 minute, terwyl hul die somme doen, sal ek deurloop en van die kinders help" (During the last 10 minutes, while they are busy doing the sums, I assist some of the learners). The teacher remarked that when she was assisting learners, she would only help them to a certain extent so that learners themselves could get an opportunity to grapple with the work. The teacher agreed that longer periods would be better and enable her to finish everything that she wanted to do.

When asked what she did when she saw that a learner did not understand the work while she was busy teaching, the teacher said that she would ask the learner easy questions rather than difficult ones so that she did not expose the learner's ignorance. (This did not correspond with what was observed. The teacher, who worked very fast, did not reformulate questions.) In answering the question about the learners' role in the classroom, the teacher indicated that she occasionally asked learners to write the answers to homework exercises on the board (the researcher never observed this during classroom practice). When the researcher probed further, the teacher explained that if she requested learners to write on the board she did not expect them to explain how they were working. Furthermore, she allowed all learners chosen to write on the board to do so simultaneously so that the learners who wrote an incorrect answer would not be exposed. According to the teacher, the learners liked writing on the board.

The teacher told the researcher that she loved to tell stories and also tried to work a humorous part into the story wherever she could. These stories served two purposes: to make mathematics enjoyable and to assist the learners to remember how to do the sums. The teacher indicated that when learners did not understand, she explained the sum using her story. In some cases she tried to explain another method of doing the sum or told a different story to the learner in order to explain the sum. (This was not noted during the period of observation).

The teacher's reply when asked about group work was that she did not like using group work much and preferred learners to work individually. The fact that group work could disrupt the class was her biggest objection to this method. However, she was happy for the learners to work in pairs. She was in favour of learners helping each other.

The teacher explained that it was not always up to her to decide when summative assessment should take place – she had to adhere to a specific time-table to write tests and examinations. Tests were written during test week. It was evident that the teacher coached learners for these tests. In the interview she explained that if learners were to write a test on Friday, they would write a class test on the Tuesday before the actual test. On Wednesday she would explain the work again and then on Thursday she would write sums on the board again so that the learners could practice them. It appeared that her assessment was test and examination driven.

The learners were given warnings if homework was not done. The teacher trusted that the learners would do their homework after these warnings had been given since the learners would feel bad about not doing homework. The teacher also preferred the learners to tell her that they had not done their homework at the beginning of the period, rather than sitting and hoping that the teacher would not realise that homework had not been done. There was no specific system in place to deal with learners who did not do their homework. The teacher had an arrangement with learners that if they were absent from school, they should catch up on work done in their absence themselves.

Prior-knowledge was determined through a question-and-answer series and the teacher indicated that she never did baseline assessment by giving the learners a test to write. In addition, the teacher indicated that learners did set targets for themselves. Learners had to determine the percentage that they wanted to achieve in mathematics and then write it down at the back of their books. However, she made no attempt to let learners review this mark and to adjust the mark once the target had been achieved.

When asked about how she did feedback, the teacher responded that she expected the learners to do corrections when she gave them feedback.

According to the teacher, it was impossible for her to attend to all learners' individual problems. When learners were working in class or when they wrote tests, the teacher got an idea of the general problems that the learners experienced. She then focussed on these general problems. She acknowledged that not all learners asked questions, especially in front of the whole class. She indicated that more learners would ask questions if she helped them individually.

6.3.2.2 School AE

6.3.2.2.1 Classroom observations

School AE is situated in Bloemfontein. Learners come from all over Bloemfontein as well as from the outlying townships to attend this school. In addition, the school provides boarding and thus accommodates learners from outside Bloemfontein. The LoLT of the school is English.

All learners had workbooks and basic stationery. Most learners had calculators. Apparatus was available when the teacher wanted learners to do practical work. All learners had textbooks and, when photocopies were used, there were enough to go around. There was an average of 30 learners in classes taught by teacher AE. The teacher taught 5 grade 9 classes. Periods were 45 minutes long. On some days, her classes had double periods.

At this school the researcher entered the classroom either before the learners came in or after they were already sitting down. The learners would greet the researcher in a friendly manner. The teacher usually met the researcher in the school foyer, but on one occasion she sent a learner to escort the researcher to the classroom. On the way to the classroom, the researcher had a short conversation with the learner who replied in a very friendly way in English and the learner did not have a problem to express himself well.

In teacher AE's mathematics classroom, double tables were arranged in rows with two learners sitting at each table. The classroom was beautifully decorated with colourful wall charts, newspaper clippings and photos against all walls. Windows also had colourful paintings on them. Although the atmosphere in the classroom was comfortable, the researcher noticed that learners were very well disciplined. Teacher AE managed to keep the classroom disciplined without making any apparent attempt to do so. The teacher spoke slowly and clearly. Every time she gave an instruction, she waited patiently for learners to follow the instruction.

Teacher AE made a definite attempt to involve the learners in the lesson. When she introduced new work, she allowed them to work with concrete apparatus if the topic lent itself to doing so. In one lesson the teacher wanted learners to investigate the relationship between the volume of a cone and the volume of a cylinder of the same height. Pairs of learners were given a cone and a cylinder of equal height and diameter. There were buckets full of water and learners had to establish the volume of the cone since the volume of the cylinder was known. The learners behaved well and followed the teacher's instructions carefully. All learners were involved in the activity. The teacher guided the proceedings, giving instructions all the way. She said for example: "How many times must you fill the cone and pour water in the cylinder to fill the cylinder?" and then "What is the formula for the volume of the cylinder?" followed by "Can you see now that the volume of the cone is a third of the volume of the cylinder?" For all learners the cylinder-cone models were of the same height and diameter. The cylinder-cone combinations did not come in different heights and diameters. The learners would thus not have been able to generalise results. However, this did not seem to bother the teacher as she was convinced she had shown the learners that three cones would fill the cylinder and so the volume of a cone is equal to one third of a cylinder (if they have the same height and the circular base has the same diameter).

In a follow-up lesson, the teacher wanted learners to determine the volume of an actual cone. She brought sugar cones to the classroom (bought from her own pocket) and gave every learner a cone. The learners had been told to bring a piece of string from home to the classroom. It appeared to the researcher that all learners had done so. The learners had to determine the diameter of the circular base as well as the height of the cone with their piece of string. After they had used the string to determine the diameter, they used a ruler to measure the actual length of the string (i.e. the diameter). The teacher emphasised details such as that the diameter should be measured on the inside of the cone if the volume of the cone was to be determined.

One learner measured the circumference of the circular base of his cone. The teacher told the learner that that was not how it should be done and requested the rest of the class to correct the learner. Nevertheless, it was possible to determine the diameter of the circular base of the cone using the formula for circumference (namely π x diameter), once the circumference had been measured. This provides an example of how the teacher guided the learners by showing them exactly what to do and by following her way of doing things.

All learners were involved during the activity. It seemed that they were enjoying the venture. Yet, the researcher could not always establish what they were saying to each other, as they did not always speak to each other in the LoLT. The teacher moved around, assisting learners. In a later part of the lesson, the teacher requested the learners to imagine a scoop of ice cream on top of the cone. If this scoop of ice cream were in the shape of a hemisphere, learners had to determine the volume of ice cream needed for every cone. She then challenged the learners to determine how many ice cream cones they could make if they had 2 litres of ice cream.

The teacher ended all her lessons by writing a summary of what had been done during the period on the board, and explaining to the learners how to reach the answer(s). When the teacher asked questions, she directed the questions to the whole class. The teacher waited patiently for a reply from the whole class. She did not ask individual learners to answer questions during whole class teaching, unless she was assisting learners in groups. The teacher asked closed questions such as: "What is the formula to determine the volume of a cylinder?" When learners answered correctly she would say from time-to-time "right" or "good", for example. At the end of the lesson, the teacher emphasised that it was very important that learners should memorise all formulae.

The teacher started all observed lessons by giving an overview of the previous day's work or doing revision of the learning that should already have been in place. She never specifically said what they were going to deal with in class that day. During the period of observation, the teacher was busy with the topic of perimeter, area and volume. She would ask learners to recite the formulae that they had learned previously and always emphasised the importance of remembering the formulae.

In cases where homework had been given the previous day, the teacher would start the lesson by reviewing these assignments. She explained all sums that had been given for homework on the board. The teacher made a definite effort to speak very clearly. Learners worked in pairs whenever an activity was to be done. From time to time the teacher asked the class as a whole: "Do you understand?" Some learners (not all) would answer that they did understand.

6.3.2.2.2 Interview with teacher AE

During the interview; the teacher AE never used to words "summative assessment" and "formative assessment". She also did not distinguish between various types of assessment. When she was asked how she assessed the work in her mathematics classroom, she replied: "Direk na eksamen, na die vakansie, dan skryf ons weer die vraestel oor, maar dan sit ek dit op transparante en ons behandel die vrae een vir een…" (Directly after the examinations, after the holiday we rewrite the examination paper, but then I write it on transparencies and we deal with the questions one at a time). In most cases, the information she gave corresponded with the summative assessment described in the literature (cf. 2.4.5.3, 3.2.1).

When asked about the role of the learners in assessment the teacher replied: "Ek dink dis nogal belangrik – ek gebruik my sterker klasse, my kinders om dit te doen, deur groepwerk ruil hulle boeke om. Hulle moet mekaar se boeke assesseer" (I think this is rather important – I use it with my stronger classes, my learners do it during group work they exchange books. They must assess each other's books). This was an indication that the teacher saw the act of marking as a form of assessment. This peer marking was not noticed during document analysis, mainly because the answers had been marked right or wrong only, with no indication of who had marked the exercise.

When the researcher probed the strategies used for formative assessment, she had to reformulate the question and ask the teacher: "Dit wat die leerders daagliks doen om te oefen of sodat jy kan sien of hulle regkom, is dit klaswerk en huiswerk?" (The work that the learners to daily to practice or for you to see that they can do the work, is it classwork and homework?). The teacher replied: "Klaswerk en huiswerk, dit doen ons op 'n daaglikse basis" (We do classwork and homework daily). The researcher proceeded to ask "Wat anders?" (What else?).

The teacher referred to summative assessment tasks: "Wel, ons formal tests en assignments en projects …" (Well, our formal tests and assignments and projects…). The researcher probed where she had sourced the exercises that she gave the learners. The teacher indicated that these came from a variety of textbooks, as well as the exercises in learners' textbooks. If questions came from a textbook that was not in the learners' possession, the teacher copied the pages for learners. The teacher gave learners scissors and glue so that they could paste loose pages into their workbooks in the presence of the teacher. In the document analysis, it was observed that this had been neatly done.

Investigation into baseline assessment revealed that the teacher believed that it was much easier to teach the grade 9 learners if she had had the same learners in grade 8. She would know exactly what prior-knowledge should be in place and what learners had struggled with in the past. The teacher indicated that learners at their school were placed in different classes based on their academic achievement. This made it easier for the teacher to differentiate, as she knew that some classes would take longer to do exercises. From the teacher's explanation it appeared that she was differentiating by pace (see 3.5.1.3), using the same exercises but giving more time.

When asked what she would do if she realised that all learners did not understand the mathematics that she was teaching, the teacher responded that she would explain the work again. The teacher did not mention that she would attempt another teaching method to assist learners to understand work better. In her own words: "… moet die swartbord maar weer praat" (the blackboard must talk again).

From the interview, it appeared that she was in favour of group work, although this meant rearranging her classroom. However, she explained that if she told the learners "we are going to work in groups, move the desks", they knew what to do and would move the desks so that they could sit in groups. When the learners were working in groups, the teacher allowed the learners to converse in whatever language they preferred. She emphasised that it was more important to her that the learners should understand the mathematics than insist on the LoLT. For this reason the teacher also allowed learners to choose their own group members.

When asked about feedback, the teacher's answer indicated that her understanding of feedback was the marking of homework and doing corrections and thus described feedback from her to the learner. Marking of daily assessment was done in different ways, but she expected the learners to mark their own homework. Sometimes she wrote the answers on the board or on the overhead projector. In other instances the teacher handed out copied versions of the memoranda and learners had to mark their homework in their own time. From time to time she asked learners to write the answers on the board. She never requested learners to explain their answer to fellow learners while writing on the board and when choosing who would write on the board, she focussed on learners who performed well in mathematics. The teacher described the LoLT to be a problem for learners, especially when they needed to express themselves. For this reason, she was not very keen to ask learners to explain their answers or write down their thoughts on how they had reached an answer. She explained that learners were shy and that she did not want to expose learners not knowing how to express themselves in the LoLT.

During the interview the teacher emphasised the importance of memorising formulae (as well as other mathematical "facts") just like she did in lessons. She maintained that learners should know them by heart.

6.3.2.3 School BA

6.3.2.3.1 Classroom observations

School BA is situated in the traditionally coloured township on the outskirts of Bloemfontein. The majority of learners in the school are coloured, but there are also black learners at the school. Coloured learners are taught in Afrikaans and black learners in English. Teacher BA is Afrikaans speaking and taught one grade 8 and two grade 9 Afrikaans-speaking classes at the time of this investigation. There was an average of 30 learners in her classes. Periods were 45 minutes long. There were no textbooks for the learners to use. All learners had a workbook and basic stationery. Few learners had calculators.

Teacher BA taught in kind of an "annex" classroom with access via another classroom. The walls were painted blue and there were no posters against the walls. The light in the room was not good. Most fluorescent lights did not work. There were only two small blackboards, standing apart from each other, for the teacher to write on. During the lesson the teacher continuously had to erase to have space to write on the board. One blackboard had permanent lines on it as if it had been used to teach music. On one side of the classroom there was a big garage door that was closed at all times.

The furniture was a mixture of single desks, double desks, technical drawing tables, ordinary chairs and laboratory chairs. Since the laboratory chairs were higher then the ordinary chairs used in classrooms, some learners sat much higher than others, blocking the view of learners behind them. This did not seem to bother either the learners or the teacher. If the teacher wanted to do group work she simply told two learners to turn around and face the learners sitting behind them. Groups of four were then formed. Most of the time during lessons, the class was disturbed by a loud noise from the neighbouring classroom.

The atmosphere in the classroom was relaxed. The teacher spoke softly and slowly. Learners were slow to respond to questions and not very talkative. This improved when they worked in groups. In all the classroom observations done, the researcher observed that only one learner asked questions in front of the class.

In the lessons observed at the beginning of the fourth term, the teacher was busy discussing the examination paper of the September examination with the learners. The teacher read the question on the examination paper and then did it on the board. The learners copied the correct answers from the board. Learners were not requested to do the sums before the teacher had explained them.

The teacher did not put her questions to any individual learner and did not call out the names of any learner to answer the questions. This meant that the learners determined the waiting time between question and answer, as they answered them in their own time. Learners did not put up their hands. Either one learner or several learners replied with an answer. From time to time the teacher made remarks about the answers such as "Ja dit is reg" (Yes, that is right) or "Ja" (yes). The teacher then continued her explanations on the board. If the learners answered questions wrongly, the teacher had a tendency to repeat the questions as if she wanted learners to re-think the question. Questions asked by the teacher were closed questions such as "Wat sal die volgende stap wees?" (What will the next step be?) or "Hoe doen ek dit, kan julle onthou?" (How do I do it – can your remember?). In many cases the teacher answered her questions herself.

The teacher emphasised that the learners should show each "step". Learners also had to know the steps by heart. In the words of the teacher: "Al vra ek jou vroeg in die môre, moet jy die stappe vir my kan opnoem" (Even if I ask you early in the morning, you must know the steps). An example of this is the teacher's explanation on how to solve an equation such as: 2a – 3 = 5 + 4a:
"Stap 1 – kom ons bring die a's na die een kant toe en die sonder die a's na die ander kant – onthou om die teken te verander…" (Step 1 – let us bring all the a's to one side and those without a's to the other side – remember to change the sign...).

The researcher observed the teacher for two days during which the teacher was busy with the question paper; and then arranged to observe lessons when the teacher had finished discussing the examination paper. Observed lessons for teacher BA from then on proceeded in more or less the following way: the teacher discussed the learners' homework of the previous day with them and did new examples; after this, if time allowed it, the teacher gave them classwork, to be done individually or in groups, followed by giving the learners homework. This classwork and homework were always similar to the examples the teacher had done earlier in the lessons when explaining examples. Questions and answers were handled in a similar way as had been done previously with the teacher putting questions to the whole class.

Group work was done especially when learners had a double period. The teacher gave the learners a task and then moved from group to group, assisting learners. Some groups called the teacher to come and assist them. When the teacher visited groups, she indicated to them whether their answers were right or wrong. She would then explain how to get the correct answer if sums had not been done correctly. The period was always over before the teacher could assist all groups.

Except for one learner mentioned previously, the researcher did not observe the learners asking the teacher any questions unless they were working in groups and called the teacher to come and assist them. When teaching, the teacher would stop and ask the whole class: "Verstaan julle" (Do you understand?). Some learners replied but the majority of the class said nothing.

6.3.2.3.2 Interview with teacher BA

The teacher described the assessment in the same way as it had been observed and described above: "Ek gee vir hul huiswerk … Dan die volgende dag, laat ek die huiswerk merk deur die kinders, ek doen dit voor op die bord" (I give them homework … Then, the next day I let learners mark the homework, I do it in front on the board). Learners always marked the homework. The teacher only marked formal (summative) assessment tasks. From time to time the teacher signed homework books to indicate that she had checked whether learners had done their homework, but she did not check whether learners were doing the homework correctly.

When asked about the role of the learners, the teacher emphasised that corrections should be done by learners, but acknowledged that not all learners did them. Although she was aware of the problem, she did not take any action to curb it. Learners were frequently absent from school – a problem that over which the teacher had no control. When learners were absent they were supposed to catch up on lost work in their own time and consult the teacher if they had any problems.

The teacher indicated that she had heard about formative and summative assessment but could not distinguish between the two. The researcher had to explain the difference to her.

When probing the teacher about what she did when learners did not understand the work that she was doing, she indicated that she normally explained that part of the work again. When asked about group work, the teacher said that both she and the learners enjoyed doing group work. According to her, learners participated quite well in group work.

Regarding baseline assessment, the teacher indicated that learners in grade 8 had very poor prior mathematical knowledge. She explained that she usually had to start with basic operations and let learners do calculations. Since the curriculum was very demanding, she did not have enough time to do this thoroughly with learners and had to push on. The teacher indicated that she had done baseline assessment at the beginning of the year. This gave the impression that she regarded baseline assessment as a once-off activity.

When asked about resources and textbooks, the teacher explained that resources in school BA were minimal. Learners did not have mathematics textbooks. The teacher usually wrote exercises on the board and the learners then copied these exercises in their workbooks. From time to time the teacher made photocopies for the learners, especially if exercises involved sketches such as in geometry, with enough photocopies being made to give every learner a copy. However, the teacher did not let them paste the photocopies into their books during class time, as there were no resources to do so. It was the responsibility of the learners to keep the photocopies safe.

For this teacher, feedback implied that she should mark learners' work so that they could see whether their answers were right or wrong. When asked how she used feedback from learners she replied: "Maar die kinders in my klas gee baie, baie min terugvoering, so dis baie moeilik om dit te kry" (But the learners in my class give very, very little feedback, so it is very difficult to get it). It appeared that the teacher regarded feedback as something that learners should tell her.

6.3.2.4 School BE

6.3.2.4.1 Classroom observations

School BE is a school situated in a Bloemfontein township. All learners come from surrounding neighbourhoods. All learners are black and the LoLT of the school is English. The teacher who teaches grade 8 and 9 mathematics is a lady whose home language is SeSotho. The home languages of learners in the school are SeSotho, IsiXhosa and SeTswana. There was an average of 30 learners in a class. The teacher taught five grade 9 classes. Periods were 45 minutes long, with some double periods. Resources were minimal. Learners shared textbooks, but all had workbooks.

The tables in the class were arranged in twos, so that the learners sat opposite each other, facing each other. That is, row one and row two learners faced each other, row three and row four and so on. Learners could thus communicate in groups but could still see the board. There were posters on the noticeboard at the back of the classroom. Some of these posters had been distributed to schools by the DoE and had the national symbols, coat of arms or general health issues on them. The teacher had made posters depicting different aspects of mathematics on pieces of white paper. Two of the posters were inscribed with the multiplication tables from one too twelve: i.e. 1 x 1 = 1; 1 x 2 = 2 and so on. The atmosphere in the class was relaxed and inviting.

Teacher BE did not introduce any of her lessons. She would simply start with the topic of the day. The teacher asked several closed questions such "Can you show me the perimeter of the classroom?" or "Can you show me the area?" The teacher asked a question and immediately called out the name of a learner for an answer. The waiting time was less than one second. Some learners answered the teacher, while others gave no response at all. When this happened, the teacher called out the name of another learner to answer the question. If the teacher did not get a satisfying answer after one or two attempts, she answered the question herself. The teacher did not return to any of the learners who had given no answer or the wrong answer. Some questions were put to the class as a whole in which case the teacher waited longer for an answer. If there were no answer she would say "Huh?" or repeat the question. Learners then answered the question either individually or in a choir. If the questions had been answered correctly, the teacher said "Yes", "Good" or "OK" or even asked the classmates to give the learner a round of applause: in her own words to "polish the child on the shoulder".

In the case of questions where the learners had to use words to answer the questions, most learners answered the question in their home languages. The teacher accepted this and did not attempt to translate the answer into English or any other language. When one learner however said "tree" instead of "three" the teacher asked: "What is a tree? Ke sefate. Tree is sefate not three tharo" (the Sotho word for tree is *sefate* and the Sotho word for three is *tharo*).

Teacher BE had models of solids in the classroom while explaining the difference between perimeter, area and volume. In this lesson the teacher had to improvise because of a lack of resources and used an empty chalk box and an old calendar that had been folded into the shape of a triangular-based prism. However, the learners had no models to work with and the teacher never allowed the learners to handle the models she had – she merely held them up for them to see. The teacher referred to the chalk box as a cube although the box was not in fact a cube because the faces were rectangular.

The teacher asked learners some questions about perimeter and area on a copied piece of paper as classwork. Learners worked in groups of six to answer these questions. The learners did not write the questions or answers in their exercise books but directly onto the copied paper. Not all learners had the necessary stationery and borrowed pens and pencils from each other. Very few learners had calculators with them.

While learners were discussing the questions given to them in groups, the teacher moved around and assisted each group. Sometimes she spoke in English and sometimes in SeSotho. Nonetheless the learners in this smaller group setting spoke to her only in their home languages. The teacher did not manage to assist all groups: she assisted two groups (spending a long period of time with one group) before the end of the period. Learners sitting next to the researcher at the back of the class were making jokes, and were not interested in doing the activity.

Although the teacher told the learners that she would give them two minutes for discussion, she allowed the learners to discuss the problem for approximately 35 minutes before they gave her any feedback. For feedback the teacher asked one person per group to give the group's answer. Answers were given either in their home language or in English. Learners helped each other if questions had not been answered correctly. These conversations took place in their home languages only. The teacher took back the photocopied papers after the group work had been done and then gave learners some classwork to do from their textbooks. The teacher explained in the interview that learners could choose with whom they wanted to share a textbook and then they had to make an arrangement with each other if they needed to use the book after school hours.

The teacher followed the same pattern for all classes, but the classes that followed the first class found that the answers had already been written on the photocopied papers since the same papers were given to every class. The teacher later explained that there was not enough money in the school to copy everything and that emphasis was placed on the copying of formal summative assessment tasks such as tests and examinations.

Teacher BE did something that the researcher had never experienced before. During the lesson she mentioned the "topic" of the day's work and requested the learners to identify the learning outcome as it was stated in the policy document for the relevant topic. She then wrote the whole learning outcome on the board. During the interview when the researcher asked the teacher why she had done that, she replied "because it is expected from learners to know the outcome of the lesson".

The teacher persisted with the same teaching pattern during all lessons observed: giving the answers to the classwork of the previous day, doing new examples and then asking learners to practice in groups. The teacher mainly used explanations and asked questions when new examples were done.

6.3.2.4.2 Interview with teacher BE

When responding to questions during the interview, it became evident that teacher BE could not distinguish between the concepts of formative and summative assessment and had to be guided by the researcher to make a distinction. This was despite the fact that the teacher had recently completed her ACE (cf. Table 6.1). Teacher BE indicated in her interview that she did most formative assessment (after explanations by the researcher) by giving learners work in the class to do. She said that she did not give homework to learners because they would not do it any way: "I don't do homework a lot because the learners are not doing [sic] it as they are supposed to." She complained that either parents or older brothers and sisters did the homework for learners or they copied it from classmates: "it is like fooling you that these learners understand the work that you are been [sic] giving them only to find that they don't understand". Only unfinished work was given as homework and this happened but occasionally.

The teacher explained that she was keen on doing group work but also allowed for individual work from time to time. According to the teacher, the learners enjoyed group work. Baseline assessment was done in the form of a question-and-answer series in the classroom. When asked what she would do if she saw a learner struggling, she said: "Still, I'll continue with the lesson, I'll continue with that and then those two maybe it is that they have forgotten it or maybe they don't know it. So I'll try to help them to see if they don't know …. and then try to help: OK this is how we do it."

Teacher BE indicated during the interview that she did not want to embarrass learners at any stage. She therefore would not "be loud about it" if learners answered questions incorrectly. She would also not ask learners to explain their answers. When asked what she would do if learners continued to struggle to understand the mathematics she was doing, she said "that one needs referral, I'll refer the learner to someone …". She explained that these problems were not in her area of expertise and so she could not help the learners. When addressing problems of learners, she preferred to concentrate on common problems experienced by learners.

According to teacher BE the role of the learner in assessment was to mark the work that they were doing as either right or wrong. After doing so, the learners were supposed to do corrections but the teacher indicated that not all learners did so. Learners who were absent when work was discussed had to catch up in their own time and ask the teacher if they needed assistance. However, this did not happen in most cases. Absenteeism is a problem at school BE.

Teacher BE had the following to say about feedback: "It tells me how much did the learners learn, did they understand what we were doing, what is it that I must do, maybe to repeat for the learners to get along [sic]." Although the teacher was thus not able to distinguish between formative and summative assessment, she did have some ideas about the application of both. When the researcher asked the follow-up question about feedback from her to the learner, she said "…that, I do it verbally, sometimes in class when the learner is doing good, I tell the learner there and there you are doing very good …." She only referred to positive learner-orientated feedback.

6.3.2.5 School CA

6.3.2.5.1 Classroom observations

School CA is situated in a small town in the Motheo district. The medium of instruction in a class is determined by the number of learners that speak Afrikaans or English. If the number of learners speaking one of the two languages is small, the learners are placed in one classroom and a double medium approach is followed. The school has a hostel and learners are from the town in which the school is situated, the township surrounding the town, the neighbouring towns and farms as well as from Lesotho.

Teacher CA is a white male and has one year's teaching experience. His home language is Afrikaans and during this investigation he taught learners mathematics in a combination of English and Afrikaans. There were both black and white learners in his class. He taught one grade 9 class in which there were 36 learners. Periods were 40 minutes long. Learners did not have textbooks since the school used the study material of an external company. Lesson plans, completed worksheets, activities to be completed as well as classwork and homework were included in the package. All learners were given copies of the worksheets. All learners had workbooks and basic stationery. Few learners had calculators.

Most of time the teacher spoke in English but, from time to time, he spoke in Afrikaans for the sake of the Afrikaans-speaking learners. He would ask learners, "Verstaan die Afrikaanse leerders dit?" (Do the Afrikaans' learners understand?) after having explained in English. He explained parts of the work in Afrikaans even when learners had not indicated whether they understood the English explanations. Teacher CA is well qualified in mathematics in which he has a master's degree. He does not have a teaching diploma but is guided by an experienced HOD who also teaches mathematics to the grade 9 learners in the only English class. There were no posters against the walls and no noticeboard in the classroom. The atmosphere in the classroom was relaxed and both the teacher and the learners seemed comfortable.

The classroom in which teacher CA taught mathematics was an old science laboratory. In it there were long laboratory desks where 4 to 5 learners sat on high laboratory stools, as well as at a few single tables that stood in the middle of the classroom. This comprised all the furniture that was available to the learners in the classroom. The Afrikaans learners (who were all white) all sat on one side of the classroom and the English learners (the black learners) sat on the other side. The lessons in teacher CA's class all followed the same pattern: Teacher CA started by explaining homework/or classwork that had been given to learners. Sometimes the teacher also re-explained work that had been done in a previous period. The teacher just started explaining without any reference to the lesson outcomes or the topic of the day.

During his explanations, teacher CA directed some questions to the class as a whole. When learners did not answer questions immediately, the teacher looked around and then answered the questions himself. It seldom happened that the teacher rephrased any questions or probed for answers. Questions asked by the teacher were closed questions, such as, "If you add on the left hand side (of an equation), what must be done on the other side?" The teacher followed an algorithmic approach, explaining a specific way to do the problems. During his explanations he made sketches and set up tables to aid his explanation. From time to time he would stop and ask: "Does everybody understand this?" or "Any questions?" When formulae were to be used, the teacher wrote them on the board such as speed = $\frac{\text{distance}}{\text{time}}$. If the teacher wanted an answer, he worked it out on the calculator by himself.

Learners were silent most of the time, except for two girls on the English side and one Afrikaans boy who would ask for clarification or ask a question from time to time. In one lesson the teacher asked: "Is everyone with me?" The English girl who sometimes asked questions, shook her head to indicate that she did not understand, but the teacher proceeded with his explanation nonetheless. Later on the girl again asked the teacher to explain the work. The Afrikaans learners sat very still and only copied the work that the teacher had written on the board into their workbooks.

Sometimes the teacher explained the whole sum again after having completed it. He made comments such as: "It is quite difficult, I know …" or "This is difficult". The teacher constantly invited the learners to ask questions but only the mentioned learners complied. The homework given was based on the work done in the class. The teacher emphasized that learners should "…practise, practise, practise" mathematics.

6.3.2.5.2 Interview with teacher CA

The teacher started the interview by saying that he viewed assessment as being extremely important. Teacher CA explained that he had a firm belief that learners learned mathematics by doing it: "Jy leer wiskunde met 'n pen in die hand" (You learn mathematics with a pen in your hand). In order to understand mathematics, the teacher emphasized that one had to be willing to struggle with it. However, he maintained that the learners in his classes were not prepared to do so. He also believed that the learners who did better in mathematics were more willing to struggle with mathematical problems than learners who did not do well in the subject. The teacher was also sure that his learners had not yet reached the point where they were intrinsically motivated by the mere fact that they could solve a problem.

For teacher CA, the learners' role in assessment meant that the learners should be willing to do the assessment. They should want to do mathematical problems. Yet, teacher CA said that he did not experience this with his learners. He expected his learners do mark their own homework. Teacher CA did not mark learners' homework at all; neither did he sign the books. He indicated that he was aware that the majority of learners were not doing their homework, and that they just copied the answers from the board. This meant that learners usually had the correct answer in their workbooks. Corrections were thus not such a factor in his classroom. For him, the difference between formative and summative assessment was that the one was not marked by the teacher and the other one was marked by the teacher.

In teachers CA's opinion, his learners were not really serious when doing their mathematics homework. He also got the impression that the Afrikaans learners were more dedicated to doing their homework than the English-speaking learners. He confirmed that learners did not ask questions in the mathematics classroom except for the two English girls and the one Afrikaans boy that had asked questions during the classroom observations. Teacher CA speculated that learners did not want to look "stupid" to other learners. The researcher enquired whether the teacher thought that the LoLT could be the problem, especially for the English learners. He did not see this as a language problem but as a problem linked to mathematics.

When asked what he did when he realised that learners did not understand the mathematics, the teacher replied: "Ek doen dit oor en oor en voer dit in …" (I do it over and over and feed it in …). He also indicated that he "drilled" the mathematics into learners. The teacher expressed his concern that learners did not know when they made mistakes in mathematics and said that they were not very motivated to keep on trying until they could solve a problem.

When answering a question regarding baseline assessment, the teacher indicated that he usually did a quick revision of things that learners were supposed to know about a topic when starting with a new topic. Even so, the teacher indicated that he would not spend much time on this and that he did not consult the NCS document to find out what learners were supposed to have done in previous grades.

Teacher CA indicated that he did not get good results when he gave learners mathematical problems (especially real-life challenges) to solve. As it wasted much of the teaching time, he had stopped doing this. Teacher CA also stated that he did not want to ask learners open-ended questions because of the learners' lack of enthusiasm and lack of interest. The HOD who guided teacher CA remarked one day while escorting the researcher to Teacher CA's mathematics classroom: "Wiskunde leen hom nie juis toe aan oop-einde vrae nie" (Open-ended questions do no actually have a place in mathematics").

When asked about group work, the teacher indicated that he did not do group work per se but that he allowed learners to discuss a problem when they saw an opportunity to do so. The seating in groups at tables made these discussions possible.

In terms of feedback, teacher CA explained that after he had assessed the learners, he determined the general mistakes made by learners in the class and discussed the general problems. To this teacher, feedback implied that he should correct the learners' work.

Teacher CA viewed mathematics as a subject that was difficult to present in an interesting way: "Wiskunde is ongelukkig weereens 'n vak wat moeilik is om interessant te maak volgens my opinie, selfs al gebruik mens snaakse goedjies in die klas, die wiskunde daaragter kan jy nie verander nie." (Mathematics is unfortunately a subject that is difficult to present in an interesting way according to my opinion, even if you use funny things in the class – the mathematics behind it cannot be changed).

6.3.2.6 School CE

6.3.2.6.1 Classroom observations

School CE is situated in a small town outside Bloemfontein. Teacher CE is an experienced teacher and was already at the level of a master teacher at the time of this project. Teacher CE's home language is SeSotho although the home languages of the learners in the schools were mostly SeTswana at the time of this project. For this reason, SeTswana was offered at home language level at the school. All learners in the school were black and came from the town in which the school is situated. The LoLT of the school is English. The school works according to a system where learners stay in the same classes all day and teachers move from one classroom to another. To attend each class the researcher had to walk to a different classroom with the teacher. The teacher introduced the researcher to the learners who greeted her in a friendly fashion. Before the classroom observations started, teacher CE also took the researcher to all his grade 8 and 9 learners where teacher CE introduced the researcher and explained why the research was necessary and how the learners could help the researcher. There were between 30 and 40 learners in a class. Teacher CE taught one grade 8 class and three grade 9 classes. Learners did not have textbooks and some did not have basic stationery. Most did not have calculators. All learners had a workbook. Periods were 40 minutes long and sometimes learners had double periods.

During the whole time that the researcher was doing classroom observations, a loud noise made by learners in neighbouring classrooms disrupted the lessons. Classrooms in this school were not in a very good condition. In addition, the classrooms were not neat and tidy. In one classroom it seemed that part of the ceiling was about to collapse. There was not enough furniture in the classrooms and no posters on the walls. Tables were either double desks or big staff room tables. There were not enough chairs and learners had to sit on the tables, on frames of old chairs, some kneeled while others simply had to stand. Because of the learners who were sitting on tables, there was often no space for the learners to work. They had to hold their workbooks on their laps or place them on windowsills. What was surprising was that learners placed their suitcases on the already full table, making the space even smaller. The learners standing at the back of the classroom did not have any space on which to write and they had to write in their books while supporting them on one arm while writing with the other hand. Here and there, some learners shared chairs without a table. The arrangement of learners and tables was such that group work could be done, although no specific pattern was evident. There were 3 to 8 learners in a group. Learners always worked in groups. The atmosphere in the classroom was comfortable. Learners did more or less what they wanted to and the teacher condoned this.

At the beginning of classes, teacher CE usually started by writing an example on the board. The teacher did not introduce the lesson or give instructions – he would just turn to the board and start writing. While the teacher was writing on the board, one of the boys came to the board and erased the work of the teacher who had taught there during the previous period. It seemed as if these boys were used to this task and the teacher did not even have to call on them to do it. There were no board erasers and learners used toilet paper to clean the board. Some learners started copying what the teacher was writing on the board, into their workbooks. For example, the teacher wrote days of the week on the board in no order. He repeated the name of each day a number of times. When he had finished, he told the learners that the days that he had written on the board were days when learners would celebrate their birthdays that year. He instructed the class to make a frequency table of the data and draw a bar graph in their groups. He asked one closed question to the class: "Can you remember how to draw a frequency table?" One learner asked for clarification of the question in his home language. The teacher explained the question, using the home language. When the researcher asked the teacher later in the interview what language he had spoken to the learners, he said it was a combination of SeSotho and SeTswana and, according to the teacher, learners were used to it.

During the lesson on bar graphs the teacher went to assist the group in the furthest corner from the researcher. The researcher went closer to get an idea of how the teacher was assisting the learners. The teacher was busy explaining some algebra to the learners in the group where he was assisting in a mixture of English and the vernacular. When the researcher later enquired about this in the interview, the teacher explained that, according to the NCS, he was required to do more than one learning outcome. Although it is true that this has to be done during a school term, the teacher had misinterpreted this as something that had to be applied during a school period.

While learners were busy doing the frequency table and bar graph, the teacher did not offer them any assistance but from time to time he said something to the learners like: "You must put headings in the frequency tables" or "Label your axes when drawing the bar graph". Not all learners stopped talking to listen to the teacher.

Because the learners were conversing in their home language, the researcher could not say without doubt that the conversations were about the classwork that had to be completed. Nevertheless, it appeared that not all learners were discussing the work to be done. By the end of the period some learners had still not constructed the frequency table. The teacher, who was busy assisting approximately the third group, simply stood up, told the learners to complete the work for homework. He waved at the researcher and both he and the researcher left the classroom.

Where classes had double periods, the teacher proceeded in the same way, but at the end of the first period the teacher instructed a learner to draw the frequency table on the board. Learners constantly gave the chosen learner advice on how to draw the frequency table. The learner writing on the board obviously did not always know how to do the frequency table. He made mistakes, erased them and tried again, made more mistakes, erased them again before reattempting to draw the graph. During the time when the learner was writing on the board, teacher CE was still explaining the algebra exercise to learners in groups. At one stage the teacher got up, walked to the front of the classroom and drew the frequency table as well as the bar graph while explaining to learners. He did not ask any questions during the explanation and would say from time to time: "Are we together?"

Grade 8 lessons proceeded in a similar way, except that here the teacher did not write the exercise on the board. He gave each group a piece of paper with an exercise on it. The learners had to complete the exercise while the teacher was moving from group to group. This time, however, the teacher explained work on the worksheet to each group. A definite problem was that the learners in each group received only one photocopied question paper. Learners were constantly grabbing the paper from one another to be able to see the questions. Some learners became passive and did not attempt to do the work. The copied papers were collected at the end of the period to be used by a next class. The teacher explained that photocopying was limited to important work only (such as tests and examinations). Learners had no textbooks. At the end of every period, the learners were instructed to complete the exercise done in class as homework, whether they had written down the questions down or not.

Teacher CE always used group work in all observed lessons. He believed that this was how OBE should be done. At a later stage, when the researcher was doing classroom observations, the teacher sat at a table in the front of the classroom. He called the group leaders of four groups to his table and explained some work on a worksheet to them. They had to go back and explain it to the other learners in the group. During this process, the rest of the class was very noisy. When he had finished explaining to the first lot of group leaders, the teacher called the next four learners and explained work to them. This continued for the whole period. By the end of the period the teacher had not yet explained the work to the group leaders of the last groups. In other words, these groups had spent the whole period doing nothing. The teacher indicated to these learners that they would have to do the exercise the next day.

6.3.2.6.2 Interview with teacher CE

Teacher CE was not familiar with the concepts of formative and summative assessment. The researcher rephrased questions to get relevant responses from the teacher. Teacher CE indicated that he did assessment in his classroom by asking questions, doing classwork and allowing learners to work in their groups. Homework was only given if classwork had not been finished at the end of the period. When asked about determining prior-knowledge, teacher CE indicated that he asked learners questions and their answers indicated to him what they knew.

During the interview, teacher CE indicated that he did not always do group work but that he also did individual work from time to time, despite the fact that the learners always sat in groups. When asked about feedback, the teacher replied that he or certain learners wrote the answers on the board and allowed the learners to copy the correct answers on their workbooks.

Teacher CE explained during the interview that it was important that learners should first try to do the work themselves before he explained it. The teacher was convinced that learners were actually making sense of work while doing it in their groups. He did not even want to consider that learners were not utilising the time optimally. In his words: "They are committed all the time, all the time. Even when I'm not there, even when I'm not there".

When asked about the furniture, teacher CE responded that it had a very negative effect on the learners and on the learning experience. Yet he did not indicate how or why he thought that the effect was negative. When asked about the role of the learners in assessment, teacher CE replied that the learners' role was to help learners who could not do the work. He then emphasized that it was important for learners to work in groups.

Teacher CE indicated that he liked to ask learners who performed well in mathematics to illustrate a sum on the board. Weaker performers are not asked because teacher CE believed that doing so would waste time and expose the learners as ignorant. When learners gave wrong answers in the classroom, other group members were called upon to assist the learner.

The teacher explained that learners did not have textbooks and that photocopying was limited. As a result he had to write the exercises on the board. This was time-consuming and the teacher had to do so every time he went to a new classroom. Teacher CE found it difficult to complete all aspects of the curriculum. Learners coming from primary schools also did not have the necessary prior knowledge and the teacher had to explain necessary concepts to the learners first. According to teacher CE, he controlled the learners' workbooks regularly during class time and, if he saw that learners were struggling, he explained the work again. In spite of this he preferred to concentrate on general problems that the learners experienced. Teacher CE signed the learners' workbooks from time to time but did not check for correctness and mistakes. When asked about feedback, teacher CE responded in such a way that it appeared that he was referring to doing corrections with learners. He was also under the impression that "…feedback becomes relevant in this way are [sic] very important specially to the slower learners".

6.3.2.7 School D1

6.3.2.7.1 Classroom observations

School D1 is a farm school that lies about 30 km outside Bloemfontein. The school is small and in the lower grades multigrade teaching (teaching grade 4, 5 and 6 learners together in one classroom) is practised.

At the time of the research study, the Intermediate Phase teacher was ill and this affected the normal smooth running of the school. Since no substitute had been appointed, the principal decided that the grade 4 learners should sit with the grade 8 learners; the grade 6 learners would be accommodated with the grade 7 learners; and the grade 5 learners with the grade 9 learners. This decision was based on the available space in every classroom and the number of learners in each class. There was an average of seven learners in the Senior Phase classes and an average of 14 learners in the Intermediate Phase classes. The researcher proceeded with classroom observations, monitoring teacher D1 teaching mathematics to grade 8 and 9 learners (one class each) since this situation represents an example of the reality that farm schools cope with daily. Although the presence of the younger ones in the classroom influenced the mathematics lessons, the focus in what follows will be on observations made regarding grade 8 and 9 mathematics teaching. Although periods at school D1 were 45 minutes long, the teacher continued doing mathematics until she was satisfied that she had done enough. Lessons were up to two hours long.

The teacher is a lady whose home language is SeSotho. The home language of learners was also mostly SeSotho. Both the teacher and the learners seemed comfortable with each other. The learners sat still in their classrooms and teachers moved from one classroom to another. All classrooms were painted green and brown. In all the classrooms there were coloured posters on the walls. These posters were relevant to different learning areas since tuition for several different learning areas was offered in the same classroom.

As previously explained, the grade 4 learners shared a classroom with the grade 8 learners. The classroom had been divided into two sections using cupboards so that part of the room could be used as an office. Learners sat in groups of three to four. The learners sat together according to their grades. The lesson was disrupted by constant distractions: i.a. a telephone ringing, the microwave oven being used, the kettle boiling. When the clerk answered the telephone, she made no attempt to speak softly. The teacher and learners went on as if nothing out of the ordinary was happening.

The teacher always started the lessons with a mental arithmetic exercise. This was for the sake of the Intermediate Phase learners since the foundations for learning specify that the mental arithmetic exercises be used daily. After that, the teacher started teaching the grade 8 or 9 class. Most of the teaching was done in English but the teacher did switch code to use the learners' home language. She always started with explanations. During the explanation the teacher asked several closed questions and immediately nominated a learner to answer the questions. Most of the time the questions were only answered after the teacher had asked several learners. Some of the learners answered in English while others used their home language. When learners were answering questions incorrectly the teacher would say things such as, "No", "That is rubbish" or "Think again, my child". In some cases, if the correct answer had been given, she repeated the answer.

After the explanations, the teacher gave learners a class activity to do in groups and she moved around to assist learners. It appeared as if learners were discussing the problems in their groups, but all discussions took place in their home language. After the teacher had assisted the older learners, she moved over to the learners in the Intermediate Phase and gave them an exercise. These younger learners had been sitting very still while she was teaching the older learners; with some of them staring at the researcher continually.

When the teacher returned to the older learners, she sat on a chair and called on learners to write on the board. If a learner did not write the correct answer, the teacher made remarks such as: "Ooho, Thabiso, go and help him!" or, "Oh my

God, how can you say that?" On one occasion when the learners were calculating compound interest, a learner wrote the following on the board:

Interest = R1 000 x $\frac{10}{100}$ x 5

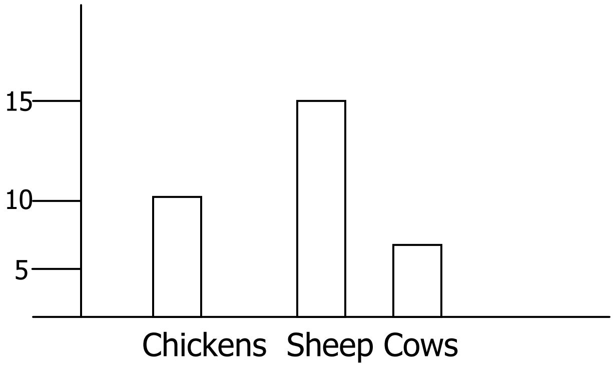
= R500

= R1000 + R 500

= R1 500

The teacher indicated that this was correct, making no effort to rectify the incorrect use of the equals sign (=). Consequently, the learners copied it incorrectly into their workbooks.

In the grade 9 class the teacher wanted the learners to draw a bar graph. Teacher D1 asked a learner to draw the graph on the board. The learner used an ordinary ruler (30 cm) to draw lines on the board. As a result the scale was wrong:



Again the teacher ignored the mistake, and learners copied the incorrect work into their workbooks.

It became clear that the teacher did not pay particular attention to minor details.

6.3.2.7.2 Interview with teacher D1

Teacher D1 did not know the meaning of the concepts of formative and summative assessment. The researcher had to explain these words to the teacher several times. Teacher D1 explained that the learners in school D1 were from a very poor background. The learners got one meal at the school (which was part of the DoE feeding scheme) and for many learners this would be the only meal of the day. Many learners stayed far away from the school and many of them were orphans staying with grandparents or other family members. This resulted in high rates of absenteeism.

When asked how she did assessment in her classroom, teacher D1 replied: "I usually want learners understanding how – more especially I want them to understand the mathematical concept using the assessment". It appeared that the teacher wanted to use assessment to determine what the learners knew and understood.

According to teacher D1, giving homework was a useless exercise. For this reason she had to use class time optimally so that learners could learn mathematics. The teacher did sign the learners' workbooks from time to time and marked some questions (as right or wrong) about two to three times a term.

Teacher D1 indicated in the interview that she definitely preferred learners to work in groups. She also explained that she often called on learners to write on the board. Every group had a leader who had to write on the board. The rest of the group had to assist the group leader if he could not find the correct answer. Learners choose the group leaders themselves.

When asked about feedback, teacher D1 answered as follows: "I like feedback, I like feedback … uh ... I always write in the book – later we come on the chalkboard and then we will write those again … I like chalkboard because I am what I am because of a chalkboard". The researcher interpreted this as meaning that feedback implied writing answers on the board. When asked about the role of the learner in assessment, the teacher described it as follows: "The role that I want the learners to show understanding, understanding what is all about in the assessment". The researcher interpreted this as meaning that the teacher saw the learner's role in assessment was to do assessment tasks.

6.3.2.8 School D2

6.3.2.8.1 Classroom observations

School D2 is situated about 120 km outside Bloemfontein in a remote area and is attended by learners from the surrounding farms. Some learners travel far to get to school. They are transported to school in buses and mini-buses. All learners in the school are black and the LoLT is English. The teacher is male and his home language is SeSotho, which is also the home language of the majority of learners at the school.

At the time of the research project the school did not offer grade 9 and there was one grade 8 class. When all learners were present, there were 42 learners in the grade 8 class. Periods were 30 minutes long and learners had double periods on some days according to the time-table. However, teacher D2 went on with a lesson until he was satisfied with what he had achieved for the period.

There were a variety of posters on the walls of the classroom. Not all of them were related to mathematics since the learners were taught all learning areas in this classroom. Tables in the classroom were arranged in groups. These were mostly double tables, with two learners sitting at a table. The learners sat in groups of six, but in a manner that enabled them to see the board. The classroom was very full. The atmosphere in the classroom was comfortable, yet disciplined.

In the first lesson observed at school D2, the teacher introduced a new topic. The teacher started an explanation while illustrating it on the board. The explanation was in English but the teacher did switch code to SeSotho. Initially the teacher did not ask any questions, he just explained the new work. Later on, he started asking questions, directing them to the whole class. The learners put up their hands and the teacher requested one of them to answer. These questions were all closed questions such as: "Simplify $\frac{3}{6}$ for me". If the learners answered correctly, the teacher would say: "Let us give him a hand of applause [sic]". The learners then clapped their hands. Teacher D2 frequently asked, "Are we still together?" to the whole class. Learners answered the questions in their home language. After the teacher had completed the explanation, he asked a learner to come to the board and do a sum on it. The learner did this in silence. Teacher D2 then instructed the learners to do an exercise. He posed a problem verbally and did not write it on the board: "Simplify 250:200". He repeated this several times.

Learners did not write any answers in their workbooks at this stage of the lesson: they did not even have their workbooks on their tables. Some wrote the work on their hands. Others wrote on pieces of paper and some learners did not write at all. The teacher did not move among the learners while they were working. He stood in front of the classroom, overlooking the class. After a short while, he requested learners to give the answer to his question. Some learners were still busy working when the teacher asked them to give him an answer.

The teacher asked more questions but this time he wrote them on the board. He instructed learners to answer the questions on the board in their groups.

Even then the learners had not taken out their workbooks and the teacher did not move around. He again requested answers before the learners had finished doing the calculations. One learner in the class had a calculator and gave all the answers.

In other observed lessons, the teacher started by discussing the homework that had been given to learners the previous day or work not completed the previous day. The teacher did move around the classroom to check whether homework had been done. Still, not all learners took out their workbooks. The teacher wrote the answers of the exercise done by learners on the board asking occasionally closed questions such as, "What is 5 x 4?" Some learners answered in a choir as no specific learner had been asked to answer the questions. Teacher D2 was in all observed lessons the active person, writing on the board and explaining most of the time.

6.3.2.8.2 Interview with teacher D2

When asked about assessment, teacher D2 answered as follows: "I do give learners some activities in class, maybe formal assessment so that they can complete those activities". When the researcher asked the teacher: "Is that the formal assessment, that has to be recorded?" teacher D2 answered that it was. It can thus be deduced that Teacher D2 was under the impression that the word "assessment" referred to formal (summative) assessment. When the researcher asked about informal assessment in order to find out about formative assessment, the teacher referred to the learners' doing activities in groups. He also explained that he allowed the learners in one group to mark the tasks of the learners in another group. At this stage of the interview the teacher referred to assessment as if it was "marking". The teacher did not know the concepts of formative and summative assessment and the researcher had to use explanations when formulating questions.

Although teacher D2 mentioned in the interview that he always told the learners what they were going to do at the beginning of the period, the researcher did not notice this while doing her classroom observations. When asked about baseline assessment, teacher D2 answered that he did baseline assessment by asking questions. He continued by explaining that he could not direct questions at all learners and consequently only asked some learners so that he could get a general feeling of what his learners knew.

During the interview, the teacher often referred to the teaching of mathematics. This implied that teacher D2 believed that he had to show his learners the methods of how to do the sums and that the learners then had to practise them themselves. Teacher D2 did give his learners homework. Learners of school D2 were often absent, sometimes for several days at a time. So, it might be said that absenteeism was a big problem. The learners were transported to school by bus and if the bus did not run, the distance to school was too great for learners to walk to school. On rainy days the attendance was also poor.

When asked about the role of learners in assessment, teacher D2 replied: "In fact they play a very vital role because sometimes they do um…. make themselves assess, they assess themselves". It appeared as if the teacher believed that the learners should mark their own work. When the researcher remarked that she had noted in her analysis of the documents that teacher D2 did mark learners' books, the teacher replied that he had to do so because learners could not copy down the corrections correctly. Once a term he collected all learners' books and marked them. He indicated that he allowed the learners to mark their peers work as an alternative to his marking.

If learners did not understand, teacher D2 indicated that he explained the work to the learners again. As in the case of teacher D1, teacher D2 was in a position to continue a lesson after the period had finished. According to teacher D2, this helped greatly and allowed him to assist learners with problems. To teacher D2, the concept of feedback meant doing corrections so that learners knew what was right and what was wrong.

When teacher D2 was asked whether he gave individual learners some extra work to do if he saw that they were struggling, teacher D2 said: "I think I'll just tear that learner apart".

There were few resources such as measuring instruments and models, but every learner had a mathematics textbook. Copying facilities were restricted.

6.3.3 Analysis of qualitative data

Qualitative data was collected by means of document analysis, classroom observations and interviews. During the analysis of the qualitative data, the researcher encoded the data. According to McMillan and Schumacher (2001:467), coding refers to a classification system where data are divided into parts. The researcher wanted to look for patterns or particular ideas or events that might emerge from the data (collected from the participants in the research study) that was relevant to formative assessment (Denscombe 2005:271) and then categorise it.

Because triangulation took place within the qualitative study, aspects of the study that were revealed in one data collection method were also illuminated in data collected by other data gathering methods. The results of the analysis of qualitative data are discussed below.

6.3.3.1 Knowledge and view of formative assessment

In 2.3.5.1, where the teacher's role as assessor was discussed, it was mentioned that teachers should know how to integrate assessment into learning and teaching and use the assessment effectively as part of the teaching and learning processes to enhance learning in the mathematics classroom. This implies that teachers need to be knowledgeable about assessment.

Except for teacher AA, none of the teachers used the words formative and/or summative assessment or tried to distinguish between different types of assessment when they spoke about assessment. Teachers were only familiar with the term assessment per se. It was only after the researcher had used and explained the terms that some teachers attempted to use them. Teacher AA, who was furthering her studies in education at the time, knew that she had heard about formative and summative assessment before but was not sure about the meanings of the words: "…dis mos formatief aan die einde … ja formatiewe asses… wat sê ek nou … summatief – ek raak altyd deurmekaar" (…is it now formative at the end, yes, formative assess – what am I saying? summative – I always get confused).

During interviews the researcher had to rephrase questions to get responses from teachers. For example, when teachers were probed about the strategies they used for formative assessment, the researcher was compelled to ask: "How do your learners do mathematics?" or, "What do you do informally to assist your learners to understand mathematics?" In some cases the researcher ended up asking teachers: "Do your learners do their homework?" and, "Do your learners do classwork?" and also, "Do your learners write informal tests?" and "Are there any other ways in which you check your learners' progress?"

When the teachers did not know what the term "baseline assessment" referred to, the researcher had to probe by saying: "How do you determine the learners' prior-knowledge?" After the researcher had used the term, the teachers started using the term "baseline" too. Overall the teachers in the interviews did not use terminology, such as diagnostic assessment, reflection, feedback, self-assessment and other phrases that are associated with assessment. Some tried to use it after the researcher mentioned it.

During their interviews, teachers AA and CA indicated that they saw "assessment" as very important. Teacher AA remarked: "… assessering in wiskunde is vir my verskriklik belangrik …" (…assessment in mathematics is very important to me…), and teacher CA remarked: "Ek beskou dit [assessering] as vreeslik belangrik …" (I see it [assessment] as very important). However, neither of these teachers indicated what form of assessment they were referring to and why they regarded assessment as important. None of the other teachers referred to assessment as being important.

In 3.3.1 it was suggested that teacher's lesson plans should be scrutinised to determine the quality of formative assessment in the teacher's classroom. In document analyses, no indication could be found in these documents that the teachers had planned any formative assessment. This raised concerns regarding teachers' knowledge of formative assessment as a deliberate way of assisting learners to master mathematics. It appeared that it was not only the terminology that was problematic but the also the whole idea of formative assessment and the execution of the formative assessment process.

Classroom observations revealed that teachers followed one of two specific patterns when teaching mathematics: Pattern one entailed the teacher introducing a new topic using examples, practicing the topic during the classwork and then doing homework (assignments) based on the topic, except in the cases of schools BE and D1 where homework was not usually given. Pattern two entailed that teachers started explaining the homework of the previous day, did new examples and then allowed the learners to practise some new examples. These unimaginative teaching patterns, which are very much in line with the behaviourist way of teaching described in 2.2.1.2, were an indication of how teachers think learners learn mathematics and thus hinted that teachers' knowledge and view of formative assessment were poor. More aspects regarding this knowledge and view of formative assessment will be discussed in the paragraphs that follow.

6.3.3.2 Quality of planning for formative assessment

The fact that the formative assessment process starts with thorough planning was discussed in 3.3. This section (3.3) also emphasised that the success of formative assessment depends on its planning. For this reason, document analysis provided the best opportunity to reach a conclusion regarding planning for formative assessment.

It was found during the document analysis that teachers AA and BE had no written lesson plans in their teachers' files. Teachers AE, BA, CA, CE, D1 and D2 did not have the term "formative assessment" in their lesson plans and when the researcher interpreted the work, she concluded that the extent of planning for formative assessment did not go any further than selecting exercises to be done by learners, either in class, or at home. None of the teachers participating in the research showed any evidence that they had worked out the classwork and homework exercises themselves before the learners attempted them.

Lesson plans presented by teachers for document analysis did not give an indication of how the lessons would unfold and there was no evidence that teachers had planned for question-and-answer series to be done in class. None of the lesson plans scrutinised during document analysis indicated any anticipated questions. Teacher D2 confirmed this during the interview saying: "No, the questions, I don't plan them – they just come as I'm teaching…"

In some classroom observations it became evident that the teachers presented examples to learners without having planned them properly. An example of this is teacher AA's lesson in which she did an exercise based on the budget of the school in one of the grade 8 lessons (cf. 6.3.2.1.1). She wrote amounts for certain items in the budget on the board. When the amounts she wrote did not seem to be viable, she erased them and changed the figures on the board.

Another example was observed in the classroom of teacher CA. The teacher drew a table on the board to illustrate an indirect proportion. He wanted to give learners a real-life example of this indirect proportion. After he had started, he realised that the scenario he had given the learners was not an example of what he wanted it to be. He stopped doing the example, telling learners to ignore it.

6.3.3.3 Variation of assessment strategies

In 3.9 the importance of using a variety of assessment strategies to collect formative information was discussed. Various formative assessment strategies that could be used in mathematics were identified (cf. 3.9). These strategies should not only aim to collect information about learners' knowledge of mathematics, but also of their understanding of the subject, as well as the skills that they had acquired in mathematics (cf. 3.3.2).

During classroom observations it was observed that the teachers asked various questions when doing examples with learners or when explaining work to the learners. All the teachers, except teachers CA and CE, asked many questions. Teacher CA asked fewer questions than the other teachers, and teacher CE asked almost none. The questions asked by the teachers were almost all closed questions such as: "Hoeveel grade is daar in 'n sirkel?" (How many degrees are there in a circle?) (teacher AA); "What is the formula to calculate the area of a rectangle?" (teacher BE); and "What does direct proportional mean?" (teacher CA). No open-ended questions designed to make the learners think and give argumentative responses were asked by teachers AE, BA, BE, CA, CE, D1 or D2. Teacher CA remarked in the interview when asked about this: "Ek sal sê daar is so tipe vrae wat sy eie opinie het, maar soos ek sê as gevolg van die te kort van entoesiasme en belangstelling is dit nie vir my goed om dit te vra nie" (I would say there are questions where a learner's own opinions are important, but like I say, because of lack of enthusiasm and interest, it is not good for me to ask questions like that). Teacher AA did ask an open-ended question which required an argumentative response: "Hoekom verskil ons antwoorde?" (Why do our answers differ?). In this case there was a difference in interpretation of the mathematical problem. When the learner hesitated before answering the question, the teacher answered it herself.

During document analysis it was found that the classwork and homework exercises given to learners corresponded with what was described in 3.9.5 as assignments. This was deduced because these exercises consisted mostly of routine problems and sums, resembling examples done by teachers during the lessons. It was also found in the document analysis that the exercises did not practice skills such as doing actual measurements, setting real questionnaires and collecting authentic data.

Teachers AE and D2 used informal tests as a formative assessment strategy but this was only done once per term. None of the teachers participating in the research used journal writing as a formative assessment strategy and none of them requested the learners to write down their thoughts when solving a mathematical problem (cf. Table 6.3). In this connection, teacher BA said in the interview: "As ek vra hoe het hulle by dit uitgekom, verduidelik vir my, maar hulle kan glad nie vir my sê nie" (If I ask them how they reached the answer; explain to me, they cannot tell me).

In teachers' documents, there was no indication of any investigation where learners could explore new mathematical ideas and concepts to enhance their understanding of them; neither was there any project where learners could apply their mathematical knowledge and skills in real life. The learners' documents also indicated that they did not do this type of exercise. During none of the classroom observations were the learners requested to complete any such exercise.

When asked about this in the interviews, the teachers' answers were a clear indication that investigations and projects were only done as summative assessment tasks which were recorded. In the words of teacher AE: "Nee, ek doen dit [investigations and projects] net vir CASS" (No, I only do it for CASS). This is because the teachers are required to use strategies such as investigations and projects to compile a formal continuous assessment (CASS) mark for learners (summative assessment). The researcher concluded that teachers did not view assessment strategies such as investigations and projects as formative assessment tasks.

6.3.3.4 Keeping records

Section 3.10 discussed that it was essential to keep records of formative assessment so that, amongst other reasons, learners' progress could be monitored. In 3.10 it was discussed that these records can be done in various ways.

During document analysis, all teachers had record sheets, but only the formal summative assessment marks were recorded – there was not evidence of records of formative assessment. This summative assessment comprised three assessment tasks of the teachers' choice during each term (as stipulated in the assessment policy). The record sheets for this summative assessment were up to date in the case of teachers AA, AE, BE, CA and D2 for summative assessment. The other teachers did not have an updated record of summative assessment.

During interviews the teachers confirmed that they either did not keep any record of formative assessment or they explained: "… ek skryf dit [records of formative assessment] nie self in my book ook nie …" (I do not write them [records of formative assessment] in my book – teacher AA); "Ek rekordeer dit [formative assessment] nêrens nie…" (I do not record it [formative assessment] anywhere … - teacher AE); "…again, there is a question of time constraints – I would love to do it [keep records of formative assessment] but I was overtaken by time…" - teacher CE).

6.3.3.5 Reflection

In the discussion of the formative assessment process in 3.3, the act of continual reflection on actions as a conscious act was emphasised. In addition, the teachers were advised to reflect on lesson plans to decide which actions worked in the execution of the lesson and which did not (cf. 3.3.5). It was suggested that these reflections should be summarised briefly for future reference.

The document analysis revealed that none of the teachers participating in the research had any evidence of reflection in their writing. Although space had been provided for it on teacher CA's lesson plan, only a tick (√) appeared in the space to indicate that it had been done in some way. During interviews it became clear that teachers did in fact reflect on the success of a lesson after it had taken place, but did not make a conscious effort to analyse what had occurred, make notes about the reflection or keep records of it. For example, when asked teacher CA said: "…nee ek het dit nie neergeskryf nie, maar ek het al gaan dink hoe ek goed beter kan verduidelik" (…no, I did not write it down, but I did go and think about how I can explain things better).

There was also no evidence that learners reflected and discussed their thoughts with teachers or that teachers invited other teachers to sit in on their lessons in order to reflect on the lesson together.

6.3.3.6 Formative assessment as information

Information gathered through formative assessment should be used to inform teachers about their learners' strengths, weaknesses and progress (cf. 3.3.1). In addition, it should give teachers an idea of learners' mathematical knowledge and understanding (cf. 3.3.2) and help teachers find recurring errors and the sources of the errors (cf. 3.3.3). All of this information should be used by the teacher to plan future actions (cf. 3.3.4).

Analysis of learners' documents showed that teachers AA and CA never marked learners' exercises in their workbooks. Teachers BA and CE signed learners' workbooks occasionally, but did not check whether exercises had been done correctly. Teachers AE and D2 marked one exercise per term and teacher D1 marked about three exercises per term. Teachers AE and D2 also marked one informal test per term. Together with the observation that teachers did not keep records or make notes of the results of formative assessment, and the fact that there was no evidence that the teachers reflected consciously on lessons and formative assessment during lessons, this gave the impression that the teachers did not use formative assessment to gather information about various aspects of learners and learning.

The fact that information gathered through formative assessment should give teachers an indication of whether learners were ready for summative assessment or not was also discussed in 3.2.1.

In school AA there was a test week during the period of lesson observation. This test week took place at predetermined dates, making it virtually impossible for the teacher to use formative assessment to inform her about learners' readiness for summative assessment. Teacher AA remarked in the interview: "…groot toetse weet hulle [learners] lank voor die tyd…" and "…ons het 'n toets week in die eerste en derde kwartaal en eksamens in die tweede en derde [term]…" (they [learners] know about formal test in advance … we have a test week in the first and third term and examinations in the second and fourth [term]…The same was true for schools AE and CA.

Linking lesson plans with work schedules (the year plan) during the document analysis, showed that teachers taught at a pace that was in line with the year plan (where this had been done), and tried to address all assessment standards. This was most probably because of the specification in the policy requirements that all assessment standards for a grade should be done within a year. Learning facilitators checked the implementation of the policy and requested teachers to tick off the work that had been completed on the work schedules.

Despite the fact that some learners' books had been marked or signed by some teachers, there were still shortcomings in some workbooks in all schools. Learners marked incorrect work as correct, exercises were not marked at all and the corrections were not always complete. The teachers wrote no remarks (feedback) for learners and there was no suggestion that the teachers indicated the learners’ mistakes to them and how to correct them. At all schools there were several indications that learners who had been absent made no attempt to catch up on the lost work, e.g. blank pages in work books and dates that were far apart. Thus, it would be difficult for these learners’ knowledge of mathematics to benefit from formative assessment.

The suggestion was made in 3.5.3.1 that information gathered in formative assessment should inform the teachers about whether their teaching strategy was effective or not. In the document analysis there was no evidence that the teachers ever repeated lessons using a new teaching strategy.

When it became apparent that the learners had not understood the work, the teachers reacted by explaining the work again. In none of the observed lessons did the teachers come up with a new teaching strategy. During interviews all teachers agreed that they would act if they saw that the learners did not understand. Probing the teachers about what action they would take, revealed that their strategy would be to explain the work again. Teacher AA and AE indicated that they would try another method - but observations revealed that this did not mean another teaching method, rather another way to explain how to do the sum.

When assisting learners, the teachers did not guide them with questions or other approaches – here they also just re-explained. The following remarks were made in this regard by teachers during the interview: “… en ek sal voor die bord gaan staan en dan verduidelik ek maar net weer” (…and I stand in front of the board and then I explain again – teacher AE), “…ons vat weer die aktiwiteit van vooraf en dan kyk ons na al die probleemareas en doen al die probleem areas van voor af. Ek verduidelik dit weer” (…we start the activity from the beginning and look at all the problem areas and do all problems again. I explain them again – teacher BA), "…ek doen dit oor en oor en voer dit in …" (…I do it again and again, feeding it in… – teacher CA).

6.3.3.7 Differentiation

Differentiation of formative assessment tasks is essential so that learners' individual needs can be addressed (cf. 3.5.1, 3.5.3.2). Differentiation can take place in a variety of ways (cf. 3.5.1.1 – 3.5.1.4). Planning for differentiation should be done carefully and consciously (cf. 3.3.1).

Document analysis as well as classroom observations revealed that the teachers who had lesson plans did not have separate lesson plans for the different classes they taught in the same grade. The researcher observed that the execution of the lesson plan was not always exactly the same in all classes but that the same exercises were given as classwork and homework. Where there were no lesson plans (in the cases of AA and BE), lessons presented were also the same for all classes of a grade.

Teacher AA had the following to say in the interview: "Die oefeninge is presies dieselfde want daar's sterker en swakker kinders in almal se klasse …" (The exercises are exactly the same because there are always stronger and weaker learners in all the classes). Teacher BE: "If I plan for this lesson for today, I give them all the same lesson".

There was no indication of either remedial or enrichment formative exercises to be done for expanded opportunities. The same classwork and homework were given to all learners in the same grade at a particular school. When teacher CE was asked whether he ever prepared individualised exercises for learners to practice, he replied: "No, no - there is no time..." The classroom observations proved this: the teachers made general statements such as "Verstaan julle?"

(Do you understand?) or "Are we together?" - without really making an attempt to find out whether all learners understood. The researcher heard learners saying explicitly that they did not understand when these questions were asked but found that the teachers paid no attention to them.

In interviews the teachers indicated that they usually got an idea of learners' general level and then pitched exercises at this level. For example, teacher AA maintained: "… mens sien nogal as jy merk kom jy 'n tendens agter …" (…when marking you pick up a tendency…), teacher AE observed: "… en waar die meerderheid leerders hulle foute gemaak het en daarop lê ek dan klem" (…I emphasise where majority of learners made mistakes).

6.3.3.8 Self-assessment

In 2.3.5.2.1 the learners' role in regulating their own learning was discussed. The discussion indicated that the learners should take control of their own learning process. Self-assessment is thus of the utmost importance. Self-assessment implies that learners should become involved in monitoring their own learning - making decisions such as where they need more practise or clarification when mistakes are made.

Classroom observations hinted that self-assessment did not go beyond self-marking. Learners marked their own classwork or homework using a memorandum that had been written on the chalkboard. This is probably done because the teachers think that self-marking and self-assessment are the same thing. In interviews the following was said: Teacher BE: "…one can assess himself or herself by marking his own work …"; Teacher CE: "… I ask them to assess themselves using facilities [sic] like a red pen …"

Teachers assumed that the learners' marking would be accurate. It was found that this was not always the case. At school CE for example, it was found that some learners had accepted 9 as a prime number and marked it correct.

Additionally, the learners marked sums correct simply because the value of the final answer was the same as the correct answer, without the sum being mathematically correct. The following example was found in school BE:

Perimeter = 2 length x 2 breadth
= 2 x 4 x 2 x 2
= 12 (marked correct)

Instead of: Perimeter = 2 length + 2 breadth
= 2 x 4 cm + 2 x 2 cm
= 12 cm

This showed that both teachers and learners over-emphasised the importance of the answers.

It was also found that learners did not write the whole correct answer in their workbooks. Some learners just marked their answer wrong and next to it write the final correct answer. Example from a learner in school AA:

Opp ▭ $= \frac{1}{2}(12) \times 4$
$= 6 \times 4$
$= 24\ \text{cm}^2$ × 36

In all schools it was found that the learners did not always mark their homework as right or wrong.

At schools BA, BE, CE, D1 and D2 there were many open pages in the workbooks. There were also cases where the dates of work done were weeks apart. The researcher could not establish with certainty whether this was because learners had been absent or because learners just had not done their homework. In the case of D1 and D2, the attendance registers hinted that mostly the learners had been absent: however, teachers BA, BE and CE could not provide registers.

Teachers BA and CA indicated in interviews that the learners themselves were not very committed to doing homework. Teachers BE, CE, D1 and D2 explained that the learners' lack of commitment meant that most work was done at school. Classroom observations indicated that very few learners asked questions in the class. This raised concerns about learners' commitment to self-assessment if they did not even attempt to do their homework or ask questions in mathematics classrooms.

6.3.3.9 Group work

In 2.2.2.2, 2.2.5.5 and 2.3.6 the importance of collaborative work was discussed as an essential element in the teaching and learning process. Through classroom observations, the following concerns regarding collaborative work arose: some teachers (like AA and CA) rarely used group work and the teachers who did, used it ineffectively.

Teacher AA admitted during the interview that she used group work from time to time but not very often; and teacher CA remarked that he "does not use group work per se". This being so, the chances of collaborative learning are restricted.

Classes at schools BE, CE, D1 and D2 sat in groups permanently so that group work could be done at any time. The teachers at these schools used group work more often than individual work. Teacher BA also used group work frequently but the learners did not sit in permanent groups. For this reason, the teacher instructed the two learners sitting in front of two other learners to turn around to form groups of four without rearranging the classroom. The tables in class BE were arranged in such a way that the learners were facing each other - but they could always see the board. In classes BA, CE, D1 and D2, some learners sat with their backs to the board and had to turn around when the teachers were writing on the board. This caused difficulties when learners had to copy work from the board onto their workbooks.

In all cases where group work was done, it was simple group work and did not involve co-operative learning (cf. 2.3.6). The instructions were always the same: "Discuss in your groups…" and later, "give the answer…" In some classes the learners spoke in the vernacular so that the researcher could not really determine whether the learners were talking about the work or not. The learners' actions indicated that some learners were in fact discussing the work. Teachers AE, BA, BE and D1 moved between the groups, assisting the learners. Teacher AE also asked the learners questions and asked them for explanations. The only assistance that teachers BA, BE and D1 offered was in the form of explanations. Teacher CE moved from group to group but did not always assist the learners with their problems (cf. 6.3.2.6.1). In some cases he explained work that had been done previously but that was unrelated to the current topic. Teacher D2 stayed in front of the board and did not move around when group work was being done. The rest of the time he was always busy explaining work to learners. In cases where teachers went around, supporting learners in groups, most of the time the teachers could not manage to visit all groups before the end of the period or before they decided that feedback was due. In the case of teacher CE, too great a responsibly was placed on the learners during group work.

While doing group work, learners' involvement was also questionable, except in class AE where the teacher took out practical apparatus. In this case everybody attempted to do the required task. For teachers BA, BE, CE, D1 and D2 there were always learners who remained silent during group work. In CE's classes, the researcher noticed that a number of learners did not write anything in their workbooks while doing group work. In the case of teacher D2's classes, in which the learners did use their workbooks, it appeared that most of the time only certain learners participated in discussions.

6.3.3.10 Learner involvement in formative assessment

From interviews it became apparent that most teachers were generally in favour of learners doing quite a few mathematical problems themselves before moving on to a new topic. This gave learners a chance to find out where their difficulties were and/or strengths in this formative exercise. Follow-up actions could then be planned. In the case of schools BE, CE and D2, there was less opportunity for learners to do formative exercises. Because teachers BE and D1 did not give learners as a rule homework to do, the learners did not have enough opportunity to do as many exercises as the learners in schools AA, AE and CA. A lack of resources, such as not enough photocopies, contributed to the problem. Although teacher D2 did give homework, because of socio-economic problems, it was also not completed properly. Document analysis showed that in the books of the learners attending school AA, AE and CA significantly more exercises had been done than in the books of the learners in the other schools. It appeared that the number of assignments done by learners decreased significantly when fewer resources were available. Although teacher BA gave the learners homework, document analysis revealed that the learners' written work was in line with the quantities of work done in schools BE, CE, D1 and D2.

As formative assessment requires learners to interrogate their own learning (cf. 3.6), an important aspect of this type of assessment is that learners should answer and ask questions during lessons. During classroom observations it became evident that very few learners asked questions in front of the whole class. This was better when learners could speak to the teachers individually or in groups. In every class it was always the same few learners who answered the questions. This was true for all schools

6.3.3.11 Question-and-answer sessions

In 3.9.1 the use of questions and answers as a formative assessment strategy was discussed. The use of open-ended questions (cf. 3.9.1.2), handling responses (cf. 3.9.1.3) and allowing enough waiting time (cf. 3.9.1.4) was discussed.

In classroom observations it was noticed that teachers AA, BE and D1 did not allow learners time to think. These teachers called out the names of learners to answer the questions immediately after putting the question. Teachers AE, BA and D2 allowed more time for learners to think, but they directed the questions at the class as a whole and any learner who wanted could answer questions. The result was that a big group of learners remained relatively inactive during these sessions.

Furthermore, the researcher observed that the teachers usually asked closed-questions during question-and-answer sessions. The questions were lower order questions such as: "What is the formula to calculate the perimeter of a rectangle?" or: "4^2?" and "8 x 9 = ?" Questions were testing knowledge or direct application. This corresponded with document analysis which also showed that the learners were not asked to answer written open-ended questions (cf. 6.3.3.3) and that teachers did not plan for question-and-answer sessions (cf. 6.3.3.2).

6.3.3.12 Feedback

Feedback forms a non-negotiable part of formative assessment. In 3.7.6.3 (cf. Table 3.3 also), productive and counter-productive feedback was discussed.

From the interviews it became apparent that the teachers saw feedback as the answers to homework and classwork exercises. When asked what role feedback played in the assessment of mathematics in their classrooms, examples of replies were as follows: "…as hulle vandag werk gedoen het in die klas en hulle kry bietjie huiswerkies om meer te gaan oefen. Dan, die volgende dag kom hulle terug en ons merk eers daardie huiswerk" (…if they do work in class today, they get homework to go and practice more. Then the following day they come back and we first mark the homework – teacher AE). Teacher CE: "…after they've been given classwork or the group work in the class, now this is done after that [sic]: checked by the teacher on the chalkboard together". During classroom observations, no task-orientated feedback was given during lessons. Document analysis also showed that no written task-orientate feedback was given to learners in their workbooks.

When handling question-and-answer sessions, teachers did not provide any appropriate feedback. The researcher observed that teachers asked questions and occasionally remarked "Good" or "Correct" if learners had given the correct answer. In other cases teachers did not give any indication of whether answers were right of wrong. The following is example of such an event occurring during classroom observations in school BE:

Teacher BE: Learner 1, do you know how to calculate the perimeter of a rectangle?

Learner 1: Length x breadth

Teacher BE: Learner 2, how do you calculate the area of a rectangle?

Learner 2: Length x breadth

Teacher BE: How do you calculate the perimeter of a rectangle, Learner 3?

Learner 3: I don't know

Teacher BE: Learner 4?

Learner 4: Length plus breadth plus length plus breadth

The teacher proceeded with further questions. Learner 1 did not get an indication that his answer had been wrong and neither did the teacher return to the learner (1) to find out if he was able to give the correct answer or ensure that the misconceptions had been cleared. Learner 2 did not get any feedback about whether her answer had been correct, either.

6.3.3.13 Baseline assessment

In 3.4 it was discussed that new mathematical knowledge should be connected to existing knowledge. In order to do this effectively, it is important that new knowledge should be linked to the learners' prior-knowledge. In 3.5, it was suggested that baseline assessment should not just take place at the beginning of a new topic, but throughout the learning process.

When document analysis was done, no evidence could be found in the learners' workbooks that baseline assessment had been done to establish the learners' prior-knowledge. Teachers AE and BA indicated that they had given learners baseline tests to write at the beginning of the year to find out what they knew - but there was no evidence of this in learners' workbooks. No evidence of baseline assessment could be found in teachers' files either. All teachers indicated that they did baseline assessment through a question-and-answer series. In the interviews the researcher had to reformulate questions regarding baseline assessment since the term was unfamiliar to the teachers. The teachers answered as follows when asked how they determined learners' prior-knowledge: Teacher AA: "Nee, dit is nie 'n toets nie, ek vra vrae…" (No it is not a test, I ask questions…); teacher AE: "Ja, dit is gewoonlik vrae en antwoorde" (Yes, it is usually question and answers). Teacher BE used the word baseline after he had heard the researcher use it: "I do it as my introduction of my lesson. I start with the baseline to see how much do they know [sic] about the topic. It usually is questions". Teacher D2 commented: "…just from the questions, maybe to check whether they got a background [sic]". All the other teachers gave similar remarks.

As already discussed in 6.3.3.2, the teachers did not plan their questions. It can rather be said that the teachers choose the questions intuitively.

6.3.3.14 Dialogue

In a constructivist classroom, dialogue is of the utmost importance (cf. 2.3.5.1.1). Should dialogue only take place in one direction, it results in what Freire calls "banking education" (cf. 2.3.5.1.1).

During classroom observations, no dialogue between teachers and learners was observed. The teachers continued to explain to the learners how mathematics should be done. The learners asked few questions and the question-and-answer sessions did not result in dialogue. Some teachers tended to answer their own questions.

The teachers structured lessons in a similar way to the behaviorist example in 2.2.1.2, using an algorithmic approach to teaching (cf. 6.3.3.1). Teachers did acknowledge that learners should use their own methods, but when helping learners, the teachers always referred to their own method. In 4.3.2 it was mentioned that, if teachers valued learners' understanding rather than rote memorisation, they would give the learners activities that promote understanding. Classroom observations, document analysis and interviews indicated that this was not the case.

Even in class AE, where practical work was done, the teacher guided the practical work so that learners would deduce what was necessary. In 2.3.5.1.1, the teacher's role as a facilitator was discussed. It appears that facilitation was absent in all the classes and that the teachers still imposed their knowledge instead of facilitating the process to allow learners to construct their own knowledge from it.

6.3.3.15 Duration of contact sessions and the number of learners per class

From lessons in all observed classes, it soon became apparent that the school periods were too short to conclude lessons properly. Where learners stayed in mathematics classes for two consecutive periods it did not happen as often as with single periods. Consequently, not all learners who required assistance from their teacher received the necessary assistance. Teachers also often had to rush to finish lessons without paying enough attention to whether the learners had conceptualized the mathematics correctly or not. The number of learners in the classes of teachers AA, AE, BA, BE, CA and CE made it impossible for the teachers to attend to all of the learners' problems, especially because of the short time allowed per period. In none of the observed lessons could the teachers assist all learners during classwork, whether learners were working in groups (teachers AE, BA, BE, CE and D1) or individually (teacher AA). This was so despite the fact that teacher D1 could increase the duration of her period without influencing the school’s time-table. Teacher D2 did not assist learners during group work.

6.3.3.16 Availability of resources

Resources influence the implementation of formative assessment in the sense that learners require implements like stationery and calculators to do formative assessment (in this case, with the limited strategies used, the implements are only used for classwork and homework). The lack of textbooks and notes raised the concern that the learners would not have a frame of reference when doing follow-up assessment tasks. Learners actually had no sources of information to refer to when completing a task; neither did they have the information needed to prepare for tests or examinations. Learners needed resources such as textbooks or photocopies as sources of exercises to determine their progress regarding a topic.

Document analysis, classroom observations and interviews revealed that the only two well-resourced schools were school AA and AE. All the learners had textbooks, most had calculators and, when apparatus was used, there was enough available for all learners to handle. Both schools had a computer centre with access to the Internet. Stationery was not a problem.

In the cases of schools BA, BE, CE and D2, the resources were limited. There were no textbooks for learners, no apparatus and few calculators (they had to be supplied by the learners themselves). Learners did not have enough stationery. In all schools, however, learners had workbooks, some with hard covers; and some ordinary 72-page books.

Learners of school CA received notes that they had to paste into their books as the teacher used a set of ready-made notes with examples and exercises that could be copied, instead of a textbook. Enough copies were made so that all learners got a copy. At school CA, learners had more or less the required stationery and most had calculators. Few learners had drawing instruments for lessons and the teacher did not have drawing equipment for the board.

At school CE there was no textbooks. Despite this, learners received one photocopied paper per group if classwork was being done. At the end of the period these pages were taken back to be used by the next class. Bearing in mind that classwork flowed over into homework, the necessity for learners to copy exercises into their books before they answered the questions was obvious. This took up precious class time, which could have been used for teaching. In general, the researcher observed that where learners had to copy work because of the unavailability of textbooks, like in the case of BA, BE, CE and D2, it was very time-consuming. Furthermore, the researcher noted that some learners did not write the questions into their workbooks.

Surprisingly, at school D1 where textbooks were available the teacher is quoted as follows: “I don’t like textbooks”. However, she did request learners to do the exercises in the textbook and occasionally she gave learners copied exercises that had been taken from other textbooks.

Problems were also experienced when learners were involved in group work. In class BA, where the researcher could understand conversations in groups, the following example illustrates how learners got stuck during group work:

Learner 1: Ek dink ons moet Pythagoras gebruik (I think we must use Pythagors)
Learner 2: Ek ken dit nie (I don’t know it)

Learner 1: Ja man, ons het dit gedoen (turning to learner 3) kan jy dit onthou? (Yes, we have done it – can you remember it?)

Learner 3: Nee (No)

Learner 1: (Turns to learner 4 in another group.)

Learner 1: Kan jy onthou wat het ons met Pythagoras gedoen? (Can you remember what we did with Pythagoras?)

Learner 4: Ek dink dit was driehoeke (I think it was triangles)

Learner 1: Nee, man daar was iets van vierkante (No there was something about squares)

Since there were no resources available, learners remained stuck and the teacher did not get an opportunity to assist them because the period was over before this could happen.

6.3.3.17 Lesson outcomes

In 2.2.5.4 the importance of goal-orientated learning was explained. Section 3.8 considered the principle that when learners are goal oriented, they work more purposefully. For this to happen, learners need to know what is expected of them.

During classroom observations the researcher noted that teachers did not formulate the outcomes of the lessons. Teachers such as AA started their lessons by saying: "Vandag gaan ons weer kyk na …" (Today we will again look at …). Apart from specifying the topic, there is no other way in which teachers can inform learners of the outcomes for the lesson. In the document analysis it was seen that teachers did not write lesson outcomes on the lesson plans. However, they did write the number of the intended learning outcomes as the appeared in the policy document on their lesson plans. Teacher CE wrote out the learning outcomes fully (as they appear in the policy document).

6.4 PRESENTATION, ANALYSIS AND INTERPRETATION OF QUANTITATIVE DATA

As mentioned in 5.2, a mixed-methods research design was used in this research project. After the qualitative research had been done, a quantitative study was conducted to triangulate the data from the qualitative research. Where the qualitative research was performed on specific dates pre-arranged with teachers, the quantitative research stretched wider time wise in the sense that the learners' responses were based on their experience over a longer period of time.

In this section the quantitative data obtained by means of a questionnaire (cf. Appendix C) will be presented and analysed. In each subsection, quantitative presentation and analysis of the data will take place, followed by interpretation which involves comparing the data with the relevant qualitative data and/or quantitative data. These processes took place simultaneously.

6.4.1 Number of respondents

In total, 661 learners from the eight participating schools completed the questionnaires. These learners were taught mathematics by the teachers who participated in the study. Of these learners, 116 were in grade 8 and 543 were in grade 9. Two learners did not indicate their grade.

One teacher from every school participated in the study and at some schools the particular teacher taught more than one grade 8 and/or grade 9 class. The following table indicates the number of learners per school per teacher participating in the study:

Table 6.4: Number of learners per teacher participating in the study

	AA	**AE**	**BA**	**BE**	**CA**	**CE**	**D1**	**D2**	**Total**
Number of gr. 8 and 9 learners taught by teacher	115	142	94	149	36	145	15	42	738
Number of learners answering questionnaires	112	138	79	130	32	126	10	34	661
Percentage answering questionnaires	97,4	97,2	84,0	87,2	88,9	86,9	66,7	80,9	89,6
Gr. 9 classes	3	5	2	5	1	3	1	1	21
Gr. 8 classes	1	0	1	0	0	1	1	1	5

Of the learners taught by teachers participating in the study, 89,6% completed the questionnaires. The highest percentage of learners that completed the questionnaires was at schools AA and AE. This can be attributed to the fact that at these schools, absenteeism was less of a problem than at the other schools. The lower percentage of learners who completed the questionnaires in D1 and D2 can be attributed to the fact that learners at these schools are absent more frequently than at the other participating schools because of problems such as the unavailability of transport (cf. 6.3.2.7, 6.3.2.8).

6.4.2 Biographical detail of respondents

Of the 661 respondents, 344 were male and 317 were female (N = 661).

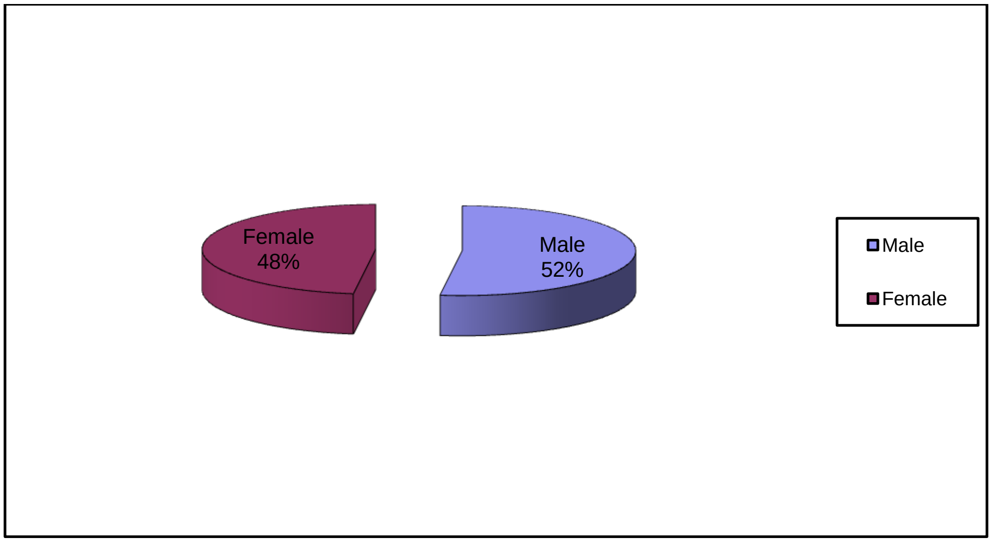


Figure 6.1 Gender distribution of respondents

The home languages of learners participating in the study are represented in figure 6.2:

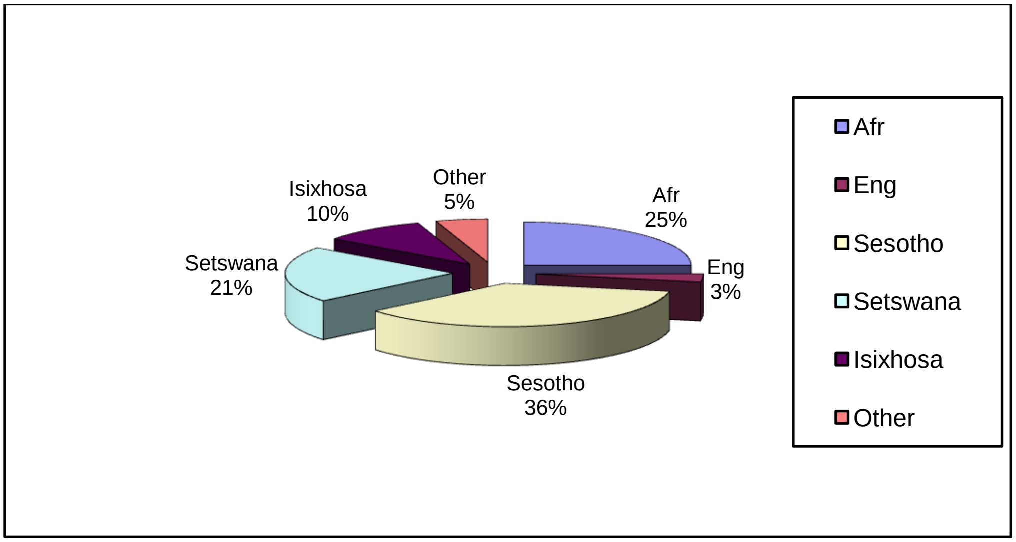


Figure 6.2 Home language of respondents

English, Afrikaans, SeSotho, SeTswana and IsiXhosa are the languages mostly spoken in the Free State. Languages grouped under "Other" included South African languages not normally spoken in the Free State such as IsiZulu and TschiVenda, but they also included foreign languages such as Mandarin (Chinese) and Mandarin Chinese, Taiwanese or Cantonese (Taiwan). Most respondents participating in the study are taught in a language different from their home language, as illustrated in the next figure:

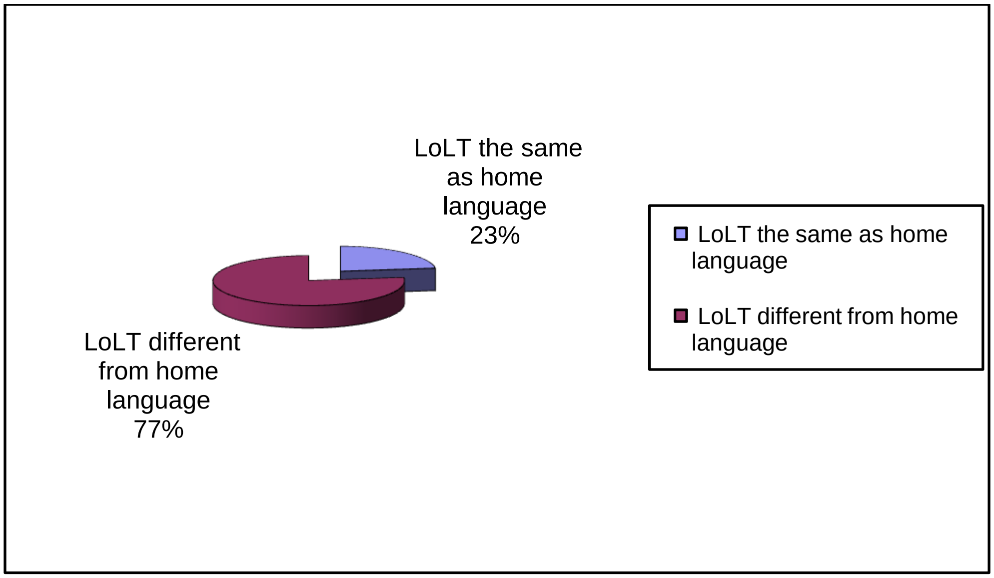


Figure 6.3: Language of learning and teaching

Figure 6.4 displays the respondents' achievements in mathematics at the end of the term before the research took place. The achievements for grade 8 and 9 learners are shown on the same graph because all marks are reflected as a percentage, and learners are assessed on a level appropriate to them.

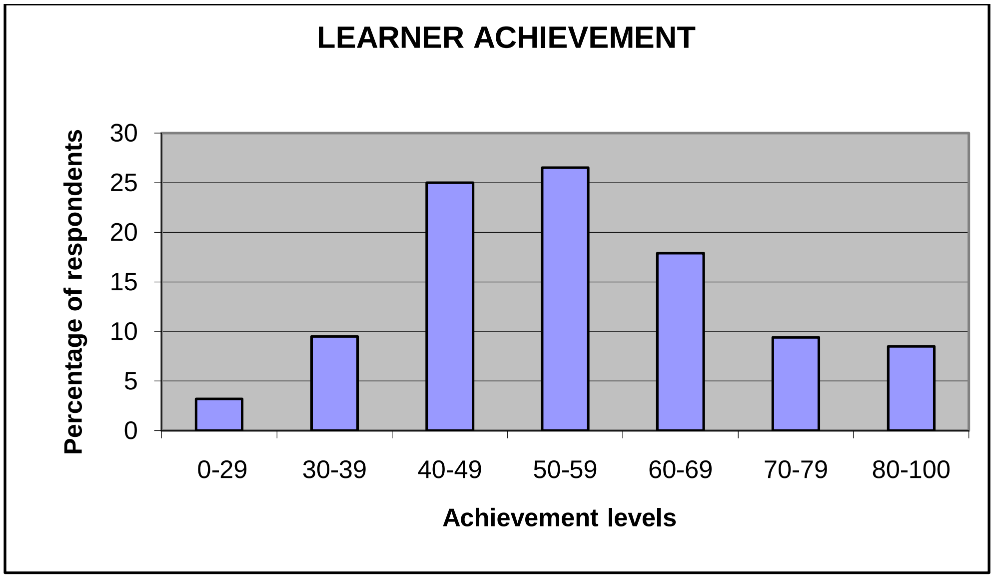


Figure 6.4: Respondents' achievement in mathematics

In figure 6.4 it can be seen that this representation of learners' achievements inclines towards a normal distribution curve with the exceptions that the number of learners in the achievement level 40-49% is higher than in a normal distribution curve, as is the number of learners in the 80-100% level.

6.4.3 Reliability of questionnaire

In Table 6.5, a summary of the total number of cases who completed the formative assessment section (cf. Appendix C; Section B; Part 1), the teaching-learning environment (see Appendix C; Section B; Part 2) and the questionnaire as a whole is indicated.

Table 6.5: Number of cases for formative assessment and classroom environment

<table>
<tr><th colspan="4">Formative assessment</th><th colspan="4">Classroom environment</th></tr>
<tr><td colspan="2"></td><td>N</td><td>%</td><td colspan="2"></td><td>N</td><td>%</td></tr>
<tr><td rowspan="3">Cases</td><td>Valid</td><td>531</td><td>80,3</td><td>Cases</td><td>Valid</td><td>524</td><td>79,3</td></tr>
<tr><td>Excluded</td><td>130</td><td>19,7</td><td></td><td>Excluded</td><td>137</td><td>20,6</td></tr>
<tr><td>Total</td><td>661</td><td>100</td><td></td><td>Total</td><td>661</td><td>100</td></tr>
<tr><th colspan="8">ENTIRE QUESTIONNAIRE</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2">N</td><td colspan="2">%</td></tr>
<tr><td colspan="2" rowspan="3">Cases</td><td colspan="2">Valid</td><td colspan="2">445</td><td colspan="2">67.3</td></tr>
<tr><td colspan="2">Excluded</td><td colspan="2">216</td><td colspan="2">32.7</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">661</td><td colspan="2">100</td></tr>
</table>

The total of 130 of the cases for the formative assessment part (i.e. Section B; Part 1) of the questionnaire were excluded; and in the section on the teaching-learning environment (Section B; Part 2), 137 were excluded. Deletion of observations with missing values is necessary to calculate the Cronbach's alpha coefficient correctly. This excludes all observations with missing values from the analysis.

Section 5.2.4.3.1 discussed the fact that the Cronbach's alpha coefficient was used to determine the reliability of the two sections of the questionnaire as well as the reliability of the whole questionnaire. This is reflected in Table 6.6:

Table 6.6: Summarising Cronbach's alpha coefficient

Formative assessment		**Classroom environment**	
Cronbach's alpha coefficient	Number of items	Cronbach's alpha coefficient	Number of items
.787	32	.872	32
Entire questionnaire			
Cronbach's alpha coefficient		Number of items	
.904		64	

The formative assessment part of the questionnaire had a reliability coefficient of .787; and for part of the questionnaire concerning the classroom environment, it was .872. For the entire questionnaire, the reliability coefficient is .904. As was discussed in 5.2.4.3.1, regarding reliability, the value of .7 is low, .8 is moderate and .9 is high. Values higher than .8 are acceptable; and values below .6 are unacceptable. Although the value of .787 is not above .8, it is still acceptable (Pietersen & Maree 2007:216). In the following table, the reliability coefficient of the whole questionnaire covering all 64 items is indicated per school:

Table 6.7: Summarising Cronbach's alpha coefficient per school

School	**Cronbach's alpha coefficient**	**No of items**
AA	.918	64
AE	.910	64
BA	.889	64
BE	.890	64
CA	.938	64
CB	.858	64
D1	.961	64
D2	.746	64

From the table it can be deduced that high reliability coefficients were obtained for schools AA, AE, CA and D1. For schools BA, BE and CB, the values of the Cronbach alpha coefficient were moderate. For school D2, the value of the Cronbach alpha coefficient was low. This low Cronbach Alpha coefficient at school D2 could possibly be the result of the learners' inability to understand all statements because school D2 is very remote (cf. 6.3.2.8), the learners are not exposed to English (the language of the questionnaire) as much as the learners in the other areas.

6.4.4 Quantitative analysis and interpretation of Section B of the questionnaire

In the quantitative analysis of the data, the positive responses, namely: *agree* and *strongly agree* are grouped together. The negative responses, namely: *disagree* and *strongly disagree* are also grouped together while the *uncertain* response will be considered as a stand-alone. When coding of the questionnaires took place, the positive responses *agree* and *strongly agree* became 4 and 5 respectively and the negative responses *disagree* and *strongly disagree* became 2 and 1 respectively. The *uncertain* response had a value of 3. A question that was left unanswered was allocated a 0.

The options exercised by learners are presented as percentages. In 5.2.4.6 it was explained that the researcher investigated two methods to calculate overall responses. It was stated that in many instances the two methods yielded similar results. In line with this the researcher opted to calculate the percentage as follows: the total number of learners of all the schools in the sample who had chosen a specific option was divided by the total number of learners answering questionnaires. In cases where the results of an individual school agreed with the results of all schools collectively, the result was not reported per school.

However, if a specific school's individual result was different from that of all the schools collectively, the results of that school(s) were reported (where significant). This was done because the schools where more learners participated in the research study will influence the overall result to a greater extent if the result is calculated with the total number of learners at all schools in the sample being divided by the total number of learners answering the questionnaires.

The data of the overall responses from all schools were also compared with the responses of learners from different achievement levels. In these cases the following levels are applicable: level 1 (0 – 29)%; level 2 (30 – 39)%; level 3 (40 – 49)%; level 4 (50 – 59%); level 5 (60 – 69%); level 6 (70 – 79)%; and level 7 (80 – 100)% (cf. Question 4; Appendix C; Section A). Mention will be made of the number of learners who perform at a certain achievement level that differs from the overall response.

6.4.4.1 Formative assessment

Part 1 of Section B of the questionnaire interrogated learners' experiences of formative assessment in their mathematics classrooms. In chapter 3 the link between the attributes of formative assessment and De Corte's definition of learning was tabulated (cf. Table 3.2). The analysis of the learners' responses to the questions on formative assessment was done according to De Corte's definition (cf. 2.2.5) as the questionnaire was based on the definition (cf. 5.2.4.2).

6.4.4.1.1 Learning is constructive

Table 3.2 shows that constructivism has several implications for learning. The role of the teacher is to guide learners to make links between new and existing information, to make meaning of mathematics and to emphasise understanding. The role of the learner is to actively be part of the process (cf. 3.6). There were six statements (cf. Appendix C; Section B; Part 1) pertaining to formative assessment in a constructive teaching-learning environment, of which four (1, 19, 8 and 27) pertained to the teacher's assistance of learners when doing exercises in the mathematics classroom; and two (17 and 22) concerned learners' preferred ways of learning mathematics.

Table 6.8: Learning is constructive

	N=661			
	1 2	3	4 5	0
1. The mathematics teacher checks several times during a lesson to see if I understand the mathematics that we are doing.	74 11,2%	54 8,2%	523 79,1%	10 1,5%
19. The teacher does not check during the lesson whether I understand the mathematics that we are doing.	381 57,6%	94 14,2%	172 26,0%	14 2,1%
8. While I am struggling with a sum on my own, the teacher assists me several times during the period	127 19,2%	78 11,8%	435 65,8%	21 3,2%
27. When I am struggling with a sum alone, the teacher does not usually offer me any assistance.	410 62,0%	100 15,1%	141 21,3%	10 1,5%
17. I prefer to do a sum myself before the teacher explains it.	211 31,9%	92 13,9%	338 51,1%	20 3,0%
22. I prefer the teacher to do many examples so that I know exactly how to do the sums.	86 13,0%	44 6,7%	519 78,5%	12 1,8%

Regarding statements 1 and 8, most of learners at all the schools were of the opinion that mathematics teachers checked several times during a lesson whether they understood the mathematics that they were doing, (average 79,1%) and assisted learners during class time (65,8%). However, although the result of the negative statements (19 and 27 that appeared later in the questionnaire) was lower, the majority of learners indicated that during a lesson the mathematics teacher checked whether they understood the mathematics.

During classroom observations (cf. 6.3.2.1.1, 6.3.2.2.1, 6.3.2.3.1, 6.3.2.4.1, 6.3.2.1, 6.3.2.7, 6.3.2.8.1) the researcher noticed that the teachers asked many questions to determine what learners knew but not necessarily whether learners understood (cf. 6.3.3.3, 6.3.3.11). In addition, she perceived that teachers would ask all the learners in the class in general: "Do you understand?" or, "Are we together?" This could give the learners the impression that the teachers were trying to find out what they understood - and this might be the reason why their overall response to statement 1 was positive.

In the qualitative analysis of data gathered during the mentioned classroom observations as well as what was gleaned from the interviews, it could be concluded that teachers supported the learners - especially those who requested assistance (although not all learners always) - while doing exercises/activities in class. The duration of the periods and the number of learners in a class influenced this support, since teachers could not help all learners who requested assistance during class time (cf. 6.3.3.15). In some instances teachers did not succeed in assisting all learners within the time frame of one period. None of the teachers made any alternative arrangement to assist the learners who still required help at the end of the period. Also, no follow-up was planned in which they could establish whether learners whose problems had been addressed, understood the work properly.

Statement 17 elicited a mixed response. Slightly more than half of the learners overall (51,1%) preferred to do a sum before the teacher explained it; while 31,9% of learners did not want to struggle with a sum before the teacher explained it. An analysis of the quantitative results per school resulted in the following graph.

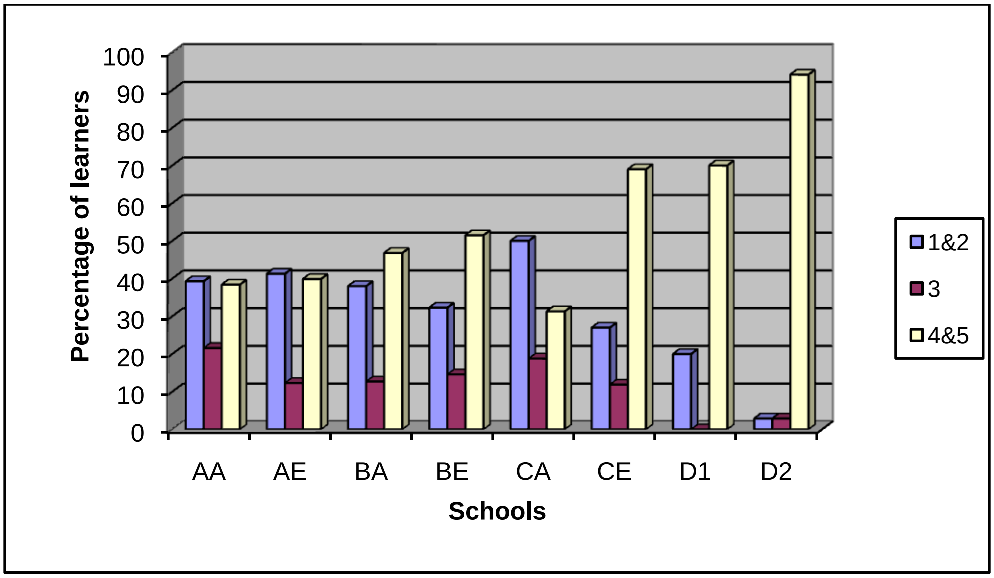


Figure 6.5: Learners' responses to statement 17 per school

In the graph, the learners of schools CE, D1 and D2 overwhelmingly agreed or strongly agreed that they would prefer to do a sum before the teacher explained it. During the classroom observations (cf. 6.3.2.6.1, 6.3.2.7.1, 6.3.2.8.1), it was observed that teachers in these classes demonstrated fewer examples than the teachers at other schools; and that the learners had to work in their groups to do exercises for classwork. It would seem that help was available to them in the form of group assistance. School CA gave the opposite response, with more learners preferring not to do a sum before the teacher had explained it. In the case of schools AA and AE, the learners who preferred to do a sum themselves numbered more or less the same as those who preferred not to do a sum themselves.

During classroom observations (cf. 6.3.2.1.1, 6.3.2.2.1, 6.3.2.5.1), lessons in classes AA, AE and CA took place in a very structured way with teachers leading learners in a specific direction when doing sums. Thereafter, the learners completed various exercises on their own, and then they practised several sums themselves based on the examples done by the teacher. This was not done in groups - although learners were not forbidden to speak to each other. Learners were thus not necessarily getting help from other learners. In schools BA and BE, the number of learners who were willing to try a sum before the teacher had explained it was greater than those who did not, with a smaller difference than in the cases of CE, D1 and D2. Lessons at schools BA and BE were also structured in the same way as in schools AA, AE and CA, except that the learners worked more in groups to discuss classwork.

The analysis of statement 17 in terms of performance levels is shown in figure 6.5:

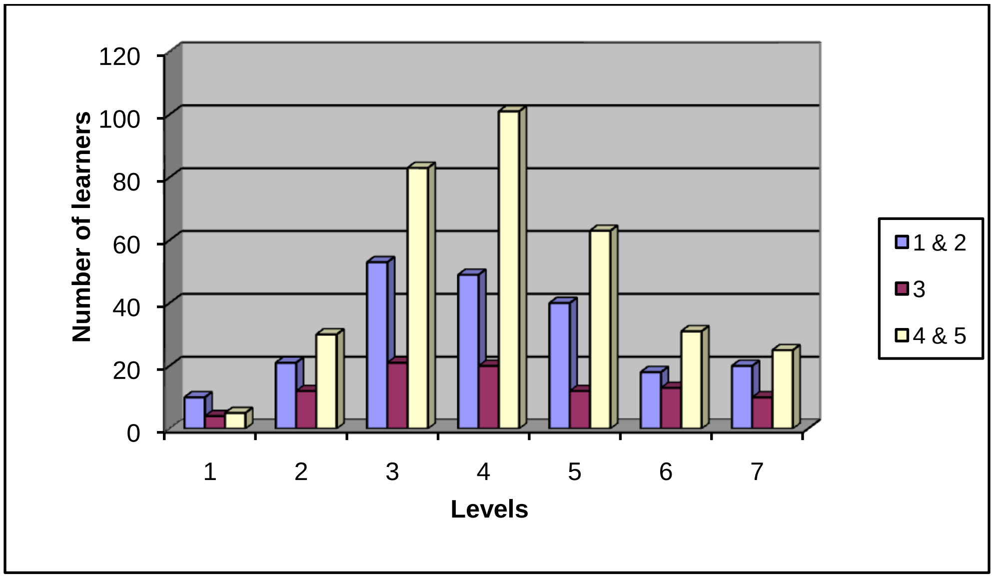


Figure 6.6: Analysis of statement 17 in terms of achievement

More level 1 learners disagreed with the statement that they liked to do a sum before the teacher did it. For all the other levels, more learners agreed that they preferred to do a sum before the teacher did it. The group who were most positive about trying a sum first was the level 4 learners. The lowest achievers were thus less willing to try a sum before the teacher had done it, than higher achievers. Overall it can be said that more learners were willing to try a sum before the teacher explained it, should they get the chance to do so. Results from qualitative research have shown that teachers structure lessons in such a way that they do examples with learners first before they allow learners to practise them in exercises done in class or at home (cf. 6.3.3.14). Learners are thus used to this way of work.

Regarding statement 22, the results were the same at all the schools, with high percentages of learners either agreeing or agreeing strongly with the statement. This is in line with classroom observations where it was noted that teachers structured their lessons in such a way that examples were always done first - before the learners were given an opportunity to practise them.

Although (when setting the questionnaire) the intention was that statements 17 and 22 should be opposites, there is a possibility that not all learners interpreted it like this. Statement 17 did not clearly indicate when the learners preferred to do a sum themselves. It intended to say that learners preferred to do a sum themselves before the teacher had done any work on the topic. Learners could have interpreted it to mean that they preferred doing sums themselves during classwork, before the teacher gave them the memorandum. The answers to statement 22 could thus be more accurate when considering the way in which learners preferred to learn mathematics (behaviourism versus constructivism). This is because the statement could lead to fewer misinterpretations. A comparison of this result with the results obtained from the qualitative research (cf. 6.3.3.1, 6.3.3.14) confirms that learners prefer the behaviouristic way of learning: teachers doing many examples.

6.4.4.1.2 Learning is cumulative

The concept that learning is cumulative had strong implications for formative assessment: that teachers should continuously determine what learners already know and then link new knowledge to existing knowledge (cf. 3.4, 3.5). Statements 3 and 15 were about linking new knowledge to existing knowledge.

Table 6.9: Learning is cumulative

	N=661					
	1	2	3	4	5	0
3. The mathematics teacher always tries to find out what I know about a topic before he/she starts explaining new work.	109 16,5%		69 10,4%	470 71,1%		13 2,0%
15. The mathematics teacher often talks about things in the mathematics class that I do not have any idea about.	285 43,1%		125 18,9%	231 34,9%		20 3,0%

Overall 71,1% of learners agreed or strongly agreed with statement 3. However, the negative statement (15) did not evoke the opposite response as expected. Less than half of the learners (43,1%) disagreed or strongly disagreed with the statement. The wording of the statements could have caused the confusion. Statement 3 is specific about prior-knowledge in mathematics whereas statement 15 could imply that teachers spoke about other matters in the mathematics class. Qualitative research does not assist with the interpretation here as the learners filled in the questionnaires based on experiences that had developed over a longer period of time than the time it took for the observations to be done.

A further analysis of statement 15 that studied the results for each school showed that schools AA, AE, BE and CA responded differently from the overall result:

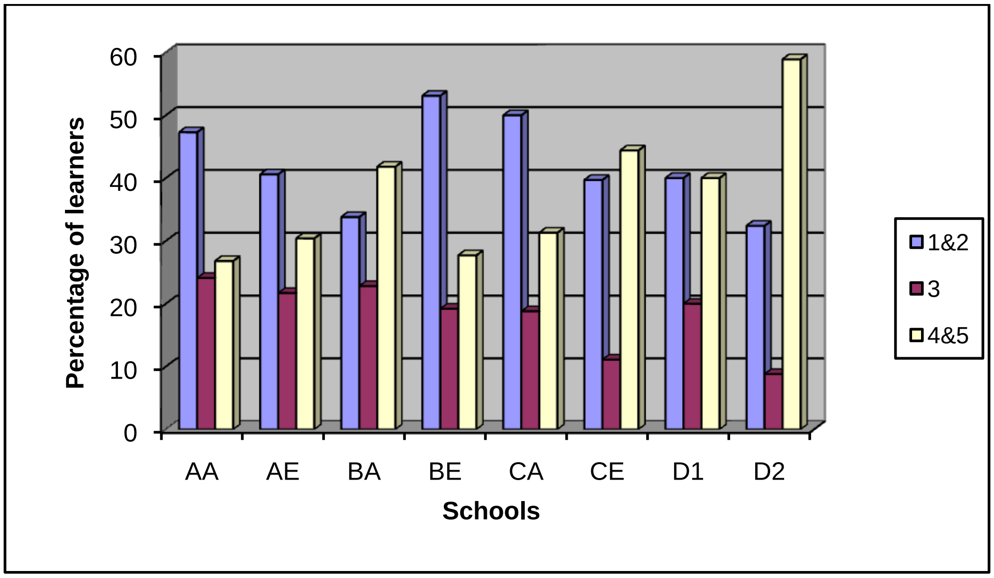


Figure 6.7: Learners' responses to statement 15

For schools AA, AE, BE and CA, more learners disagreed or strongly disagreed with the statement that in the mathematics class the teacher often talked about things of which they were totally ignorant. This result can be interpreted together with the qualitative results from individual schools. In schools AA, AE, BE and CA, the lessons were structured in such a way that the teachers always did examples before giving the classwork to do. Generally, teachers AA, AE and CA presented lessons in which specific methods of doing sums were propagated. Teacher BE also had specific ideas in mind about how to do a sum, but allowed learners more exploration during group work.

When the results of the statement that learning is cumulative are compared with the qualitative analysis (cf. 6.3.3.13), it would appear that the reason why learners often did not have any idea about what the teacher was talking could be the teachers' omission of a proper baseline assessment. It could also have resulted from their negligence in attending to the needs of individual learners (cf. 6.3.3.7). In the case of school CE, it can also be that the teacher's presentation of his lessons confused his learners (cf. 6.3.2.6.1).

6.4.4.1.3 Learning is self-regulated

Attributes 4 and 5 of formative assessment emphasise the learners' role in this type of assessment. Attribute 4 specifically focuses on the learners' active involvement in all aspects of formative assessment (cf. 3.6.1) and their commitment to doing it. Attribute 5 focuses on the importance of self-regulation (cf. 3.7) and self-assessment (cf. 3.7.3) as part of meta-cognition (cf. 3.7.2). Teachers should make classwork and homework relevant to learners so that they know that doing it will aid their understanding and assist them to take ownership of learning (cf. 3.7.4).

Table 6.10: Learning is self-regulated

	N=661					
	1	2	3	4	5	0
4. The classwork and homework that we do in mathematics help me to know if I can do the mathematics.	36 5,4%		34 5,1%	584 88,4%		7 1,1%
18. The classwork and homework that we do in mathematics do not help me to know whether I can do the mathematics.	433 65,5%		75 11,3%	137 20,7%		16 2,4%

23.	I like to assess myself in mathematics so that I know exactly what I do right and what I do wrong.	97 14,7%	90 13,6%	465 70,3%	9 1,4%
5.	I do not like to assess myself in the mathematics class.	301 45,5%	98 14,8%	240 36,3%	22 3,3%
6.	I know when my answers are correct in mathematics even if the teacher has not yet given the answer.	173 26,2%	181 27,4%	297 44,9%	10 1,5%
20.	I am not always sure whether I am doing the mathematics right or wrong.	177 26,8%	160 24,2%	311 47,1%	13 2,0%
30.	I do my mathematics homework regularly.	114 17,2%	89 13,5%	444 67,2%	14 2,1%
7.	I don't do my mathematics homework regularly.	363 54,9%	73 11,0%	205 31,0%	20 3,0%

Statements 4 and 18 did not elicit exactly the same response, but the answers to both strongly suggest that learners believe that the homework they do in mathematics assists them to know whether they can do the mathematics or not. These statements involved the words *classwork* and *homework* since the idea of formative assessment tasks is not known to learners who are unfamiliar with the complex terminology associated with formative assessment.

Of the respondents, 70,3% agreed with the statement (23) that they liked to assess themselves in mathematics; while a considerably lower 45,5% disagreed or strongly disagreed with the negative statement (5). In this case, statement 5 did not have a qualitative part as was the case in statement 23 namely: "so that

I know exactly what I do right and what I do wrong". This part of the statement clarified the statement and learners who did not know what "to assess" meant when responding to statement 5 could be assisted when responding to statement 23. Results from the qualitative research (cf. 6.3.3.8) indicated that self-assessment was more about self-marking in classes than about self-assessment. Self-marking implies that learners are expected to mark their work as either right or wrong (as stated in statement 23) according to the memorandum written on the board (cf. 6.3.3.8).

In the case of statement 6, less than half (44,9%) of all learners indicated that they knew whether their answers were right or wrong, even if the teacher had not yet given the answer. The number of learners disagreeing or strongly disagreeing with the statement was 26,7% while 27,4% were uncertain . The combined result of learners not agreeing and those who remained neutral was 54,1% which is higher than the result of those who agreed. Statement 20 did not elicit a negative response as expected. Learners agreed (47,1%) that they were not always sure whether they were doing the mathematics correctly or incorrectly. Again the statements could have been problematic since statement 6 clearly specified, "even if the teacher has not given the answer yet"; while statement 20 did not specify "when", resulting in learners who might not be sure of their answers in the same manner as in statement 6. It could, therefore, also refer to whether learners knew that the answers were right or wrong after the teacher had given the answers to classwork/homework. Results from qualitative research confirmed the latter statement: it was found that in many learners' books all classwork and homework exercises had been marked (cf. 6.3.3.8). It was also found that learners did not seek answers to exercises if they had been absent. The high percentage of uncertain responses for both statements 6 and 20 showed that learners found these statements confusing.

Correlating statements 6 and 20 with learners’ achievement resulted in the following:

Table 6.11: Correlating mathematics achievement and statements 6 and 20

	Statement 6						Statement 20					
	N =651						N =648					
	1	2	3	4	5	Tot	1	2	3	4	5	Tot
Level of achievement:												
1 (0–29)%	12		5	3		20	4		4	11		19
2 (30–39)%	19		25	18		62	19		17	26		62
3 (40–49)%	52		36	73		161	43		32	85		160
4 (50–59)%	45		44	85		174	41		42	92		175
5 (60–69)%	21		37	58		116	25		29	61		115
6 (70– 9)%	14		19	29		62	21		17	24		62
7 (80–100)%	10		15	31		56	24		19	12		55
Total	173		181	297		651	177		160	311		648

It can be said that more learners that are level 1 and 2 achievers disagreed or strongly disagreed with statement 6; whilst learners on levels 3 – 7 mostly agreed or strongly agreed with statement 6. Regarding statement 20, it was only among the highest achievers (level 7) that the majority of learners disagreed or strongly disagreed with the statement. For level 6, the difference between those who disagreed and those who agreed was slight (21 to 24). However, from level 5 and lower, the majority of learners agreed or strongly agreed that they were not always sure whether they were doing the mathematics correctly. As the analysis of qualitative research revealed that task-specific feedback was not given after formative assessment, learners found it difficult to know when their work was right and when it was wrong (cf. 6.3.3.12). The way in which teachers handled questions-and-answer series (cf. 6.3.3.11), without giving clear feedback to learners concerning whether they are right or wrong when answering questions, is also a matter of concern.

Overall 67,2% of the learners agreed or strongly agreed that they did their homework regularly (statement 30). Regarding statement 7, the number of learners who disagreed with the statement was 54,9% which is less than 67,2%. If it is taken into consideration that 31,0% of the learners answered statement 7 by agreeing or strongly agreeing that they did not do their homework regularly, it could be said that more or less one third of the learners did not do their homework regularly. When one combines the results of statements 30 and 7 with that of statement 17 (cf. Table 6.8), it appears that there were always a certain number of learners who were willing to try and do sums in the class, but who were not willing to do homework. All learners' commitment to doing homework exercises should be questioned. This was also found in qualitative research (cf. 6.3.3.8).

6.4.4.1.4 Learning is goal orientated

The importance of setting goals for formative assessment was described in 3.8. Two statements (one positive and one negative) were made about the setting of goals in mathematics.

Table 6.12: Learning is goal-orientated

	N=661					
	1	2	3	4	5	0
25. I do set goals for myself in mathematics.	115 17,4%		109 16,5%	420 63,5%		17 2,6%
14. I do not set goals for myself in mathematics.	334 50,5%		96 14,5%	207 31,3%		24 3,6%

Regarding statement 25, of the learners, 63,5% indicated that they agreed or strongly agreed. The percentage of learners who disagreed with the statement and the learners who chose the uncertain response was almost the same. This could be an indication that learners were not certain about how to respond to this statement. In terms of statement 14, about half (50,5%) of the learners disagreed or disagreed strongly with the negative statement; while 31,3% of the learners agreed or strongly agreed with the statement that they did not set goals for themselves.

Unfortunately, questions 25 and 14 did not specify the types of goals set by learners. The analysis of the qualitative research shows that it is more likely that goals were set in terms of the learners' marks and not their outcomes: because learners are not given any outcomes to achieve (cf. 6.3.3.17).

6.4.4.1.5 Learning is situated

Section 3.9.7 described that the inclusion of real life examples in the mathematics class was an essential part of bringing variety into assessment strategies and give meaning to mathematics teaching. In 4.4, the value of doing real life problems was also described as contributing to a positive teaching-learning environment.

Table 6.13: Learning is situated

	N=661					
	1	2	3	4	5	0
10. I think it is necessary to solve real-life problems in mathematics.	86 13,0%		65 9,8%	499 75,5%		11 1,7%
26. I do not think it is necessary to solve real-life problems in mathematics.	376 56,9%		99 15,0%	172 26,0%		14 2,1%

Learners answered statement 10 convincingly enough to be able to deduce that the majority of learners were under the impression that it was necessary to solve real life problems in mathematics. The reverse statement (26) was not answered as convincingly as the positive statement, a detail that could hint that learners were not certain of their response. However, document analysis did reveal that real life problems were addressed in exercises given to learners to do in class or as a home assessment task, especially in topics such as data collection, financial mathematics, probability, perimeter, area and volume calculations.

6.4.4.1.6 Learning is collaborative

Through collaborative learning and assessment, the important aspect of dialogue in the teaching and learning of mathematics can be enhanced (cf. 3.6.2, 3.7.5). It is also through collaborative learning that learners get an opportunity to be active in an attempt to make meaning of mathematics. The discussion of this section is split into three sections, based on learners' responsibilities when working collaboratively, learners' gain from working collaboratively and teachers' responsibilities when learners work collaboratively. Each statement with its negative statement will be analysed separately.

Table 6:14: Learners' responsibilities: Learning is collaborative

	N=661					
	1	2	3	4	5	0
11. When we are doing mathematics in groups, everybody in the group works together to find the answers.	121 18,3%		70 10,6%	459 69,4%		11 1,7%
32. When we are assessed in groups in the mathematics class, some learners do all the work, while others relax.	214 32,4%		58 8,8%	382 57,8%		7 1,1%

In the case of statements 11 and 32, the opposing statement did not elicit the anticipated responses. Statement 11 had 69,4% of learners agreeing or strongly agreeing with the statement; while the reverse statement 32 also had a majority of learners (57,8%) agreeing or strongly agreeing with the statement. A re-examination of the statements brought a possible explanation for this finding. In statement 11, the words "when we are doing" are used versus "when we are assessed". This might have led learners to think that statement 32 referred to when their work was marked and the marks assigned to the assessment task (for summative purposes). It is also possible that when answering statement 11, learners might have considered that everybody was working although not all group members contributed to finding the answer. In the case of statement 32, it is possible that only some learners were going to be assessed by the teacher. Analysis of qualitative research also questioned whether all learners had been involved in collaborative learning (cf. 6.3.3.9). Qualitative research also provided evidence that teachers used ordinary group work rather than co-operative learning and this could also explain why the majority of learners agreed or strongly agreed with statement 32 (cf. 6.3.3.9).

Table 6:15: Personal gain: Learning is collaborative

	N=661					
	1	2	3	4	5	0
9. I find that I can learn mathematics from discussions in groups with my peers.	86 13,0%		65 9,8%	499 75,5%		11 1,7 %
21. I cannot learn mathematics from other learners.	326 49,3%		85 12,9%	225 34,0%		25 3,8%

In the case of these two statements, once again the phrasing of the statements could have led to the discrepancy that the negative was not as strongly discarded as the agreement with positive statement. The positive statement (9) implies learning mathematics from group discussions. However, the negative statement (21) does not specifically refer to group discussions. It may be that some learners interpreted it to mean that they could learn mathematics from only *certain* learners.

Analysis showed that both statements 9 and 21 can be interpreted to mean that there was a big group of learners who believed that they could learn mathematics when discussing it with other learners. Unfortunately, a clear distinction could not be made as to whether the discussions should take place in groups or with other individuals.

Table 6:16: Teacher's responsibility: Learning is collaborative

	N=661					
	1	2	3	4	5	0
16. While we are doing group work, the teacher often assists us by asking leading questions.	79 12,0%		86 13,0%	486 74,0%		10 1,5%
28. When we are doing group work, we usually work alone; the teacher does not assist us.	429 64,9%		74 11,2%	145 21,9%		13 2,0%

The purpose of these two statements was to determine whether teachers assisted learners when they worked in groups and when the teacher assisted them, whether it was done by means of questions. The percentage of learners who agreed or strongly agreed that teachers helped them during group work amounted to 74,0%; while the reverse statement (28) had 64,9% of learners disagreeing or strongly disagreeing with the statement. Qualitative analysis indicated that teachers did assist learners when they worked in groups. Nevertheless, the quality of this assistance should be questioned (cf. 6.3.3.9). Whether teachers had the opportunity to assist all groups most of the time was also questionable (cf.6.3.3.15).

6.4.4.1.7 Learning is individually different

For formative assessment to be effective, it is essential that teachers should acknowledge that learning is individual and thus different for all learners (cf. 3.5.1). There are six statements pertaining to the idea that learning is individually different.

Table 6.17: Learning is individually different

<table>
<tr><td></td><td colspan="6">N=661</td></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>0</td></tr>
<tr><td>13. The teacher usually gives enough information so that I know exactly what I do wrong in mathematics.</td><td colspan="2">92
13,9%</td><td>80
12,1%</td><td colspan="2">481
72,8%</td><td>8
1,2%</td></tr>
<tr><td>29. I often do not have a clear idea about what I am supposed to be learning in the mathematics class.</td><td colspan="2">381
57,6%</td><td>94
14,2%</td><td colspan="2">172
26,0%</td><td>14
2,1%</td></tr>
<tr><td>24. The teacher shows exactly what I should do to improve in mathematics.</td><td colspan="2">79
12,0%</td><td>68
10,3%</td><td colspan="2">504
76,3%</td><td>10
1,5%</td></tr>
<tr><td>31. The teacher does not inform me what I do wrong in mathematics.</td><td colspan="2">434
65,7%</td><td>59
8,9%</td><td colspan="2">157
23,8%</td><td>11
1,7%</td></tr>
<tr><td>12. I feel like I am special in the mathematics class because the teacher always attends to my problems.</td><td colspan="2">223
33,7%</td><td>139
21,0%</td><td colspan="2">290
43,9%</td><td>9
1,4%</td></tr>
<tr><td>2. I don't think the mathematics teacher knows what my problems in mathematics are.</td><td colspan="2">241
36,5%</td><td>144
21,8%</td><td colspan="2">265
40,1%</td><td>11
1,7%</td></tr>
</table>

A bigger percentage (72,8%) of learners agreed with statement 13, while the negative statement (29) showed that a lower 57,6% of learners disagreed with it. Statement 29 includes the words "a clear idea" that might be confusing. This could be interpreted as understanding the task to be done while statement 29 could be interpreted as giving enough information about the task and how to execute it. Through qualitative research it was established that teachers always gave learners the answers to their classwork and homework and learners were expected to do corrections. For this reason, learners might have seen doing corrections as a way in which they could find out what they were doing right and what they were doing wrong - and thus monitoring their own progress.

In terms of the next positive statement (24) and negative statement (31), there was consensus that the learners believed that the teachers informed them about what they did wrong in mathematics. The results for statements 24 and 31 were close: 76,3% versus 65,7%. However, the qualitative research indicated that feedback had not been written in the learners' workbooks (cf. 6.3.3.12). It is possible that learners could interpret statement 31 in the sense that the teacher did give the memorandum for all exercises done and thus argued that teachers did inform them about what their mistakes in mathematics were. In 6.3.3.12 it was discussed that most teachers participating in the research viewed doing corrections as feedback to learners. Learners could thus think so too.

Results for the two statements 2 and 12 do not give a convincing majority. It also seems that many learners were uncertain about this statement.

For statement 2, more learners agreed than disagreed with the statement. Analysing statement 2 in terms of achievement level of learners shed some light on this result:

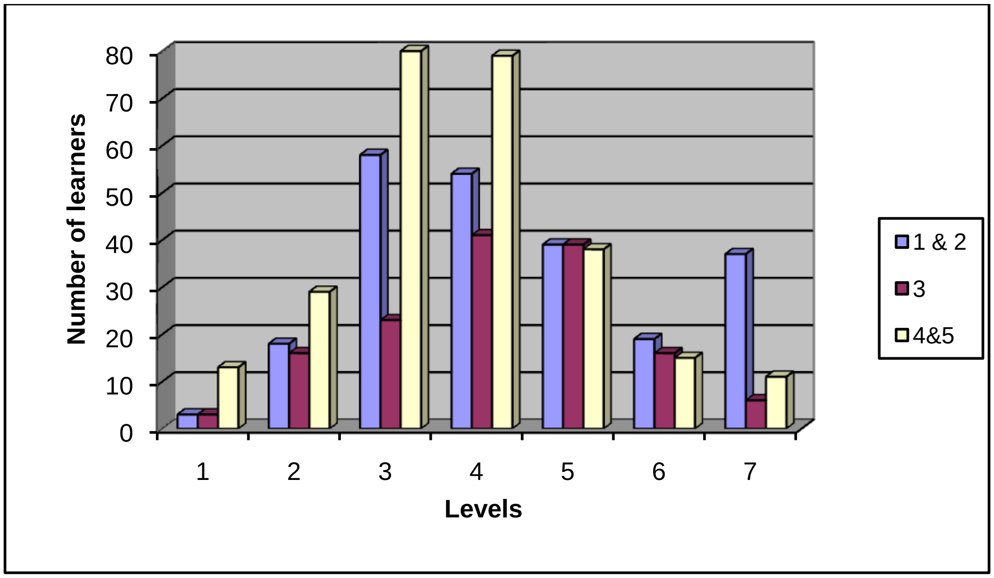


Figure 6.8: Responses of learners to statement 2

In their reactions to statement 2, the level 1 achievers did not think that the mathematics teachers knew what their problems were. This is also true for more learners on different academic levels. At level 5 the number of learners that agreed was almost the same as those that disagreed. Higher achievers – those on levels 6 and 7 - disagreed and felt that teachers were aware of what their problems were.

6.4.4.2 Teaching-learning environment

Learning takes place within a specific environment in which the learners are one of the role players. It is important that the learners' experiences of the teaching-learning environment be explored. In this section, the second part of Section B in the questionnaire (see Appendix C) will be presented and analysed. Options 1 and 2, and 4 and 5 will be combined once again. In each case the number of learners for each option will be indicated as will the percentage that this number represents of the total. Results will be reported for all schools. In cases where individual schools do not follow the general pattern, the result for the individual school(s) will be reported. Analysis of statements was also done for the learners' different performance levels and deviations from the general pattern will be discussed.

6.4.4.2.1 Relationship of trust

For formative assessment to take place effectively, learners must trust both the teacher and their fellow learners (cf. 4.6.1.1, 4.6.1.1.3, 4.6.1.2) and believe that when discussions take place they will not be ridiculed. Learners must feel comfortable in the mathematics class, and not be afraid to answer or ask questions and solve problems. Teachers and other learners should value each other's opinions. This relationship of trust is the key to a positive teaching-learning environment and it was investigated by means of 6 statements.

Table 6.18: A relationship of trust

<table>
<tr><th></th><th colspan="6">N=661</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>0</td></tr>
<tr><td>1. I feel at home in the mathematics class.</td><td colspan="2">145
21,9%</td><td>91
13,8%</td><td colspan="2">406
61,4%</td><td>19
2,9%</td></tr>
<tr><td>14. I do not feel at home in the mathematics class.</td><td colspan="2">360
54,5%</td><td>93
14,1%</td><td colspan="2">182
27,5%</td><td>26
3,9%</td></tr>
<tr><td>20. I am really excited about learning new things in the mathematics class.</td><td colspan="2">82
12,4%</td><td>92
13,9%</td><td colspan="2">465
70,3%</td><td>22
3,3%</td></tr>
<tr><td>2. Usually I do not look forward to learning new things in the mathematics class.</td><td colspan="2">383
57,9%</td><td>76
11,5%</td><td colspan="2">178
26,9%</td><td>24
3,6%</td></tr>
<tr><td>4. I look forward to being assessed in mathematics.</td><td colspan="2">107
16,2%</td><td>91
13,8%</td><td colspan="2">437
66,1%</td><td>26
3,9%</td></tr>
</table>

18. I do not look forward to be assessed in mathematics.	385 58,2%	102 15,4%	145 21,9%	29 4,4%
9. I like to answer the teacher's questions in the mathematics class.	159 24,1%	107 16,2%	365 55,2%	30 4,5%
21. I am too shy to answer to answer the teacher's questions in the mathematics class.	283 42,8%	100 15,1%	254 38,4%	24 3,6%
6. I have the courage to try to solve problems in the mathematics class.	86 13,0%	82 12,4%	470 71,1%	23 3,5%
26. I do not have the courage to solve problems in the mathematics class.	401 60,7%	89 13,5%	145 21,9%	26 3,9%
31. The teacher listens attentively to my answers in the mathematics class.	77 11,6%	109 16,5%	456 69,0%	19 2,9%
16. The teacher does not listen attentively to my answers in the mathematics classroom.	437 66,1%	78 11,8%	124 18,8%	22 3,3%

The percentage of learners agreeing or strongly agreeing with the statement 1 was 61,4%. The opposite statement (14) measured a lower percentage of 54,5%; but overall it appeared as if majority of learners felt at home in the mathematics classroom.

At all of the schools, more learners responded that they were excited about learning new things in mathematics (overall 70,3%). For the negative statement (2), however, the percentage of learners who disagreed or strongly disagreed with the statement that they did not look forward to learning new things in mathematics was lower (57,9%). When this was compared with results from the qualitative research, it seemed that learners did not mind learning new things in mathematics, because they knew that their teachers would do examples first to show them how to complete the subsequent exercises (cf. 6.3.3.1, 6.3.3.3, 6.3.3.14).

Analysis of responses for statements 4 and 18 resulted in a percentage of 66,1% of learners agreeing with the statement; while 58,2% of learners disagreed with the negative statement. These results are very similar to those for statements 20 and 2, discussed in the previous paragraph.

For statement 9, an average of 55,2% of learners agreed or strongly agreed with the statement. For statement 21 (the reverse statement), 42,8% of the learners disagreed, while 38,4% of the learners agreed that they were too shy to answer the teacher's questions in the mathematics class. The percentage of learners who was uncertain about statement 9 was 16,2%; and in response to statement 21, 15,1% was undecided. Comparing this to the information gathered by the qualitative research, one could deduce that there was a significant number of learners who did not like to answer the teachers' questions in class or who were too shy to do so (cf. 6.3.3.14). Shyness could also not be the only reason why learners did not want to answer teachers' questions.

Reacting to statement 6, the learners who indicated that they did have the courage to solve mathematics problems measured a convincing 71,1%. This percentage was also higher than the percentage indicating that learners liked to answer the teacher's questions in the mathematics class. Thus it appears as if answering questions and doing problems in writing would make learners more comfortable than doing problems and answering questions verbally. In response to the reverse statement (26), 60,7% of learners disagreed that they did not have the courage to try mathematics problems. This corresponded with the qualitative research as it was observed that when learners were asked to do classwork, they were willing to attempt it. The statement was supposed to explore problem solving as open-ended questions or questions demand more understanding and thinking, but since learners were only used to routine exercises they most probably answered the questions having this in mind.

Regarding statement 31, most (69,0%) learners judged that teachers listened to them when they answered. The negative statement (16) elicited a similar response of 66,1% in disagreement with the statement.

When the results for every school are analysed, it is evident that the majority of learners supposed that their teachers listened attentively to them. Analysis of statement 31 in terms of individual schools is as follows:

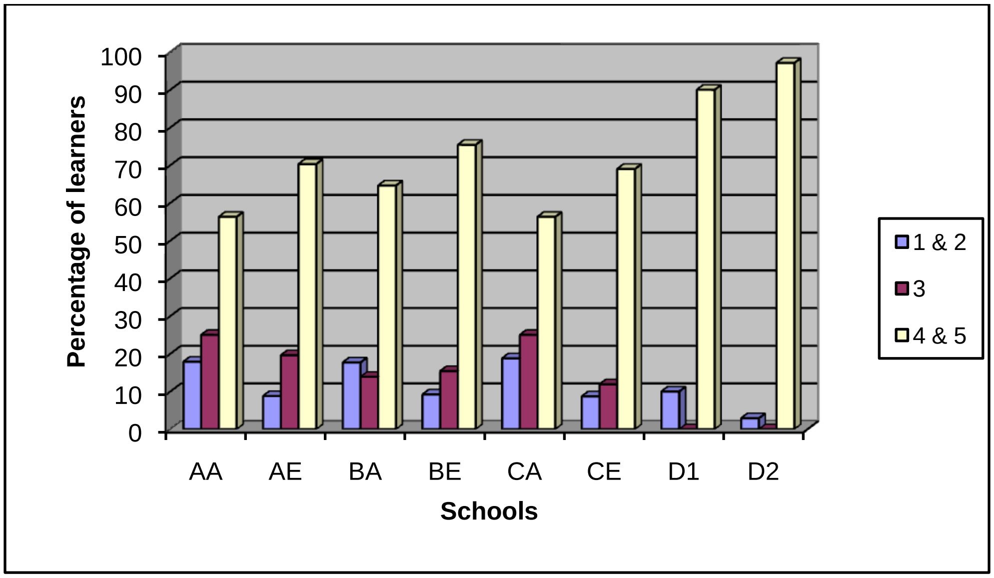


Figure 6.9: Responses of learners to statement 31

The lowest percentage of learners agreeing with statement 31 came from schools AA and CA. Since teacher AA's pace of work was observed to be very fast, learners may have felt that, since the teacher moved so quickly, she was not listening to them (cf. 6.3.2.1.1). Teacher CA, on the other hand, answered his own questions and might have given learners the impression that he was not really interested in their answers (cf. 6.3.2.5.1).

6.4.4.2.2 Ensuring “fit”

Formative assessment tasks must be aimed at the level of the learners and serve the purpose of enhancing the learning of mathematics. There are eight statements regarding ensuring “fit” in the questionnaire:

Table 6.19: Ensuring “fit”

<table>
<tr><th></th><th colspan="6">N=661</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>0</td></tr>
<tr><td>15. Many of my answers are correct in the mathematics class.</td><td colspan="2">117
17,7%</td><td>160
24,2%</td><td colspan="2">352
53,3%</td><td>32
4,8%</td></tr>
<tr><td>30. My answers are mostly wrong in the mathematics class.</td><td colspan="2">369
55,8%</td><td>111
16,8%</td><td colspan="2">156
23,6%</td><td>25
3,8%</td></tr>
<tr><td>29. When I have to learn new things in the mathematics class, I know I can learn them even if they are difficult.</td><td colspan="2">79
12,0%</td><td>77
11,6%</td><td colspan="2">485
73,4%</td><td>20
3.0%</td></tr>
<tr><td>11. Even with help and plenty of time, I am going to have difficulty learning new things in the mathematics class</td><td colspan="2">306
46,3%</td><td>94
14,2%</td><td colspan="2">239
36,2%</td><td>19
2,9%</td></tr>
<tr><td>27. The teacher allows enough time in the mathematics class for me to think when I have to answer questions.</td><td colspan="2">120
18,2%</td><td>87
13,2%</td><td colspan="2">431
65,2%</td><td>23
3,5%</td></tr>
<tr><td>3. The mathematics teacher does not allow enough time for me to think when I have to answer a question.</td><td colspan="2">358
54,2%</td><td>92
13,9%</td><td colspan="2">190
28,7%</td><td>21
3,2%</td></tr>
</table>

25. The teacher always gives us interesting real-life mathematics problems to do so that we can really use mathematics in our everyday lives.	82 12,4%	99 15,0%	459 69,4%	21 3,2%
5. The real-life mathematics problems that we do are boring most of the time.	328 49,6%	116 17,5%	190 28,7%	27 4,1%

From statements 15 and 30 it can be deduced that just more than half of the learners' answers were usually correct. The qualitative research found that differentiation did not take place and that teachers aimed lessons more or less on a general level for all learners (cf. 6.3.3.7). It is thus possible that questions were not always applicable to the learners' level at the time (they did not "fit" the learner).

For statement 29, a total of 73,4% of the learners agreed that they were able to learn new things in the mathematics class, even if they were difficult. If this is compared with the trends found in the qualitative research, the reason for this result could be that the learners knew that the teacher would do many examples when they started a new topic (cf. 6.3.3.1, 6.3.3.14). However, in response to the reverse statement (11), only 46,3% of learners disagreed that even with help and plenty of time, they would have difficulty in learning new work in the mathematics class. Although learners might have been positive that they could learn new things in mathematics and that the teachers would do many examples for them, they foresaw that it was going to be a difficult process. This negative attitude can influence the teaching-learning environment negatively (cf. 4.6.1.1.2(a))

For formative assessment to take place effectively, learners must get a chance to think about questions. For statement 27, more learners (65,2%) agreed that the mathematics teacher allowed them enough time to think when they had to answer questions. However, on the reverse statement 3, only 54,2% of learners disagreed that they were not allowed enough time to think.

If the results for statement 27 are analysed in terms of levels of performance, it can be seen that (among the lowest achievers) more learners disagreed with statement 27. For level 2 to level 7 learners, more learners agreed with the statement.

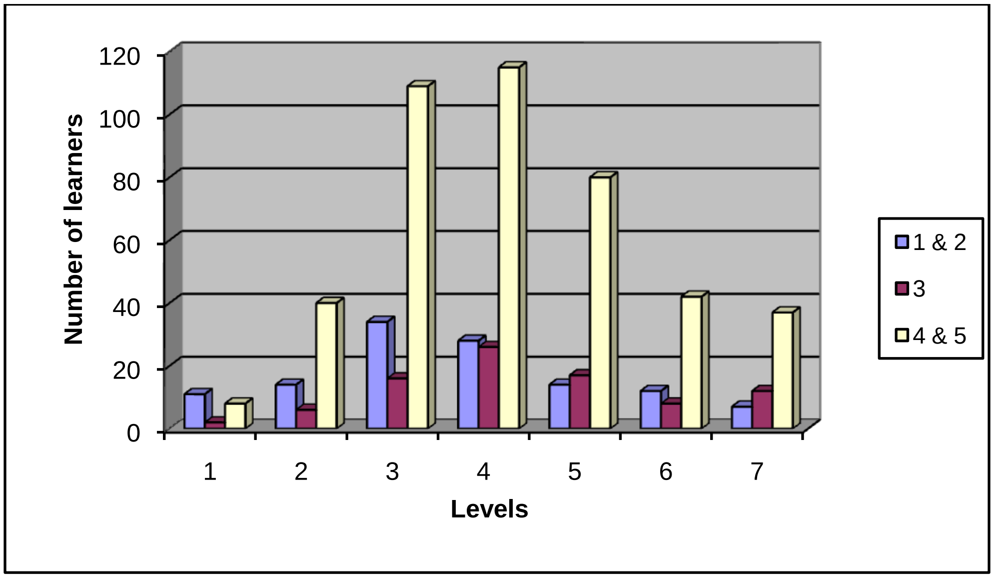


Figure 6.10: Learners' responses on statement 27 in terms of achievement

It can be said that generally the weakest performers did not think they were given enough time to think. Again this can influence the teaching-learning environment negatively (cf. 4.6.2.4).

For the positive statement (25) regarding real life problems, 69,4% of the learners agreed or strongly agreed that teachers gave them interesting real life problems to solve. The percentage of learners disagreeing or strongly disagreeing with the negative statement (5) dropped to 49,6%. The uncertain response here was 17,5%. This could be an indication that learners did not really know what the question meant.

6.4.4.2.3 Strengthening the learners' voice

In mathematics learners should also be granted the freedom to explore their own methods. The following 4 statements were put to learners and their responses indicated:

Table 6.20: Strengthening the learners' voice

<table>
<tr><th></th><th colspan="6">N=661</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>0</td></tr>
<tr><td>8. I like to ask questions in the mathematics class.</td><td colspan="2">176
26,6%</td><td>112
16,9%</td><td colspan="2">347
52,5%</td><td>26
3,9%</td></tr>
<tr><td>28. I don't like to ask questions in the mathematics class.</td><td colspan="2">309
46,7%</td><td>90
13,6%</td><td colspan="2">235
35,6%</td><td>27
4,1%</td></tr>
<tr><td>7. The teacher encourages us to use our own methods to solve problems in mathematics</td><td colspan="2">131
19,8%</td><td>90
13,6%</td><td colspan="2">417
63,1%</td><td>23
3,5%</td></tr>
<tr><td>24. The teacher wants us to use his/her methods when we solve problems in mathematics.</td><td colspan="2">262
39,6%</td><td>117
17,7%</td><td colspan="2">262
39,6%</td><td>22
3,3%</td></tr>
</table>

Reacting to statement 8, 52,5% of learners indicated that they liked to ask questions in the mathematics class. This is not quite what was found in qualitative research (6.3.3.14). It could be that the researcher's presence in the classroom influenced learners not to ask questions or that the learners did not need to ask questions in the observed lessons. Another explanation could be that the learners did not like to ask questions in front of the whole class but that they did not mind asking questions when working individually or in groups. It was observed that when teachers gave the classwork to do and started moving around, more learners requested the teacher's assistance than during the explanation.

Analysis of statement 28 in terms of learners' performance led to the following:

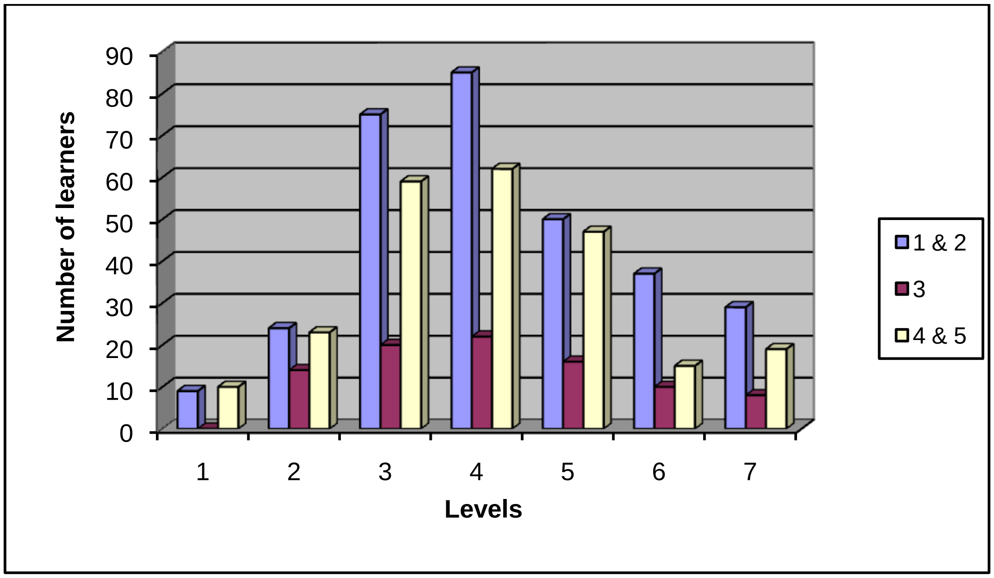


Figure 6.11: Responses of learners to statement 28

On levels 1 and 2, the number of learners agreeing with statement 28 was almost the same as the number of learners disagreeing with the statement (for level 1 slightly fewer disagreed). On levels 3 – 7, however, the number of learners who disagreed with the statement was greater than those who agreed with it. Therefore, it can be said that the learners who performed better in mathematics were more inclined to ask questions than those whose performance was not as good.

Statement 7 and 24 did not elicit reciprocal responses as expected. Although 63,1% of the learners felt that the teachers encouraged them to use their own methods, only 39,6% disagreed with the negative statement. Although teachers thus encouraged the learners to use their own methods in mathematics, the learners were convinced that teachers wanted them to use the teacher's method when solving problems or were more comfortable to use the teachers' methods. In the qualitative research it was observed that teachers structured lessons in such a way that learners did the exercises in a similar manner to how the teacher had done them (cf. 6.3.3.1, 6.3.3.14). Teachers did not use any other teaching strategy when learners could not understand something (cf. 6.3.3.6). Teachers referred to their set methods of doing something if learners needed an explanation (cf. 6.3.3.14). They emphasised the steps according to which the sum should be done. This was observed in the cases of AA, AE, BA, BE and CA.

6.4.4.2.4 Developing awareness

In order for learners to thrive in the mathematics classroom, they should be aware of happenings in the mathematics class such as what they were supposed to learn and why they were requested to do certain things (cf. 4.6.4.1). Learners should also be aware that their efforts are valued in the mathematics classroom, no matter whether they are right or wrong. This would contribute to positive motivation (cf. 4.6.4.2). Six statements were made to examine the learners' perceptions of this aspect. The six statements with the results of the responses are shown in the following table:

Table 6.21: Developing awareness

	N=661			
	1 2	3	4 5	0
13. I usually understand what is expected from me to learn in the mathematics class.	69 10,4%	74 11,2%	489 74,0%	29 4,4%
23. I often do not have a clear idea in the mathematics class about what I am supposed to be learning.	345 52,2%	121 18,3%	175 26,5%	20 3,0%
10. The mathematics teacher always explains why it is important to do mathematics classwork and homework	65 9,8%	60 9,1%	511 77,3%	25 3,8%
22. I am not sure why we have to do homework and classwork in mathematics	422 63,8%	73 11,0%	143 21,6%	23 3,5%
12. I believe that mathematics problems can be solved in several ways.	43 6,5%	65 9,8%	530 80,2%	23 3,5%
19. I believe that mathematics problems have one correct solution.	281 42,5%	117 17,7%	229 34,6%	34 5,1%

The overall percentage of learners agreeing with statement 13 was 74,0%, confirming that most learners understood what they were expected to learn in the mathematics class. The reverse statement (23) had a lower amount 52,5% of learners who alleged that they did not often have a clear idea of what they were supposed to learn in the mathematics class. The results per school can assist to clarify this lower percentage:

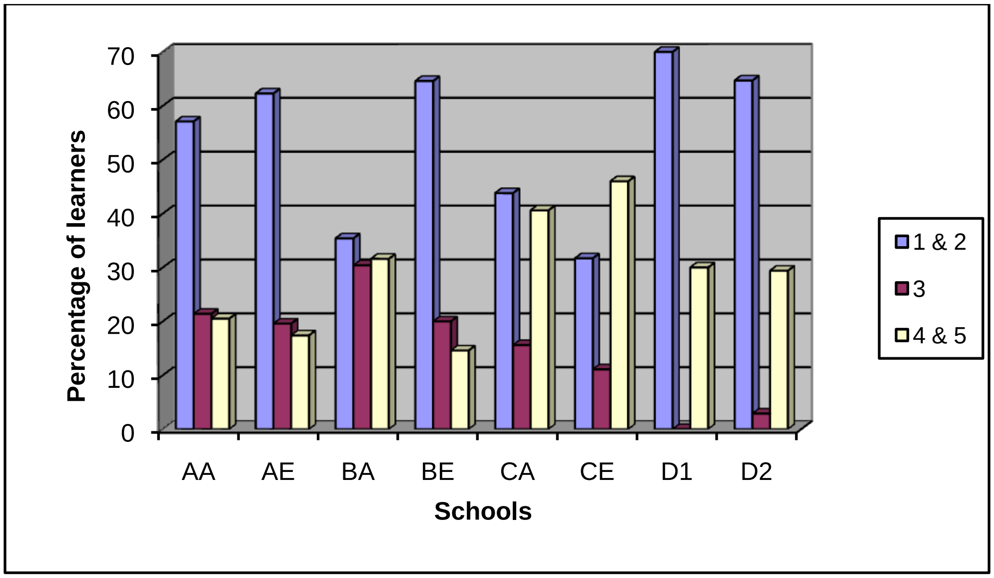


Figure 6.12: Responses of learners to statement 23

In all schools, the number of learners who disagreed with the statement that they did not know what they were supposed to learn in mathematics was greater, except at school CE where more learners agreed that they did not know what they were supposed to learn. During classroom observations it was noticed that the teacher in school CE treated two topics at the same time (cf. 6.3.2.6.1). Although the teacher said in his interview that this did not confuse the learners (cf. 6.3.2.6.2) since he always did it in that fashion and he maintained that consequently the learners were used to it, it did appear that learners were not always sure what they were supposed to learn in the mathematics class.

Learners agreed convincingly (77,3%) with statement 10 (that the teachers explained why it was important to do classwork and homework in mathematics). In terms of statement 22 (the reverse statement of statement 10), fewer learners disagreed with the statement (63,8%). Statement 10 indicated that teachers explained to the learners why homework and classwork should be done in mathematics. Statement 22 was more about what the learners thought about doing homework in mathematics. Thus it appears that, although the teachers explained to the learners why they should do classwork and homework, all of the learners were not totally convinced that the reasons that the teachers offered were valid. The 63,8% of learners who acknowledged that they knew why it was important to do homework in mathematics, corresponded more or less with the 66,7% of learners who did their homework (cf. 6.4.4.1.3). This could be an indication that learners who did not do their homework regularly were not aware that they should do it in the first place.

For the last two statements (regarding the need to develop awareness), learners agreed convincingly with the positive statement (12) - 80,2% - but they did not disagree convincingly with statement 19 that mathematics problems have one correct solution. Statement 12 involved the process of solving problems (actually doing them), while statement 19 could imply to learners that it involved the answer (product) to the problems ("one correct solution"). Learners thus acknowledged that there were different ways to find an answer but thought that there was one correct answer. This will apply to closed-questions. Qualitative research revealed that teachers seldom to never asked open-ended questions (cf. 6.3.3.3, 6.3.3.11). In other words, the learners were used to questions where there was only one answer.

6.4.4.4.5 Involving learners

Learners should be involved in all parts of the formative assessment process.
Two statements were used here. These statements focused on learners' involvement in setting tasks as their involvement had already been investigated in other statements such as the learners' involvement in self-assessment and their involvement in doing classwork and homework (cf. 6.4.5).

Table 6.22: Involving learners

	N=661					
	1	2	3	4	5	0
17. The teacher involves us learners in the setting of mathematics assessment tasks.	203 30,7%		135 20,4%	298 45,1%		25 3,8%
32. The teacher never involves learners in the setting of mathematics assessment tasks.	281 42,5%		126 19,1%	233 35,2%		21 3,2%

Both the positive statement (17) as well as the negative statement (32) confirmed that fewer than half of the learners thought that they were involved in the setting of mathematics assessment tasks. The percentage of learners taking the uncertain stance to both question 17 and 32 was high. It appears as if learners did not know how to answer the questions or what they meant. When this is compared with the qualitative findings, the learners were not involved in setting mathematics tasks and the teachers took sole responsibility for the setting of tasks (cf. Table 6.2).

6.4.4.3 The influence of language

The t-test (cf. 5.2.4.6) was performed to investigate the influence of language on formative assessment and on the teaching-learning environment. The average response for each of the categories of formative assessment and aspects of teaching-learning environment was calculated. This was done for learners taught in their home languages (series 1) and for those who were not taught in home languages (series 2). The comparison of these responses is illustrated in figure 6. The following abbreviations are used in this figure: FA – formative assessment: constr - constructive; cumul – cumulative; selfR – selfregulated; goalo – goal orientated; situat – situated; collab – collaborative; indivd –

individually different. KA – teaching-learning environment: trust – relationship of trust; fit – ensuring "fit"; voice – strengthening the learners' voice; deva – developing awareness, ilearn - involving learners:

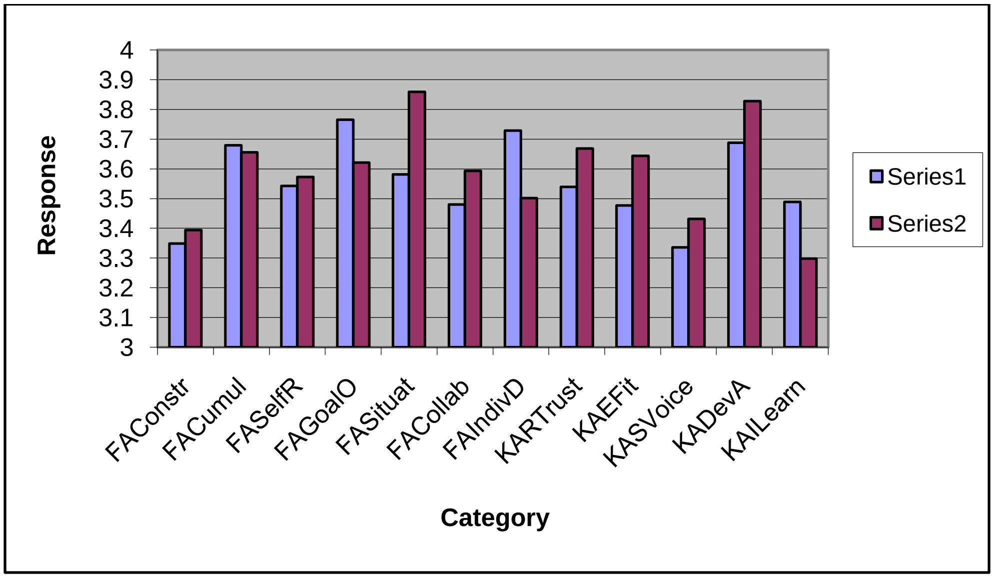


Figure 6.13. : The influence of language

From the graph it can be deduced that results are very similar for learning being constructive, cumulative and self-regulated. For learning being goal orientated, the responses of learners taught in home languages are higher, while for learning being situated and collaborative they are lower. This corresponds with the results reported in 6.3.2.1.1, 6.3.2.1.2, 6.3.2.5.1 and 6.3.2.5.2 where it was found that schools AA and CA did not do group work as often as at other schools. Schools AA and CA are the schools in which the majority of learners are taught in their home language.

For learning being individually different, the responses of the learners taught in home languages were slightly higher. As the statements asked are about understanding the teacher for progress in mathematics, it appears thus if language could play a role in the teachers' communication with the learners about what they do well/badly.

For a relationship of trust, ensuring fit, strengthening the learner's voice and developing awareness, responses were higher for learners not taught in the home language and for involving learners, they are slightly lower. It appears thus that learners not taught in the home language enjoyed a more pleasant atmosphere in the mathematics classroom. Qualitative research showed that learners in school AE, BE, CE, D1 and D2 (also BA – but learners of BA are taught in the home language) did much more group work than learners in other schools which could be why learners were at ease in the mathematics classrooms.

6.4.4.4 Correlations

The Pearson correlation coefficient (cf. 5.2.4.6) was used to determine the strengths of the relationships between each of the categories of learning (representative of formative assessment) and each of the aspects of a teaching-learning environment. The following matrix represents these results (abbreviations are the same as in previous figure):

Table 6.23: Matrix representing Pearson's correlation coefficient

	KARTrust	**KAEFit**	**KASVoice**	**KADevA**	**KAILearn**
FAConstr	.428	.377	.327	.330	.167
FACumul	.320	.283	.270	.289	.041
FASelfR	.374	.429	.228	.366	.145
FAGoalO	.202	.125	.108	.210	.060
FASituat	.260	.249	.104	.243	.027
FACollab	.287	.273	.175	.287	.073
FAIndivD	.462	.404	.348	.399	.213

All the values are positive, showing a positive relationship between all the categories of learning and aspects of a teaching-learning environment. This implies that as one variable increases, the other variable also increases. This is an encouraging indication of the potential for the implementation of formative assessment in mathematics classrooms. The values do not approach +1, which shows that perfect relationships do not exist. Surprisingly, there are no strong relationships between the categories of effective learning and certain aspects of a teaching-learning environment.

However, there are three values above .400, which can be seen as moderate relationships. The Pearson correlation coefficient measures .428 for the correlation between the ideas that learning is constructive and the relationship of trust. In order for constructivist teaching to take place, learners should trust the teacher.

A second value of .462 for the Pearson correlation coefficient is found when the construct that learning is individually different is correlated with that of a relationship of trust. An important way in which teachers can grow their learners' trust is by acknowledging the learners' individual needs.

The third Pearson correlation coefficient with a value of .429 is found between the ideas that learning is self-regulated and that the teacher should ensure fit. In order for learners to regulate their own learning, assessment tasks should be suitable to the learners' level. Assessment tasks should also assist learners to know their own strength and weaknesses. It is thus promising that there is already a positive correlation here.

The final Pearson correlation coefficient of .404 is found when correlating the concepts that learning is individually different and that teachers should ensure fit. This is an indication that teachers are moving towards providing for learners' individual needs.

It is also worth mentioning the value of .399 for the correlation between the prescription that learning is individually different and that of developing awareness. These two proposals are closely related in the sense that learners who are aware of what is happening in formative assessment, will also know that they are different from other learners and consequently that they all have their own needs.

The correlation between learning is collaborative, and strengthening the learner's voice has a value of .175. This is alarming since it is through collaborative work that the learners' voice is strengthened.

In the last column of the matrix, the calculated Pearson coefficients are relatively low in comparison to the other values. This can be attributed to the fact that only one question plus a reverse question were posted about involving learners in the setting of tasks when establishing a positive teaching-learning environment. The highest value is found in the correlation between the suggestions that learning is individually different and that learners should be involved. This is positive because by acknowledging the individual difference of learners, teachers need to involve learners more in formative assessment so that they can benefit optimally from the formative assessment process.

6.5 Summary

In this chapter the qualitative data from the research study that was described in chapter 5 were presented and analysed. After this, the quantitative data were presented. After an analysis of the quantitative data had taken place, the qualitative data were merged with the quantitative data so that both could be used in the interpretation and triangulation of data.

In the final chapter conclusions will be drawn, based on the analysis and interpretation of results presented in chapter 6. This will assist the researcher to make recommendations regarding the effective use of formative assessment in mathematics classrooms and the creation of a positive teaching-learning environment that supports formative assessment.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

In order to answer the fourth and fifth research questions (cf. 1.3.7) the researcher used a mixed methods research design. The results from both the qualitative and the quantitative research done were reported and analysed in chapter 6. Although the data were collected and analysed separately, the results of both qualitative and quantitative methods were combined and compared during the interpretation.

In this chapter, the conclusions drawn and recommendations made will be based on the interpretations made in chapter 6. Answers to the first five research questions will be used to answer the sixth research question finally (cf. 1.3.7). Ultimately an overview of the research study will be undertaken to achieve the aim that was formulated in 1.4.

7.2 CONCLUSIONS AND RECOMMENDATIONS REGARDING FORMATIVE ASSESSMENT

In 3.2.3 the attributes of formative assessment were identified and each attribute thereof linked with aspects of effective learning that was defined in 2.2.5 (cf. Table 3.2, Figure 3.3). The questionnaire used for learners in the quantitative research was based on the definition of learning as was described in 5.2.4.2. This was done because the attributes overlapped each other occasionally. However, final conclusions and recommendations will be based on the attributes of formative assessment.

From the empirical research study described in chapters 5 and 6, the conclusions that can be drawn regarding each attribute of formative assessment will be explained below.

7.2.1 Attribute 1: Assessment is a continuous, planned process

Section 3.2.3 discussed the first attribute of formative assessment - that it is a systematic, planned continuous process. In 3.3, attribute 1 was debated with specific reference to the teaching and learning of mathematics. Since all attributes do have a place in the formative assessment process, when discussing attribute 1 in the following paragraph, the emphasis will be on "planned" and "continuous". The other steps in the planning process will be described when dealing with mentioned attributes.

7.2.1.1 Conclusion

The participating teachers' knowledge of formative assessment and its application in mathematics classrooms was questionable (cf. 6.3.3.1). Because of this, various shortcomings were identified regarding the planning of formative assessment (cf. 6.3.1, 6.3.3.2, 6.3.3.7).

All teachers involved in the study usually taught according to the algorithmic (procedural) approach (cf. 2.2.1.2, 2.2.5.1, 6.3.3.1, 6.3.3.14). This gave an indication of the teachers' mindset when teaching mathematics, leaving questions regarding the use of constructivist (cf. 2.2.3.1) approaches. It is likely that, at the time of the study, the teachers saw assessment as an additional action taking place – separated from teaching and learning – and not as part of an integrated, continuous process.

It is concluded that the mathematics teachers did not have and/or could not apply theoretical knowledge of assessment done for the purpose of strengthening teaching and learning. Their planning for formative assessment was poor. Nonetheless, mathematics teachers did implement formative assessment in an intuitive manner while teaching (such as observations and asking questions) and written formative assessment such as classwork and homework (assignments).

7.2.1.2 Recommendations

It is evident that any training that the teachers have had so far regarding assessment has not effected any meaningful changes in their classrooms (cf. 6.2). In order to become effective formative assessment practitioners, teachers need to have knowledge and skills of how to go about integrating and aligning teaching, learning and assessment.

In countries such as the United States of America, where formative assessment and assessment for learning were introduced in the late 1990s, it was found that, without ongoing teacher training, teachers only paid lip-service to the theory, but did not involve learners in the assessment necessary to maximise learning (Hall & Burke 2003:75). A training programme recommended for the implementation of formative assessment in mathematics will be described in 7.5.1. As discussions of attributes continue, aspects to be included in the training will be identified.

It is important to realise that teachers have complained about the added administrative workload imposed by amongst others planning (see 1.3.3) ever since the introduction of South Africa's outcomes-based curriculum. Bearing this in mind, teachers should be allowed to follow a planning format that would suit their specific needs. They can, however, only decide about this if they have had thorough training.

Because the 2007 version of the assessment policy for the Department of Education does not refer to assessment done for "formative" and "summative" purposes (cf. 3.2.2), it is recommended that training for formative assessment in mathematics should rather be done as part of training for quality teaching and learning in mathematics. Terminology should not be the focus, but rather the application in mathematics classrooms.

7.2.2 Attribute 2: Determine learners' current level of knowledge and understanding

That learners' current knowledge and level of understanding should be the starting point of all teaching is described in 3.4. This implies that teachers ought to determine what learners know and understand and then direct their teaching to that level.

7.2.2.1 Conclusion

Although the teachers acknowledged the importance of identifying learners' prior-knowledge and linking it to existing knowledge, there was no planned attempt to do so (cf. 6.3.3.2). Identifying learners' prior knowledge took place through limited strategies, and follow-up actions were not explicitly taken (cf. 6.3.3.3, 6.3.3.11, 6.3.3.13). Teachers did not consciously and actively prioritise that they should establish the level of learners' prior-knowledge before proceeding with new work. Learners acknowledged that the mathematics teacher often talked about things that were way above their heads (cf. Table

6.9). This is especially problematic since systemic assessment done in grade 6 showed that very few learners have the necessary prior knowledge (cf. 1.3.2).

7.2.2.2 Recommendations

It is recommended that the training programme (mentioned in 7.2.1.2 and discussed in 7.5.1) should include sessions on baseline assessment. It is further recommended that teachers should be supported when baseline assessment tasks are set. A bank of written baseline assessment tests should be available to all teachers. Mathematics experts should set this bank of baseline assessment tests for every topic or concept that the teacher wants to teach. Teachers should be able to access this bank of tests via the Internet or on compact disks and compile a baseline assessment that will suit the needs of their specific learners. Questions must be graded so that the teacher can determine the current level of the learners. Advice about which exercises to choose next (based on the learners' level at the time) should also be available.

The researcher also proposes that learners should have access to computers and a computer program in which the teacher could supply the relevant information, such as the topic taught and the learners' current grade. An appropriate baseline test should then be generated to test the learners' knowledge of the work which was done in the previous grade. If learners are not able to answer these questions, they should attempt the work at a lower grade until the questions can be answered successfully. If this is used as the starting point, the learner's level can be raised with the assistance of the computer program or the teacher. Such programs are available on the market.

Finally, there are several games available to strengthen learners' knowledge and skills regarding basic mathematics (for example, calculations). Teachers should allow learners to play these games, with a specific period being allocated on the time-table for this. More games should be developed and a competition launched by the DoE, with prizes for the most appropriate games in three categories: for learners; for teachers; and for other adults interested in mathematics teaching and learning.

7.2.3 Attribute 3: Continuous diagnosis of learners' problems and taking action

Section 3.5 discussed the fact that continuous diagnosis of learners' problems, together with follow-up actions, forms an essential part of formative assessment. In addition, the need for learners' individuality to be taken into consideration and, through differentiation, that every learner should be given a chance to be successful was deliberated.

7.2.3.1 Conclusion

When teachers moved around the classroom assisting learners, there was not enough time to identify the learners' problems precisely and to act accordingly because the periods were too short and the classes were too full (cf. 6.3.3.15). In 4.6.2.4, the importance of adequate time available for formative assessment was noted.

Teachers offered assistance to learners (cf. Table 6.8), but the quality of the assistance was questionable. Teachers' ability to diagnose problem areas in mathematics was weak (cf. 6.3.3.6, 6.3.3.7, 6.4.4.1.1, 6.4.4.1.2). Most of the questions asked by the teachers in the classes aimed to evaluate knowledge and not understanding (cf. 6.3.3.3, 6.3.3.11).

Although the teachers claimed that they did differentiate, no evidence could be found in the learners' workbooks that they received differentiated exercises (cf. 6.3.3.7) and in teachers' lesson plans (cf. 6.3.1) that teachers planned these tasks. In addition, no appropriate action was taken when they found that learners experienced problems. This was also mirrored in the fact that a significant number of learners felt that the teachers did not know what their problems in mathematics were, or were uncertain about it (cf. Table 6.17). Furthermore, less than half of the learners thought that they were special in the mathematics class (cf. Table 6.17). Especially the low to average achievers did not feel special (cf. Figure 6.8). This indicates that teachers followed the pace of higher achievers and did not focus on the learners' individual needs.

7.2.3.2 Recommendations

As baseline assessment and diagnostic assessment are closely linked (cf. Figure 3.2), recommendations for both are similar.

It is recommended that the periods in the timetable be lengthened. Officials from the Department of Education should guide school management teams of individual schools in their decisions about the duration of periods. This would involve the school management and governance developers (SMGDs). Since SMGDs are not always specialists in the mathematics learning area, or even in the curriculum, they also need intensive training regarding curriculum support. Definite attempts should be made by the DoE for SMGDs to work closely with learning facilitators regarding aspects of the curriculum. SMGDs and learning facilitators should meet as regularly as is necessary for each school.

For teachers to be able to render effective support, their mathematical PCK (cf. 3.5.2) should be strengthened. The PCK should form part of the training programme discussed 7.5.1. Moreover, teachers should be properly trained in the effective setting and use of differentiated assessment task in their classrooms (cf. 3.5).

A further recommendation is that the DoE should introduce holiday camps for mathematics during school holidays. These camps should specialise in diagnosing learners' individual problems and supplying remedial assistance. This remediation could also happen with the aid of computers 7.2.2.2. The camps could be started in areas where the need is greatest.

7.2.4 Attribute 4: Learners are active participants in formative assessment

Attribute 4 emphasises the learners' active participation in formative assessment and effective interaction between teacher and learners and learners themselves (cf. also 4.6.3.1). In 2.3.5.2.1 the role of the learners in regulating their own learning was discussed.

7.2.4.1 Conclusion

At the participating schools, the learners' responses indicated that the majority of them preferred the teacher to do many examples so that they knew exactly how to do the exercises expected of them (cf. 6.4.4.1.1, Table 6.8). It can be concluded thus that the teachers saw themselves responsible for teaching and learning to take place in the mathematics classroom and did not necessarily encourage learners to become active partners in the learning process, more specifically in assessment (cf. 6.3.3.1). As a result of this, the interaction between teachers and learners was not optimum (cf. 3.6.2) and dialogue did not take place effectively (cf. 6.3.3.3, 6.3.3.11, 6.3.3.14). The availability of resources is problematic (cf. 6.3.3.16). A dearth of resources hampered the process of formative assessment in various ways: learners had to write down exercises for homework during class time since textbooks were not available as reference. This limited the time available for doing corrections and the time in which the teachers could assist learners.

7.2.4.2 Recommendations

For learners to be active in teaching, learning and assessment in mathematics, they must be involved in the whole teaching-learning-assessment process from a young age. Teachers at the primary schools should thus be trained (cf. 7.5.1) to initiate this behaviour in learners from an early age. Learners have to learn to ask questions and should be comfortable enough to answer the teachers' questions, even if their answers are wrong. Teachers should know how to ensure that effective dialogue takes place. Teachers ought to learn how to treat learners' incorrect answers as opportunities for learning and dialogue to take place. The correct attitude towards mathematics should be cultivated from a young age. For this reason, thorough teaching in the foundation phase and intermediate phase is essential. From a young age learners must learn to be creative, explore possibilities, to take chances, not be afraid to make mistakes and, above all, to love mathematics.

The mathematics holiday camps mentioned 7.2.3.2 could also be helpful in this regard. During these camps the learners should experience the pleasure and fun in mathematics. They should also learn to explore possible methods to solve problems freely and creatively. In addition, they should learn to verbalise their thoughts when doing problems.

All learners must receive basic resources, starting with textbooks. Learners' inactivity can be linked to the unavailability of resources. Also, teachers should learn to improvise with resources such as making their own rulers by pasting a copy of a ruler onto a piece of hardboard or copying protractors onto a transparency and cutting them out.

7.2.5 Attribute 5: Formative assessment is developmental

Attribute 5 states that formative assessment is developmental (see 3.7). Included in this attribute are: learners' self-assessment, metacognition, taking ownership of learning, and feedback as information to improve teaching and learning.

7.2.5.1 Conclusion

Although teachers viewed learners' activity in formative assessment as important, the learners' activities were restricted to doing and marking assessment tasks and self-assessment was seen more as learners' "self-marking" (cf. 6.3.3.8). Accordingly, it can be said that teachers did not actively promote the comprehensive role of the learner in the formative assessment process (cf. 7.2.4.1). Learners were not all committed to the role in assessment that had been assigned to them (cf. 6.3.3.8, 6.3.3.10, 6.4.4.1.3)

It seems that the teachers believed that giving feedback meant that learners should receive the correct answers to work and then do corrections (cf. 6.3.3.12). Although this can be seen as "feedback", task-specific feedback that should assist the learners to improve their performances, was absent. Teachers did not record any results of formative assessment and neither did they make anecdotal notes (cf. 6.3.3.4). No reference system was thus in place to monitor learners' progress when doing formative assessment. No evidence could be found of either teachers' or learners' reflections (cf. 6.3.1).

Teachers did not use co-operative learning, and only did ordinary group work (cf. 2.3.6, 6.3.3.9). The quality of the group work done was questionable. Learners did not always have the necessary resources to make progress when working in groups (cf. 6.3.3.16). Thus the group work did not support formative assessment and its value is debatable.

7.2.5.2 Recommendations

Research has indicated that learners can be taught metacognitive and self-regulatory skills (Boekaerts 1997:161, 162). For this reason, learners should be taught metacognitive strategies, such as self-assessment, self-monitoring and self-regulating strategies from a young age. These aspects should therefore all be included in the training programme discussed in 7.5.1.

In order for learners to take ownership of their own learning means that their mindsets about the learning process should be influenced from a very young age. The foundation and intermediate phase teachers should be empowered to teach the learners and so, once again, the appropriate training of teachers is recommended (cf. 7.5.1).

Training of teachers for formative assessment ought to include training them to give the learners quality feedback that is task orientated. After the training, the teachers should devise their own system to record/track learners' progress without overly burdening themselves with more paperwork. The length of periods in the timetable also influences feedback and the making of anecdotal notes. Thus it is recommended once again that periods should be longer to address this concern.

It is further recommended that teachers should be empowered to know the difference between ordinary group work and cooperative learning. Once more, the need for quality training is indicated (cf. 7.5.1). During this training, lessons must be presented in which the teachers act as learners doing mathematics using co-operative learning methods. In this way the teachers experience the process themselves. Since structured lessons with a limited use of group work (such as done in the cases of AA and CA) or structured group work done occasionally (as in the case of AE) would lead to more disciplined classes, it is recommended that teachers ought to limit the use of group work and that it should not be done all the time as in classes BE, CE, D1 and D2. In addition, resources should be available for learners to use when doing group work or co-operative learning.

Teachers should allow learners to express their thoughts verbally when solving mathematical problems. Learners can do this in writing if teachers do not want them to do it in front of the whole class. The use of mathematical journals should be promoted (see 3.9.3).

7.2.6 Attribute 6: Setting goals is important

Attribute 6 of formative assessment emphasises the importance of setting learning goals (see 3.8). These goals must be formulated in such a way that learners can determine their progress towards a goal with information they get from formative assessment.

7.2.6.1 Conclusion

One third of the learners indicated that they did not set goals for themselves in mathematics (cf. Table 6.12). This correlated with the number of learners who acknowledged that they did not do homework (a preferred formative assessment strategy by teachers participating in the research). If this line of argument is extended, their negligence of homework indicates once more that these learners did not take ownership of their own learning and did not regard themselves as equal partners in the learning process.

It can be concluded that the teachers did not guide the learners to set goals for themselves (cf. 6.3.3.17). Teachers also did not give the learners any idea of what goals they should attain in mathematics.

7.2.6.2 Recommendations

Learners should learn to set realistic learning goals for themselves. Teachers have to devise a way where learners can keep track of their progress towards attaining their learning goals. The use of a mathematical journal can be helpful in this regard.

Teachers ought to assist learners with the setting of goals by clearly formulating what (lesson) outcomes learners should achieve. Teachers should give learners feedback (cf. 7.3.6.2) and assist learners to monitor progress towards attainment of learning goals.

Irons (2008:41) warns that there is a real danger that learners will only fully engage in assessment tasks if it is for summative purposes. Learners should therefore be made aware that formative assessment is of equal importance. Tracking progress towards achieving goals consciously can assist with this.

7.2.7 Attribute 7: Using a variety of assessment strategies

The seventh attribute of formative assessment declares that formative assessment takes place through a variety of strategies (see 3.9).

7.2.7.1 Conclusion

Teachers used a limited number of strategies of formative assessment in mathematics: mainly class work and homework (cf. 6.3.3.3). They also asked questions during lessons and it is assumed that teachers also used observation. Questions were mainly restricted to closed-questions (6.3.3.11). Teachers used authentic exercises based on real life conditions and thus the emphasis on the solution of real life problems in mathematics did filter through to learners. More or less 75% of learners acknowledged that they were sure that the solution of real life problems in mathematics was important (cf. Table 6.13).

7.2.7.2 Recommendations

Sessions to train teachers to set formative assessment tasks using a variety of strategies such as investigations and projects ought to be included in the training programme suggested in 7.5.1. It is through using these strategies that teaching and assessment take place concurrently. Teachers should be encouraged to be creative when setting formative assessment tasks. Formative assessment tasks should be interesting and relevant to learners. Ultimately, the mathematics lessons must become an adventure for learners: they must be anxious to come to the mathematics class and be inquisitive about the new work for the day.

For teachers who experience problems, more ready-made examples should be available to use, preferably in a format can be changed to suit a particular class. Having this available on disks to be used or computers or accessing it via the Internet would be ideal.

7.2.8 General conclusions regarding formative assessment

In general it can be concluded that teachers who took part in this project did not have the necessary knowledge and skills to use formative assessment in their mathematics classrooms to assist with teaching and learning.

A further inference is that it is unlikely that the teachers saw formative assessment as integral to learning and teaching; and doubtful that they realised that the act of assessment should be used to aid the teaching and learning process. Referring to the management of OBE and the resultant administrative burden it places on teachers, Jansen (1999:151) mentions a trend found in research done on how teachers understand and implement continuous assessment. This research found that teachers continuously assessed what learners should practice rather than encouraging a more progressive, holistic assessment of students as the policy stipulated. This finding is also in line with what the researcher observed in the current research (cf. 6.3.3.1, 6.3.3.3, 6.3.3.8, 6.3.3.10).

When discussing formative assessment in the mathematics classroom, the important aspect of "dialogue" (cf. 2.3.5.1.1, 3.6.2) was mentioned. Dialogue between teachers and trainers should also be prioritised when teacher training take place (cf. 2.5.1). Teachers have many misconceptions about teaching, learning and assessment and since the important "dialogue" does not take place between trainers and teachers in training sessions, the misconceptions are never cleared (the researcher knows this because she was part of the training team). An example of this is teacher BE who believed that the learners ought to be able to recite learning outcomes from the policy document because "outcomes should be stated". Another example is teacher CE who simultaneously did algebra and data collection in the same period (with unrelated topics as examples) because the policy document stated that more than one learning outcome must be dealt with in a term.

In 6.4.4.1.1, the researcher discussed that learners' responses to statements about constructivism revealed that teachers did not teach mathematics in a constructivist manner. Teachers did a variety of examples showing an algorithm, which the learners then practiced. Although almost all teachers recognised that learners ought to be active in the mathematics class, to them the concept of activity was about doing many sums or exercises. The teachers modelled the correct behaviour which the learners imitated. This related to a behaviourist approach of teaching mathematics (see 2.2.1.2). It can be concluded that general concern should be raised about whether outcomes-based education with a constructivist approach (also social constructivist approach) to teaching and learning was in fact present in these mathematics classrooms.

7.2.9 General recommendations regarding formative assessment

From the conclusions drawn in the previous paragraphs, the following recommendations can be made:

Teachers were not aware of the continuous research being done on the teaching, learning and assessment of mathematics. Even when they were, they did not try to empower themselves by finding out more about these research projects (cf. Table 6.1). During the professional development of teachers, an effort should be made to involve them in conversations about mathematics. This can be done by allowing teachers time to attend congresses and seminars where recent research findings are presented and discussed; or by making recordings of such sessions available to teachers. The proposed system of professional development points can also assist here. Similarly, journals and academic publications ought to be more available to teachers.

Teachers should be allowed to attend mathematics conferences locally and overseas and present what they have learned to other teachers when they return home. This should be done on a rotational basis, but as a start by rewarding teachers for innovative approaches to teaching.

Teachers should also be encouraged to allow their peers to observe their classes while they are teaching mathematics. Afterwards, the teacher and his/her colleagues should sit together and discuss the strengths and weaknesses of the lesson. This should be made part of the integrated quality management system (IQMS) with the focus on development. Currently teachers perceive these peer observations as a form of control.

7.3 CONCLUSIONS AND RECOMMENDATIONS REGARDING THE TEACHING-LEARNING ENVIRONMENT

A teaching-learning environment that encourages formative assessment and all actions associated with it should prevail in mathematics classrooms.

7.3.1 Relationship of trust

This aspect of the teaching-learning environment deals with the relationship of trust between a teacher and a learner and among learners themselves (cf. 4.6.1).

7.3.1.1 Conclusion

The structured way in which mathematic teachers presented the lessons seemed to give learners a sense of security. It appeared that the learners were in a comfort zone, waiting for teachers to show them how to do mathematics. This non-threatening situation did have the positive consequence that the majority of learners felt at home in the mathematics class (cf. 6.4.4.2.1). Learners were willing to try to solve problems in mathematics, especially if the support of teachers was available. Learners did not like to ask questions in front of the whole class but were more comfortable asking questions individually or when working in groups (cf. 6.4.4.2.1). Learners are also not comfortable answering questions (Table 6.18).

7.3.1.2 Recommendations

Certain requisites for positive experiences in the mathematics classroom cannot be developed in the Senior Phase only: earlier experiences influence the learners' behaviour in the Senior Phase mathematics class to a large extent.

It is important that learners should learn from a young age to be inquisitive, to try new things and not to fear failure. Mistakes must be seen as opportunities to learn. Foundation phase teachers will have to be trained to develop more than basic mathematical knowledge and skill. They should know how to influence learners so that future behaviours can be shaped with assessment tasks with the purpose of assessing them formatively.

7.3.2 Ensuring suitable assessment tasks

Suitable assessment tasks will assist learners to track their own progress (cf. 4.6.2).

7.3.2.1 Conclusion

Learners were positive that they could learn new things in the mathematics class. However, many of them were doubtful whether this was going to happen (cf. 6.4.4.2.2). Furthermore, there was a positive correlation (although not strong) between ensuring suitable assessment tasks and learners' self-regulation as well as with learners' being individually different (cf. Table 6.23). This shows that teachers have the potential to set assessment tasks that will assist learners to know what they do correctly and what they do incorrectly in mathematics and that will also acknowledge learners' individuality.

Unfortunately, there is a low correlation between "teachers should set suitable formative assessment tasks" and "learning is cumulative" (cf. Table 6.23). Teachers thus did not set tasks that suited the learners' level of competence.

7.3.2.2 Recommendations

In order to ensure "fit", teachers must have enough time and opportunity to connect with what learners already know and can do. This implies that teachers ought to have enough contact time with learners in order to do so. Periods should be longer and there should be fewer learners in each mathematics classes. Research needs to be done to determine the appropriate number of learners per class for South African schools. Numbers should not be dictated nationally, but should be in line with every school's particular situation.

It is also recommended that teachers be trained to set quality assessment tasks. Quality assessment tasks include assessment tasks that will cater for learners' individual needs. This should thus be included in the training of teachers discussed in 7.5.1.

Resources for all schools should be prioritised. Teachers should not give learners a formative assessment task and if learners do not have resources, for example, to ask learners to measure the perimeter of the classroom, knowing very well that they do not have access to measuring tapes.

7.3.3 Strengthening the learner's voice

For learning to happen, it is important that learners should get an opportunity to discuss mathematics in order to reflect on their existing knowledge. Furthermore, learners should assess themselves so that they can track their own progress (cf. 4.6.3.1, 4.6.3.2, 4.6.4).

7.3.3.1 Conclusion

The learners at some schools did not have many opportunities to discuss mathematics in groups. Where learners did have the opportunity, in many cases the discussions did not yield the results they were supposed to (cf. 6.3.3.9). Although the learners were aware that there was no specific method to follow in mathematics, they depended on the teachers to show them how to do mathematics using algorithms (cf. 6.4.4.2.4). Teachers did not allow learners to make meaning first of mathematical problems. In this way, their understanding was often sacrificed.

7.3.3.2 Recommendations

Although it is important that teachers should model the correct behaviour to learners regarding mathematics, they should be exposed to more training sessions in which they learn teaching strategies that are learner centred (cf. 7.5.1). Aspects such as co-operative learning, promoting dialogue and involving learners in their own learning should also be included in the training.

On the other hand, learners need opportunities to talk about mathematics. Teachers should allow learners to discuss homework exercises by for example using the jigsaw technique of co-operative learning as was described in 2.3.6.

7.3.4 Developing awareness

Learners should know why they do tasks for formative purposes and be aware of their own performances (cf. 4.6.4.1, 4.6.4.2).

7.3.4.1 Conclusion

From when they introduced a topic or a lesson, teachers made no particular effort to explain to learners what they were supposed to be learning in mathematics (cf. 6.3.3.17).

That the majority of learners knew why it was important for them to do classwork and homework was an indication that teachers emphasised the importance of doing tasks in mathematics (cf. Table 6.21). (Classwork and homework are mentioned since they were the only written strategies used for formative assessment tasks except for informal tests). The majority of the learners were also convinced that they knew what they should learn in mathematics.

Finally, learners believed that mathematics problems could be solved in many ways - but since teachers mainly used closed questions that usually had one correct answer, some learners thought that mathematical problems always had one specific answer. Learners were also very dependent on teachers' teaching the correct behaviour (like showing them the algorithm).

7.3.4.2 Recommendations

Teachers should involve learners in the formative assessment process as suggested in 3.3. Should teachers do so, learners would continually become more aware of the role they can play in improving their learning. Learners ought to learn to use metacognitive and self-regulating strategies.

Teachers have to be trained to offer learners opportunities to explore problems on their own, to allow them to be creative, to trust learners and convince them that they do have the abilities to solve non-routine problems. Teachers must believe in learners' potential. Teachers also need to know how to formulate open-ended questions and assist learners to answer them. Teachers should be made aware of the influence the hidden curriculum can have on the teaching-learning environment. This should be part of the training described in 7.5.1.

7.3.5 Involving learners

This aspect emphasises the importance of involving learners in creating appropriate teaching-learning environments.

7.3.5.1 Conclusion

Teachers did not use the learners' ideas and did not involve learners in any other way when setting assessment tasks (cf. 6.4.4.4.5).

7.3.5.2 Recommendations

It is recommended that teachers involve learners in the setting of assessment tasks with the purpose of assessing learners formatively. For example, as a start learners could prepare questions for a class quiz. In this way learners engage with the learning material in a much more intense manner.

For this to happen, the mindset of teachers regarding the teaching and learning of mathematics must change. This should form part of the training described in 7.5.1.

7.3.6 Teaching-learning environment: Conclusions and recommendations

The ambiance in the mathematics classrooms was relaxed, making learners unafraid of attending the lesson. However, the fact that about a third of the learners were not committed to doing mathematics formative assessment tasks (in this case homework), and did not set goals was an indication that more effective teaching-learning environments should still be pursued. Teachers need assistance in their classrooms to help them to identify strengths and weaknesses. The training programme described in 7.5.1 could be of value in this regard.

7.4 OVERVIEW OF THE STUDY

The first two objectives were addressed in chapters 2 and 3. A literature study was done to determine from existing knowledge how formative assessment could positively contribute to teaching and learning of mathematics and to understand formative assessment within the outcomes-based paradigm. First, the problem of how effective learning should take place in the mathematics classroom was investigated. A definition for learning was sought and it was established how the NCS supports this definition of learning that enables effective teaching and learning to take place. The outcomes-based assessment paradigm, as it is contextualised within outcomes-based education, was investigated. Formative assessment was explained within the outcomes-based paradigm.

Furthermore, the investigation confronted the problem of how formative assessment should be done in mathematics classrooms to improve teaching and learning. In order to do this, formative assessment was contrasted with summative assessment so that formative assessment could be understood. The researcher decided, instead of finding a definition for formative assessment, rather to describe formative assessment in terms of its attributes. Each of these attributes was then investigated to determine how it should find application in the mathematics classroom to improve teaching and learning.

The third objective was pursued in chapter 4. The teaching-learning environment that supported formative assessment in mathematics classrooms was investigated.

In chapter 5, the fourth and fifth objectives were examined by means of empirical research. A mixed methods research design was used because of the complexity and multifaceted nature of formative assessment and the teaching-learning environment supporting formative assessment. In chapter 6, the results of the empirical research were reported, analysed and interpreted. It was found that, although mathematics teachers used formative assessment, it was unplanned. This resulted in formative assessment of poor quality that could not really fulfil the role that formative assessment has to play in the effective teaching and learning of mathematics. Teachers also did not have the necessarily knowledge and skills to use formative assessment effectively.

The investigation into teaching-learning environments revealed that learners were comfortable in mathematics classes. Despite this, the teaching-learning environments did not support formative assessment optimally.

The last objective is addressed in this chapter, namely to make recommendations on how mathematics teachers can be assisted to implement effective formative assessment (including effective teaching-learning environments) in their classrooms. In this final overall recommendation, the training programme mentioned frequently throughout the discussion of 7.2 and 7.3 will be described first. The second recommendation will involve the role of the learning facilitator in assisting mathematics teachers to implement formative assessment successfully and establish suitable teaching-learning environments. In doing this, the final objective will be reached and the aim of the study accomplished.

7.5 OVERALL RECOMMENDATION

It is evident that the training in assessment that teachers have had so far has not effected great change in their classrooms. In order to disclose the full potential of formative assessment in teaching and learning, teachers need to have a thorough knowledge of how to go about integrating and aligning teaching, learning and assessment. Topics to be included in training were identified in 7.2 and 7.3.

7.5.1 Training of teachers

According to Chapuis, Chapuis and Stiggins (2009:56), effective training should bring about lasting change in the classroom. If it does not do so, valuable time and resources are wasted doing the training. What is more, teachers become sceptical that the time that the spent in training was worthwhile. Stiggins and Chappuis (2006) recommend further that teachers should infuse new ideas from several sources into their teaching. Teachers must all the time be on the lookout for such ideas.

7.5.1.1 Pre-training motivation

Before teachers can understand how to apply formative assessment in their mathematics classrooms, they need to know the rationale for using formative assessment to improve teaching and learning in their mathematics classes. This will require the teachers to make a paradigm shift regarding assessment. Chen (2001:265) remarks that it is only through extensive questioning and reflecting that a paradigm shift can occur. The question that arises is how mathematics teachers can be brought to the point that they will question their own methods and reflect on them critically?

An expert in the field of formative assessment in mathematics should do the pre-training motivational session. Results from research done in the field of formative assessment in mathematics should be presented to teachers. DVD recordings should be shown in which mathematics teachers demonstrate the use of formative assessment in mathematics classrooms. It is only when teachers view alternative ideas and realise their potential that they will try them out in their classes. If this yields positive results with their learners, teachers will be motivated to include even more non-traditional ideas in their classrooms (Ball 2009; Olivier 2009). Therefore, after the pre-training motivational session, it is essential that mathematics teachers should go back to their classrooms and experiment with what they observed in the pre-training motivational session.

During the pre-training motivation, teachers should also be confronted with results from research studies, focusing on practices that support the teaching and learning of mathematics. This would help motivate teachers to try new strategies in their classrooms pertaining to teaching, learning and assessment. They should also be made aware that they would have follow-up support from learning facilitators and that study groups would also be established where teachers would reflect on their experiences and get advice from teachers in similar circumstances.

Finally, formative assessment should be dissociated from outcomes-based education. Teachers must realise that effective formative assessment practices promote learning, whether the curriculum is outcomes-based or not.

7.5.1.2 Training sessions

Chapuis, Chapuis and Stiggins (2009:56) recommend teacher training that is "on-site, job embedded, sustained over time, centred on active learning, and focused on student [learners] outcomes". This should include collaborative sharing, meetings with committed teachers as well as working and learning in between meetings. These authors, who are renowned researchers of the effects and implementation of formative assessment in appropriate teaching-learning environments, experienced that although they did raise awareness, traditional workshop approaches were not successful in training teachers for formative assessment for the following reasons:

- The amount of content necessary to implement formative assessment usually exceeded what could be covered in a workshop. This was true even if a number of workshops were offered.

- Course attendees remained passive and this led to information that did not reach them. This was even found in cases where the presentations were interactive and engaging (like in the case of the NCS training done by the Free State Department of Education).

- Presenters did not get the opportunity to "facilitate the reflection, the putting into practice, the collegial discussions and the learning that [could] only take place when participants return[ed] to their classrooms".

Teacher training should be an ongoing process and not a "short-term commercially promised quick fix" (Chappuis, Chappuis & Stiggins 2009:57). Learning should take place in four contexts. Firstly, new ideas must be introduced to teachers. Next, the new ideas should be transformed into classroom practice and the teachers should apply the new information in their own situations. Finally, teachers should reflect on the results and be able to answer the questions about what worked in their classrooms; whether there was any evidence that it worked enough to make them keep on trying; what ideas needed to be refined; and what they needed to know to become more effective.

7.5.1.3 Follow-up and support

After a training session has taken place, learning facilitators and/or other trainers should follow training up with support to the teacher in the classroom. International experience (such of that of the NCTM) suggests that teachers should introduce one new assessment idea at a time. If they decide to try observation, they should practise it for a while; reflect on their experience before continuing (Stenmark 1991:1).

A follow-up session in which reflection, interaction and dialogue take place will complement this. This can take place in study groups where teachers get the opportunity to reflect on their experiences and explain to peers how they feel about this. Teachers in similar circumstances can give advice where problems are experienced. These study groups should also include the learning facilitator, whose role should not be to lead the sessions. Learning facilitators ought to make recommendations if peer teachers are not in a position to make any inputs. Learning facilitators must also listen (and learn) to find out what is happening in classes. Many experienced learning facilitators have not taught for some time and could use inputs from teachers as well as to listen to the advice that one teacher give another teacher, to strengthen their knowledge. This will empower learning facilitators to assist teachers more. It must be noted that learning facilitators should themselves first be trained to become experts in the field of formative assessment. It is recommended that the process discussed in 7.5.1.2 should also be presented to learning facilitators.

Chapuis, Chapuis and Stiggins (2009:59) emphasise the active support of the school's management team. This support includes tracking and evaluating teachers' growth in order to promote a sense of accomplishment. In this regard, the Integrated Quality Management system (IQMS) that is used for the evaluation of teachers' performance should be involved. IQMS should have a performance indicator that focuses on teachers' willingness to attend training sessions and to apply what was learned in training in their classrooms. IQMS should also encourage teachers to study further and to be committed to reading articles and books regarding trends and developments in mathematics education. Teachers should be rewarded for commitment to ongoing training and development. Progress made by the teacher should be identified and teachers should be encouraged to reflect on their progress continuously.

7.5.2 Role of the learning facilitator

In 6.2 (cf. also Table 6.1) it was found that mathematics teachers relied on mathematic learning facilitators or other teachers to inform and assist them with the teaching and learning of mathematics. This could be either via workshops or support at school level. In line with this, learning facilitators could also assist teachers to implement formative assessment effectively in their classrooms.

This might be done by administering the questionnaire used in the quantitative part of the empirical research (cf. Appendix C). It is recommended that the questionnaire should first be revised and that identified problematic statements should be reformulated (as was illuminated throughout discussions in 6.4.4).

Nevertheless, the questionnaire would only give an idea of the problem areas and the immediate problems. For this reason, it is suggested that support to teachers should be accompanied by classroom observations as well as by dialogue between the teacher and learning facilitator.

In the following example, the researcher will illustrate how teacher AA could be assisted to implement formative assessment effectively in her classroom. The questionnaire serves the purpose of a diagnostic instrument. Learners' answers to the questionnaire regarding formative assessment and teaching- learning environment will be analysed in this example for school AA only.

After analysis of the questionnaire, the percentage of learners agreeing or strongly agreeing to positive statements and the percentage of learners disagreeing or strongly disagreeing to statements are reflected in the following table. The positive and negative statement pairs will be stated together with the positive statement first and the negative statement right after it, as an example. In the table below, statement 1 and statement 19 are opposite statements for formative assessment (cf. Table 5.1) while statements 1 and 14 are opposite statements for the teaching-learning environment (cf. Table 5.2).

Table7.1: Analysing questionnaires for school AA

	Formative assessment statements	**% of learners**	**Teaching-learning environment statements**	**% of learners**	
Constructive	1	78,6	1	64,3	**Relationship of trust**
	19	60,7	14	51,8	
	17	38,4	20	56,3	
	22	12,5	2	52,7	

	8	62,5	4	46,4	
	27	57,2	18	48,3	
Cumulative	3	67,0	9	47,7	
	15	47,4	21	44,6	
Self-regulated	4	89,3	6	66,1	
	18	67,9	26	56,3	
	23	59,9	31	56,0	
	5	37,5	16	55,3	
	6	33,0	15	58,9	**Ensuring fit**
	20	22,3	30	50,9	
	30	70,5	29	61,6	
	7	66,0	11	46,5	
Goal orientated	25	63,4	27	58,0	
	14	59,0	3	45,5	
	10	60,7	25	51,8	
	26	50,9	5	33,0	
Collaborative	11	60,7	8	45,6	**Strengthening learners' voice**
	32	41,0	28	49,2	
	9	73,2	7	46,2	
	21	50,9	24	35,6	
	16	69,7	13	69,6	**Developing awareness**
	28	59,0	23	57,2	
Individually different	13	72,3	10	63,4	
	29	59,8	22	55,4	
	24	66,1	12	75,9	
	31	69,8	19	42,8	

	12	48,3	17	46,4	**Involving learners**
	2	50,9	32	40,2	

The shaded areas measured below 50% and are the areas of greatest concern. With reference to constructivism (statements 17 and 22 of formative assessment), the majority of learners did not choose to do a sum before the teacher had explained it. Furthermore, the learners depended to a large extent on the examples that the teacher had done as a model of the correct behaviour. The learning facilitator might well assist the teacher to develop activities and formative assessment tasks where learners actively construct knowledge and make meaning of material. The learning facilitator should also recommend the use of a mathematics journal so that learners can write their fears and frustrations down. Learners must also be assisted to learn how to think independently and write down their thoughts. The learning facilitator should be in class when this is done, to monitor teachers' progress and give advice for improvement.

Regarding statement 15 (formative assessment) ("many times the mathematics teacher talks about things in the mathematics class that I do not have any idea about"), 47,4% of the learners disagreed or strongly disagreed with the statement. The researcher (learning facilitator) observed that the teacher spoke too fast while presenting lessons. She often did not complete her sentences fully before moving on to a new sentence. This made it very difficult to keep up with her. This is made clear when one listens to the interview with this teacher. This teacher needs somebody to pace her, help her to slow down and indicate when she does not speak clearly. The teacher should practise speaking more slowly and to keep the pitch of her voice low. Longer periods should also be suggested to the SMT of the school where she teaches so that the teacher can relax more and slow down.

From statement 5 (formative assessment) it is obvious that learners did not like to assess themselves in mathematics. In this case the learning facilitator could advice the teacher to conduct interviews (cf. 3.9.4) with different learners to find out why they did not like doing it. It is very possible that learners could not keep up in this process.

An analysis of statements 6 and 20 (formative assessment) shows that more than a third of the learners were totally dependent on the teacher to assist them to know if their answers were correct and whether they were doing the mathematics correctly or not. Learners were clearly not skilled at regulating their own learning and consequently their metacognitive abilities seemed questionable. The teacher should intervene here with the assistance of the learning facilitator. The metacognitive (including self-regulation) skills of learners need to be developed. The life orientation teacher can also be involved in this. The learning facilitator could recommend training sessions for the teachers and follow this up with support in the classroom.

The learners of teacher AA believed that mathematics problems had one correct solution (statement 19 teaching-learning environment – only 42,8% of learners disagree with the statement "I believe that mathematics problems have one correct solution."). They were also of the opinion that the teacher wanted them to use her methods (statement 24 teaching-learning environment – only 35,6% of learners disagreed with the statement that "the teacher wants us to use his/her methods when we solve problems in mathematics") and that she did not encourage them to use their own methods (statement 8 teaching-learning environment). The teacher's rigidness and constant reference to specific methods that should be used definitely created this impression (cf. 6.3.2.1.1).

The learning facilitator should make her aware of this and guide her to use alternative approaches. The teacher would need to learn alternative teaching strategies. The teacher is still young and energetic and she must learn to think "out of the box".

Teacher AA did not use group work much. This is seen in responses to statement 32. Statement 32 (formative assessment) showed that all learners did not actively participate in groups and this is most probably because they were not used to it. The teacher did not understand the difference between ordinary group assessment and co-operative learning. As before, the learning facilitator would have to assist the teacher to teach learners the important skill of working together in a group. The teacher also has to be enlightened on how to manage group assessment effectively and made aware of the advantages of collaborative learning. The learning facilitator can guide the teacher to set an assessment task and let the learners use for example the jigsaw method of co-operative learning.

Regarding statement 12 (formative assessment), less than 50% of the learners in the class felt that the teacher always attended to their problems, despite the fact that the teacher created a very relaxed atmosphere in the classroom. It was noted during classroom observation that the teacher generally worked with a certain group of learners from which many of the other learners were excluded. The learning facilitator should guide the teacher to focus on a different group of learners everyday when teaching mathematics so that all learners will receive attention at some point in time. Learners do not have to know of this arrangement. Periods should once again be longer so that the teacher can get an opportunity to assist more learners.

Regarding the teaching-learning environment, learners did not look forward to being assessed in mathematics (statement 18 teaching-learning environment).

Thus, the teacher should focus on making formative assessment tasks interesting and relevant and part and part and parcel of teaching and learning. The learning facilitator could brainstorm with the teacher to come up with creative activities. Activities could be link to events happening at the school. An example of this could be for learners to find a challenge in the Guinness Book of Records, such as making the longest hot dog. Learners would do calculations, measurements and make plans to take up the challenge of making the longest hot dog. Learners could in fact make this longest hot dog or even just a very long hot dog and in this way raise funds for the school. More calculations and planning would come in here. This would also assist with giving learners interesting real life examples to do. Learners found the problems that the teacher did at the time of the research, boring (statement 5 teaching learning environment).

Learners did not like to answer the teacher's questions in the mathematics class (statement 21 teaching-learning environment) and neither did they like to ask questions (statement 8 teaching learning environment). The teacher should conduct interviews with learners to find the exact cause of this. The teacher should find a way to use incorrect answers as learning opportunities without humiliating any learner. She also did not give the learners time to think (statement 3 teaching learning environment). The teacher must practice longer waiting time. Longer periods can help with this also.

Learners were not optimistic that they would succeed in mathematics (statement 11 teaching-learning environment). This could be devastating to the teaching and learning of mathematics. This perception should be changed. Teachers could give learners exercises on their level so that they would be successful - and success breeds more success. More advanced exercises should also be given to relevant learners so that they do not become bored. The teacher should introduce mathematical games in her classroom. Learners need to experience mathematics as fun and enjoyment. The teacher should also involve learners in the setting of assessment tasks (statements 17 and 32 teaching learning environment). The following is an example: the teacher gives learners a newspaper report related to mathematics (or an article) to read. Learners can work in groups and each group set five questions and answers pertaining to the report. The teacher combines all these questions in an assessment tasks. Teachers and learners can choose whether learners should answer their own questions.

Should the learning facilitator spend time with the teacher and her learners, aspects that the teacher are not even aware of that prevent actions from happening in the class could be ironed out. As time goes by, the second group of problems (where percentages are between 50 – 59%) would be worked on, until eventually the teacher becomes confident in how to use formative assessment effectively and create a teaching learning environment that supports the effective use of formative assessment. The learning facilitator must constantly come up with creative ideas so that the teacher's ability to think creatively is also stimulated. This interaction between the learning facilitator and the teachers should reward the teacher for professional development in IQMS.

It must be noted that to this support all teachers in all schools in this way would be impossible. This being so, the following is recommended:

- Learning facilitators should not be responsible for more than 20 schools (this will depend also on the number of teachers at schools). The researcher makes this recommendation based on her experience as a learning facilitator.

- If this is not possible, senior teachers should be identified and trained to assist with this follow-up support at their specific schools or nearby schools where a suitable teacher is not available.

- Learning facilitators should prioritise support at schools where learners are performing poorly in standardised mathematics tests.

7.6 SHORTCOMINGS OF THE STUDY

Because this study was conducted in only part of the school year, observations merely provided partial insights into teachers' practices. If this study had been done over a whole school year, more aspects regarding formative assessment practices of teachers would have been addressed. Furthermore, the researcher could have attempted to identify the best practices regarding for formative assessment and make recommendations as to what practices lead to an improvement of mathematics results.

In this study the learners' opinions regarding formative assessment and the classroom environment were investigated by means of a questionnaire. If interviews had been conducted with the learners, the researcher could have established more precisely exactly why learners responded to statements in a certain way.

Another shortcoming is that a longitudinal study was not conducted in which the ideas presented in this research report were tested to see if they could change the learners' performance in mathematics classrooms.

Finally, the categories used for sampling were categories created by the researcher. It is possible that more factors could have influenced the categories than those considered by the researcher. This could influence the generalisation of results.

7.7 FURTHER RESEARCH

The following topics are suggested for further research, based on factors that appeared to the researcher to affect formative assessment and/or teaching-learning environments:

- Factors such as differences between the cultures of the teacher and the learners, LoLT, teachers' PCK and the impact they have on formative assessment and/or teaching-learning environments could be researched.

- The nature of learners' learning goals and how learners monitor their progress towards these goals should be investigated in conjunction with learners' use of metacognitive strategies and self-regulating skills.

- This research study should be extended into an action research study in which the questionnaire (see Appendix C) that was developed as a result of the literature study can be tested and refined so that teachers can be optimally assisted to implement formative assessment in their mathematics classrooms as suggested in the example in 7.5.2.

- Empowerment of teachers as researchers to research their teaching and to teach what they have research should be investigated.

- Research could be conducted on whether the use of mathematical journals in South African mathematics classes could affect learners' performance in mathematics. This should include a study on whether it is better to use the learners' home language or the language of learning and teaching when learners write in their mathematics journals.

- Through research it should be established how many learners should be in a teacher's mathematics class and how long periods should be to ensure effective use of formative assessment in mathematics classrooms. Factors that impact on this should also be investigated.

7.8 CONCLUDING REMARKS

In his article, "When good teaching leads to bad results", Schoenfeld (1988:148) wrote the following in 1988: "… the good teacher is the one who has 10 different ways to the same thing: the student is sure to 'get it' sooner or later." Schoenfeld was referring to the traditional classroom where the behaviouristic philosophy was predominant. The results of this research prove that teachers still believe that doing mathematics over and over without emphasising understanding will lead to good results. Mathematics teachers work hard; however, learners' results do not reflect this hard work.

Teachers will have to be properly equipped with the necessary knowledge and skills to use formative assessment to learners' advantage to improve their teaching. To achieve this, the teachers themselves need to become researchers and lifelong learners as were envisaged by South Africa's outcomes-based curriculum.

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PERSONAL INTERVIEWS

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Classification:

☐ ☐

APPENDIX A

CLASSROOM OBSERVATION

Duration of period: …………………………… Class: ……………………………..

Number of learners: ………….. Arrangement of tables:……………………………

Number of learners taught in home language: ………………………………………

Number of learners taught in a language different from home language: …….

Resources used: ……………………………………………………………………………

Topic:……………………………………………………………………………………………….

Forms of formative assessment used	
Form 1:	Form 4:
Form 2:	Form 5:
Form 3:	Form 6:
Notes on quality of formative assessment:	

Stating outcomes/purpose of lesson/purpose of assessment:

Identification of prior learning:

Open-ended questions asked:

to class:	
to specific learner:	

Closed questions asked:

to class:	
to specific learner:	

Wait time:

Less than 1 second	
1 – 3 seconds	
More than 3 seconds	

Feedback given: I – immediate D - Delayed

Task specific	
Learner orientated	

Answering of questions:

Teacher	
First learner	
Multiple attempts	
Whole class	

Learners asking questions:

Checking whether learners understand:

Checking whether learners need assistance:

Teacher allows for sense-making:

Teachers explores wrong answers as opportunity to learn:

Learners encouraged to explore own methods:

Learners work in groups:

Learners work individually:

Teacher addresses individual problems:

Teacher individualises formative assessment:

Lesson plan:

Reflection on lesson plan:

Notes on learners' participation during the lesson in the mathematics classroom:

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Notes on proceedings during lesson:

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APPENDIX B

INSTRUMENT FOR DOCUMENT ANALYSES

For office use:

FORMATIVE ASSESSMENT

Lesson plans	**Does formative assessment inform Lesson plans?**	**Assessment planned for?**	**Strategies of formative assessment used + frequency of each strategy + nature + source**	**More on strategies**	**Feedback**	**Learner involvement**
Available for all lessons?	Inform	Summative assessment		Thoughts?/Explain your answer	Does the teacher assess?	Self or peer
Who set?	Reflection indicated?	Formative assessment		Journal writing?	Frequency	Corrections
Same for all classes?	Notes on progress	Remedial work		Learners asking questions (in class/after class)	Nature	Commitment to doing formative assessment?
Same for different teachers?	Records of learners' performance in formative assessment?	Enrichment	Evidence of baseline?	Groups or individual	Verbal / written	Catch-up when absent
Detailed		Individual	Performance assessment tasks?	Resources available	Follow-up	Asking learners to set tasks

For office use: ☐☐

APPENDIX C

LEARNERS' QUESTIONNAIRE

This questionnaire consists of two sections:

- ☐ Section A: General and biographic particulars
- ☐ Section B: Formative assessment and classroom environment

GENERAL INFORMATION

1. This questionnaire will take approximately 30 minutes to complete.
2. **You answer this questionnaire completely anonymously: do not write your name on this questionnaire.**
3. This questionnaire is only for use by the researcher. Please be honest.

SECTION A: GENERAL AND BIOGRAPHIC PARTICULARS

Instruction: Make an x in the appropriate box:

1. Gender and Grade

Gender	Male		Female	
Grade	8		9	

2. Home language (please choose only one)

English	1
Afrikaans	2
Sesotho	3
Tswana	4
Xhosa	5
Other (please specify): …………………………………..	6

3. In which language are you taught?

Afrikaans	1
English	2

4. What was you report mark for mathematics at the end of last term?

0 – 29 %	1
30 – 39 %	2
40 – 49 %	3
50 – 59 %	4
60 – 69 %	5
70 – 79 %	6
80 – 100 %	7

SECTION B: FORMATIVE ASSESSMENT AND CLASSROOM ENVIRONMENT

INSTRUCTIONS

Please indicate how you feel about each statement by making a cross in the applicable box:

SD = strongly disagree D = Disagree U = uncertain A = agree SA = strongly agree

For example, here is how you would respond if you agree with the statement at the left:

	I like mathematics	SD	D	U	[✓ A]	SA

All the statements that follow have to do with your experiences in the mathematics class. Think only about your mathematics classes when you complete the rest of the questionnaire.

Part 1: Formative assessment

1.	The mathematics teacher checks several times during a lesson to see if I understand the mathematics that we are doing.	SD	D	U	A	SA
2.	I don't think the mathematics teacher knows what my problems in mathematics are.	SD	D	U	A	SA
3.	The mathematics teacher always tries to find out what I know about a topic before he/she starts explaining new work.	SD	D	U	A	SA
4.	The classwork and homework that we do in mathematics help me to know if I can do the mathematics.	SD	D	U	A	SA
5.	I do not like to assess myself in the mathematics class.	SD	D	U	A	SA

6.	I know when my answers are correct in mathematics even if the teacher has not yet given the answer.	SD	D	U	A	SA
7.	I don’t do my mathematics homework regularly.	SD	D	U	A	SA
8.	While I am struggling with a sum on my own, the teacher assists me several times during the period.	SD	D	U	A	SA
9.	I find that I can learn mathematics from discussions in groups with my peers.	SD	D	U	A	SA
10.	I think it is necessary to solve real-life problems in mathematics.	SD	D	U	A	SA
11.	When we are doing mathematics in groups, everybody in the group works together to find the answers.	SD	D	U	A	SA
12.	I feel like I am special in the mathematics class because the teacher always attends to my problems.	SD	D	U	A	SA
13.	The teacher usually gives enough information so that I know exactly what I do wrong in mathematics.	SD	D	U	A	SA
14.	I do not set goals for myself in mathematics.	SD	D	U	A	SA
15.	The mathematics teacher often talks about things in the mathematics class that I do not have any idea about..	SD	D	U	A	SA
16.	While we are doing group work, the teacher often assists us by asking leading questions.	SD	D	U	A	SA
17.	I prefer to do a sum myself before the teacher explains it.	SD	D	U	A	SA
18.	The classwork and homework that we do in mathematics do not help me to know whether I can do the mathematics.	SD	D	U	A	SA
19.	The teacher does not check during the lesson whether I understand the mathematics that we are doing.	SD	D	U	A	SA
20.	I am not always sure whether I am doing the mathematics right or wrong.	SD	D	U	A	SA
21.	I cannot learn mathematics from other learners.	SD	D	U	A	SA

22.	I prefer the teacher to do many examples so that I know exactly how to do the sums.	SD	D	U	A	SA
23.	I like to assess myself in mathematics so that I know exactly what I do right and what I do wrong.	SD	D	U	A	SA
24.	The teacher shows exactly what I should do to improve in mathematics.	SD	D	U	A	SA
25.	I do set goals for myself in mathematics.	SD	D	U	A	SA
26.	I do not think it is necessary to solve real-life problems in mathematics.	SD	D	U	A	SA
27.	When I am struggling with a sum alone, the teacher does not usually offer me any assistance.	SD	D	U	A	SA
28.	When we are doing group work, we usually work alone; the teacher does not assist us.	SD	D	U	A	SA
29.	I often do not have a clear idea about what I am supposed to be learning in the mathematics class.	SD	D	U	A	SA
30.	I do my mathematics homework regularly.	SD	D	U	A	SA
31.	The teacher does not inform me what I do wrong in mathematics.	SD	D	U	A	SA
32.	When we are assessed in groups in the mathematics class, some learners do all the work while others relax.	SD	D	U	A	SA

Part 2: Classroom environment

1.	I feel at home in the mathematics class.	SD	D	U	A	SA
2.	Usually I do not look forward to learning new things in the mathematics class.	SD	D	U	A	SA
3.	The mathematics teacher does not allow enough time for me to think when I have to answer a question.	SD	D	U	A	SA
4.	I look forward to being assessed in mathematics.	SD	D	U	A	SA

5.	The real-life mathematics problems that we do are boring most of the time.	SD	D	U	A	SA
6.	I have the courage to try to solve problems in the mathematics class.	SD	D	U	A	SA
7.	The teacher encourages us to use our own methods to solve problems in mathematics.	SD	D	U	A	SA
8.	I like to ask questions in the mathematics class.	SD	D	U	A	SA
9.	I like to answer the teacher's questions in the mathematics class.	SD	D	U	A	SA
10.	The mathematics teacher always explains why it is important to do mathematics classwork and homework.	SD	D	U	A	SA
11.	Even with help and plenty of time, I am going to have difficulty learning new things in the mathematics class.	SD	D	U	A	SA
12.	I believe that mathematics problems can be solved in several ways.	SD	D	U	A	SA
13.	I usually understand what is expected from me to learn in the mathematics class.	SD	D	U	A	SA
14.	I do not feel at home in the mathematics class.	SD	D	U	A	SA
15.	Many of my answers are correct in the mathematics class.	SD	D	U	A	SA
16.	The teacher does not listen attentively to my answers in the mathematics classroom.	SD	D	U	A	SA
17.	The teacher involves us learners in the setting of mathematics assessment tasks.	SD	D	U	A	SA
18.	I do not look forward to be assessed in mathematics.	SD	D	U	A	SA
19.	I believe that mathematics problems have one correct solution.	SD	D	U	A	SA
20.	I am really excited about learning new things in the mathematics class.	SD	D	U	A	SA
21.	I am too shy to answer the teacher's questions in the mathematics class.	SD	D	U	A	SA
22.	I am not sure why we have to do homework and classwork in mathematics.	SD	D	U	A	SA

23.	I often do not have a clear idea in the mathematics class about what I am supposed to be learning.	SD	D	U	A	SA
24.	The teacher wants us to use his/her methods when we solve problems in mathematics.	SD	D	U	A	SA
25.	The teacher always gives us interesting real-life mathematics problems to do so that we can really use mathematics in our everyday lives.	SD	D	U	A	SA
26.	I do not have the courage to solve problems in the mathematics class.	SD	D	U	A	SA
27.	The teacher allows enough time in the mathematics class for me to think when I have to answer questions.	SD	D	U	A	SA
28.	I don't like to ask questions in the mathematics class.	SD	D	U	A	SA
29.	When I have to learn new things in the mathematics class, I know I can learn them even if they are difficult.	SD	D	U	A	SA
30.	My answers are mostly wrong in the mathematics class.	SD	D	U	A	SA
31.	The teacher listens attentively to my answers in the mathematics class.	SD	D	U	A	SA
32.	The teacher never involves learners in the setting of mathematics assessment tasks.	SD	D	U	A	SA

Thank you for completing this questionnaire!

Vir navorser se gebruik:
☐☐

VRAELYS VIR LEERDERS

Hierdie vraelys bestaan uit twee afdelings:

- ☐ Afdeling A: Algemene en biografiese inligting.
- ☐ Afdeling B: Formatiewe assessering en klaskameratmosfeer.

ALGEMENE INLIGTING

1. Hierdie vraelys sal jou ongeveer 30 minute neem om te voltooi.
2. **Jy beantwoord hierdie vraelys anoniem. Moet asseblief nie jou naam op hierdie vraelys skryf nie.**
3. Hierdie vraelys is alleenlik vir gebruik deur die navorser. Wees asseblief eerlik.

AFDELING A: ALGEMENE EN BIOGRAFIESE INLIGTING

Instruksie: Trek 'n x in die toepaslike blokkie:

1. Geslag en graad

Geslag	Manlik		Vroulik	
Graad	8		9	

2. Huistaal (kies asseblief slegs een)

Engels	1
Afrikaans	2
Suid-Sotho	3
Tswana	4
Xhosa	5
Ander (spesifiseer asseblief) ………………………………..	6

3. In watter taal word jy onderrig?

Afrikaans	1
Engels	2

4. Wat was jou persentasie vir wiskunde aan die einde van verlede kwartaal?

0 – 29%	1
30 – 39 %	2
40 – 49 %	3
50 – 59 %	4
60 – 69 %	5
70 – 79 %	6
80 – 100 %	7

AFDELING B: FORMATIEWE ASSESSERING EN KLASKAMERATMOSFEER

INSTRUKSIES: Dui aan hoe jy voel oor elke stelling deur 'n kruisie in die toepaslike blokkie te trek.

SG =stem glad nie saam nie SN= stem nie saam nie O = onseker
SS = stem saam SH = stem heeltemal saam

Byvoorbeeld, dit is hoe jy sal antwoord indien jy saamstem met die stelling aan die linkerkant:

	Ek hou van wiskunde.	SG	SN	O	[✓ SS]	SH

Al die stellings wat volg hou verband met jou ervarings in die wiskunde-klaskamer. Dink dus slegs aan die periodes wat jy wiskunde het wanneer jy die res van die vraelys voltooi.

Deel 1: Formatiewe assessering

1.	Die wiskunde-onderwyser(es) probeer verskeie kere tydens die periode uitvind of ek die werk waarmee ons besig is verstaan.	SG	SN	O	SS	SH
2.	Ek dink nie die wiskunde-onderwyser(es) weet wat my probleme in wiskunde is nie.	SG	SN	O	SS	SH
3.	Die wiskunde-onderwyser(es) probeer altyd uitvind wat ek van 'n onderwerp af weet voordat hy/sy met nuwe werk begin.	SG	SN	O	SS	SH
4.	Die klaswerk en huiswerk wat ons doen in wiskunde help my om te weet of ek die wiskunde wel kan doen.	SG	SN	O	SS	SH
5.	Ek hou nie daarvan om myself in wiskunde te assesseer nie.	SG	SN	O	SS	SH
6.	Ek weet wanneer my antwoorde korrek is in wiskunde, al het die onderwyser nog nie die antwoord gegee nie.	SG	SN	O	SS	SH

7.	Ek doen nie my wiskunde huiswerk gereeld nie.	SG	SN	O	SS	SH
8.	Terwyl ek besig is gedurende die periode om aan ‘n som te werk, help die wiskunde-onderwyser(es) my dikwels.	SG	SN	O	SS	SH
9.	Ek ondervind dat ek wiskunde kan leer van my medeleerders wanneer ons in groepe in die klas wiskunde bespreek.	SG	SN	O	SS	SH
10.	Ek dink dit is nodig om alledaagse (ware lewe) probleme in wiskunde op te los.	SG	SN	O	SS	SH
11.	Wanneer ons wiskunde in groepe doen, werk al die leerders in die groep saam om die antwoord te kry.	SG	SN	O	SS	SH
12.	Ek voel dat ek spesiaal is in die wiskunde-klaskamer, die onderwyser(es) gee altyd aandag aan my probleme in wiskunde.	SG	SN	O	SS	SH
13.	Die onderwyser(es) gee my gewoonlik genoeg inligting sodat ek presies weet wat ek verkeerd doen in wiskunde.	SG	SN	O	SS	SH
14.	Ek stel nie vir myself doelwitte in wiskunde nie.	SG	SN	O	SS	SH
15.	Die onderwyser(es) praat dikwels van goed in die wiskundeklas waarvan ek geen idee het nie.	SG	SN	O	SS	SH
16.	Terwyl ons in groepe werk, help die onderwyser ons dikwels deur vrae te vra wat ons gedagtes in die regte rigting stuur.	SG	SN	O	SS	SH
17.	Ek verkies om ‘n som self te doen voordat die onderwyser(es) dit verduidelik.	SG	SN	O	SS	SH
18.	Die klaswerk en huiswerk wat ons doen in wiskunde help my nie om te weet of ek die wiskunde kan doen nie.	SG	SN	O	SS	SH
19.	Die onderwyser(es) kontroleer nie gedurende die periode of ek die wiskunde verstaan wat ons doen nie.	SG	SN	O	SS	SH
20.	Ek is nie altyd seker of ek die wiskunde reg of verkeerd doen nie.	SG	SN	O	SS	SH
21.	Ander leerders kan my nie wiskunde leer nie.	SG	SN	O	SS	SH

22.	Ek verkies dat die onderwyser(es) baie voorbeelde moet doen sodat ek presies weet hoe om die wiskunde te doen.	SG	SN	O	SS	SH
23.	Ek hou daarvan om myself in wiskunde te assesseer sodat ek presies weet wat ek reg en wat ek verkeerd doen.	SG	SN	O	SS	SH
24.	Die onderwyser(es) wys my presies wat ek moet doen om beter in wiskunde te doen.	SG	SN	O	SS	SH
25.	Ek stel vir myself doelwitte in wiskunde.	SG	SN	O	SS	SH
26.	Ek dink nie dit is nodig om ware lewe (alledaagse) probleme in wiskunde te doen nie.	SG	SN	O	SS	SH
27.	Terwyl ek met 'n som self stoei, bied die onderwyser(es) nie gewoonlik aan om my te help nie.	SG	SN	O	SS	SH
28.	Wanneer ons in groepe werk, help die onderwyser(es) ons gewoonlik nie – ons werk self.	SG	SN	O	SS	SH
29.	Ek het dikwels nie 'n goeie idee in die wiskunde klas wat ek veronderstel is om te leer nie.	SG	SN	O	SS	SH
30.	Ek doen my wiskunde huiswerk gereeld.	SG	SN	O	SS	SH
31.	Die onderwyser(es) vertel my nie wat ek verkeerd doen in wiskunde nie.	SG	SN	O	SS	SH
32.	Wanneer ons in groepe geassesseer word, doen sekere leerders al die werk terwyl ander nie saamwerk nie.	SG	SN	O	SS	SH

Deel 2: Klaskameratmosfeer

1.	Ek voel tuis in die wiskunde-klas.	SG	SN	O	SS	SH
2.	Ek sien meeste van die tyd nie daarna uit om nuwe dinge in die wiskunde-klas te leer nie.	SG	SN	O	SS	SH
3.	Die onderwyser(es) gee my nie genoeg tyd om te dink sodat ek vrae kan beantwoord in die wiskunde-klas nie.	SG	SN	O	SS	SH
4.	Ek sien daarna uit om in wiskunde geassesseer te word.	SG	SN	O	SS	SH

5.	Die alledaagse (ware lewe) probleme wat ons in die wiskunde-klas oplos is meestal vervelig.	SG	SN	O	SS	SH
6.	Ek het die moed om te probeer om wiskunde-probleme op te los in die wiskunde-klaskamer.	SG	SN	O	SS	SH
7.	Die onderwyser(es) moedig ons aan om ons eie metodes te gebruik om probleme in die wiskunde-klaskamer op te los.	SG	SN	O	SS	SH
8.	Ek hou daarvan om vrae te vra in die wiskunde-klas.	SG	SN	O	SS	SH
9.	Ek hou daarvan om die onderwyser(es) se vrae in die wiskunde-klas te beantwoord.	SG	SN	O	SS	SH
10.	Die wiskunde-onderwyser(es) verduidelik altyd waarom dit belangrik is om klaswerk en huiswerk in wiskunde te doen.	SG	SN	O	SS	SH
11.	Selfs al kry ek baie hulp en het ek baie tyd, gaan dit vir my moeilik wees om nuwe dinge in die wiskunde-klas te leer.	SG	SN	O	SS	SH
12.	Ek glo dat 'n wiskunde-probleem op verskeie maniere opgelos kan word.	SG	SN	O	SS	SH
13.	Ek verstaan gewoonlik wat dit is wat ek in die wiskunde-klas moet leer.	SG	SN	O	SS	SH
14.	Ek voel nie tuis in die wiskunde-klas nie.	SG	SN	O	SS	SH
15.	Baie van my antwoorde is korrek in die wiskunde-klas.	SG	SN	O	SS	SH
16.	Die onderwyser(es) luister nie met aandag na die antwoorde wat ek in die wiskunde-klas gee nie.	SG	SN	O	SS	SH
17.	Die onderwyser(es) betrek ons as leerders wanneer assesseringstake in wiskunde opgestel word.	SG	SN	O	SS	SH
18.	Ek sien nie daarna uit om in wiskunde geassesseer te word nie.	SG	SN	O	SS	SH
19.	Ek glo dat 'n wiskunde probleem slegs een korrekte oplossing het.	SG	SN	O	SS	SH
20.	Ek is regtig opgewonde om nuwe dinge in die wiskunde-klas te leer.	SG	SN	O	SS	SH

21.	Ek is te skaam om die onderwyser se vrae in die wiskunde-klas te beantwoord.	SG	SN	O	SS	SH
22.	Ek is nie altyd seker hoekom ons klaswerk en huiswerk in wiskunde moet doen nie.	SG	SN	O	SS	SH
23.	Ek het dikwels nie 'n idee wat dit is wat ek moet leer in die wiskunde-klaskamer nie.	SG	SN	O	SS	SH
24.	Die onderwyser(es) wil hê dat ons sy/haar metodes moet gebruik wanneer ons probleme in wiskunde oplos.	SG	SN	O	SS	SH
25.	Die onderwyser(es) gee altyd vir ons interessante alledaagse (ware lewe) probleme om op te los in wiskunde sodat ons werklik kan leer waar ons wiskunde kan gebruik.	SG	SN	O	SS	SH
26.	Ek het nie die moed om probleme op te los in die wiskunde-klas nie.	SG	SN	O	SS	SH
27.	Die onderwyser(es) gee my genoeg tyd om te dink wanneer ek 'n vraag in die wiskunde-klas moet beantwoord.	SG	SN	O	SS	SH
28.	Ek hou nie daarvan om vrae te vra in die wiskunde-klas nie.	SG	SN	O	SS	SH
29.	Wanneer ek nuwe dinge in die wiskunde-klas moet leer, weet ek ek kan, al is dit moeilik.	SG	SN	O	SS	SH
30.	My antwoorde is meestal verkeerd in die wiskunde-klas.	SG	SN	O	SS	SH
31.	Die onderwyser(es) luister met aandag na my antwoorde in die wiskunde-klas.	SG	SN	O	SS	SH
32.	Die wiskunde-onderwyser(es) betrek nooit ons leerders by die opstel van assesseringstake nie.	SG	SN	O	SS	SH

Baie dankie dat jy die vraelys voltooi het!

Vir navorser se gebruik: ☐☐

Appendix D

TEACHERS' QUESTIONNAIRE

1. Gender

Male	1
Female	2

2. Home language (please choose only one)

English	1
Afrikaans	2
Sesotho	3
SeTswana	4
IsiXhosa	5
IsiZulu	6
Other (please specify)	7

3. Language of learning and teaching

Afrikaans	1
English	2

4. Teaching experience

1 year	1
2 years	2
3 years	3
4 years	4
5 years	5
6 – 10 years	6
11 – 15 years	7
15 – 19 years	8
More than 20 years	9

5. Experience teaching mathematics in GET

1 year	1
2 years	2
3 years	3
4 years	4
5 years	5
6 – 10 years	6
11 – 15 years	7
15 – 19 years	8
More than 20 years	9

6. Highest qualification

Senior certificate	1
Teacher's certificate	2
Teacher's diploma	3
Degree	4
Degree and teacher's certificate/diploma	5
Honour's degree	6
Honour's degree and teacher's certificate/diploma	7
Master's degree	8
Other (please specify)	9

7. Highest level of mathematics

Mathematics I	1
Mathematics II	2
Mathematics III	3
Other (please specify)	4

8. NCS training in GET

Generic training	1
Mathematics training	2
Training for any other learning area	3
Menu training: mathematics	4
Menu training: Other learning areas	5

9. What do you do to find out more about outcomes-based education, outcomes-based assessment and the improvement of teaching and learning in the mathematics classroom (recent trends in mathematics teaching and learning)?

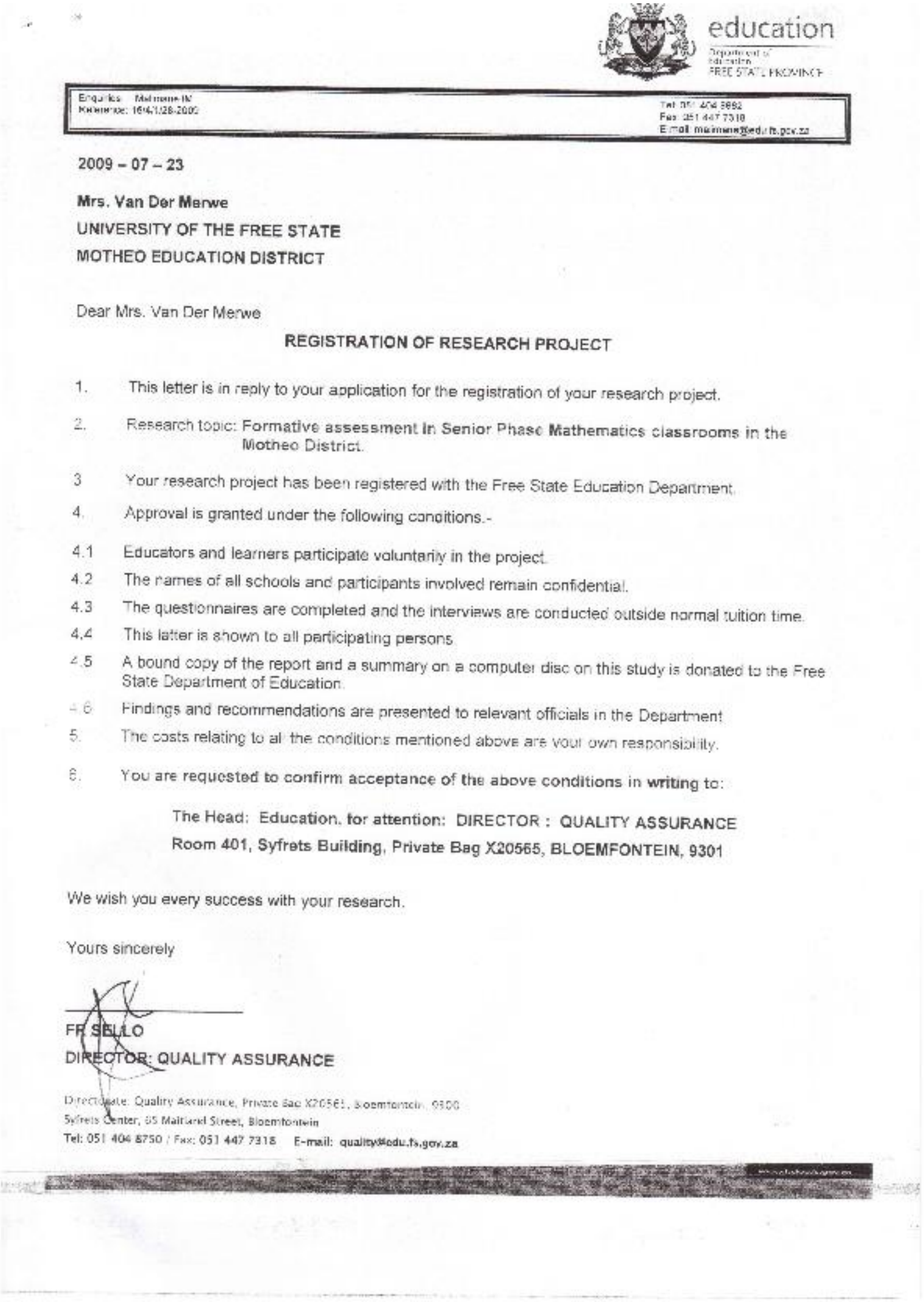
____

____

10. Indicate the last year you studied formally in an education-related direction.

____

Appendix E



education
Department of
Education
FREE STATE PROVINCE

Enquiries: Maimane IM
Reference: 16/4/1/28-2009

Tel: 051 404 9892
Fax: 051 447 7318
E-mail: maimane@edu.fs.gov.za

2009 – 07 – 23

Mrs. Van Der Merwe
UNIVERSITY OF THE FREE STATE
MOTHEO EDUCATION DISTRICT

Dear Mrs. Van Der Merwe

REGISTRATION OF RESEARCH PROJECT

1. This letter is in reply to your application for the registration of your research project.

2. Research topic: **Formative assessment in Senior Phase Mathematics classrooms in the Motheo District.**

3 Your research project has been registered with the Free State Education Department.

4. Approval is granted under the following conditions.-

4.1 Educators and learners participate voluntarily in the project.
4.2 The names of all schools and participants involved remain confidential.
4.3 The questionnaires are completed and the interviews are conducted outside normal tuition time.
4.4 This latter is shown to all participating persons.
4.5 A bound copy of the report and a summary on a computer disc on this study is donated to the Free State Department of Education.
4.6 Findings and recommendations are presented to relevant officials in the Department.

5. The costs relating to all the conditions mentioned above are your own responsibility.

6. You are requested to confirm acceptance of the above conditions in writing to:

The Head: Education, for attention: DIRECTOR : QUALITY ASSURANCE
Room 401, Syfrets Building, Private Bag X20565, BLOEMFONTEIN, 9301

We wish you every success with your research.

Yours sincerely

FR SELLO
DIRECTOR: QUALITY ASSURANCE

Directorate: Quality Assurance, Private Bag X20565, Bloemfontein, 9300
Syfrets Center, 65 Maitland Street, Bloemfontein
Tel: 051 404 8750 / Fax: 051 447 7318 **E-mail: quality@edu.fs.gov.za**