CONSTRUCTIVE TEACHER FEEDBACK FOR ENHANCING LEARNER PERFORMANCE IN MATHEMATICS

By

CHARMON NAROTH

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Supervisor: PROF Dr GF DU TOIT

Co- Supervisor: DR ER DU TOIT

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DEDICATION

Dedicated to my late mother, Gwendoline Frances, who instilled in all her children an ardent sense of commitment and dedication, and who taught us that the one thing that matters is the effort.

DECLARATION

I, the undersigned, declare that the thesis hereby submitted by me for the MAGISTER EDUCATIONIS (M.Ed.) degree at the University of the Free State is my own independent work and that I have not previously submitted the same work for a qualification at another university. I further cede copyright of this thesis in favour of the University of the Free State.

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Charmon Naroth

Date: December 2010

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SUMMARY

CONSTRUCTIVE TEACHER FEEDBACK FOR ENHANCING LEARNER PERFORMANCE IN MATHEMATICS

South Africa's participation in international achievement studies in recent years has served as a useful benchmark for learner performance in mathematics. The analysis of learning achievement against national and international benchmarks indicates that an improvement in the quality of learning output remains one of the biggest challenges facing the South African education system. Finding ways to improve learner performance in mathematics should thus be a critical priority for all stakeholders.

The extant literature proposes that strengthening the practice of using assessment for formative purposes results in significant learning gains. The value of positive and constructive feedback to learners during the process of assessment is advocated by a number of studies, yet few studies focus on investigating the use of feedback strategies in a mathematics classroom context, or reflect on the contextual realities that may impact on the provision of feedback to learners.

In this research a case study was conducted in the classrooms of two primary school mathematics teachers in order to explore evidence of feedback strategies used in their classrooms and the factors that may have an impact on their ability to provide constructive feedback to learners. The study also examined the contextual realities at classroom level that may impede on the use of constructive feedback to enhance learning. The teachers were observed in their classrooms and follow-up interviews were conducted. Samples of the teachers' documents and the learners' work were used to evaluate the teachers' feedback strategies and provide practical suggestions. The qualitative data was used to explicate findings from the literature review and enabled the study to provide recommendations pertaining to the provision of feedback to learners.

OPSOMMING
KONSTRUKTIEWE ONDERWYSER-TERUGVOER OM LEERDERPRESTASIE IN WISKUNDE TE VERBETER

Suid Afrika se deelname in internasionale studies in onlangse jare het as ’n nuttige maatstaf gedien om leerderprestasie in wiskunde te meet. ’n Analise van leerderprestasie teen nasionale en internasionale standaarde dui daarop dat verbetering in die kwaliteit van leeruitsette nog steeds een van die grootste uitdagings vir die Suid-Afrikaanse onderwyssisteem is. Om leerderprestasie in wiskunde te verbeter moet dus ’n kritiese prioriteit vir alle aandeelhouers wees.

Die bestaande literatuur stel voor dat die gebruik van assessering vir formatiewe doeleindes heelwat verbetering in leeruitsette tot gevolg kan hê. Die waarde van konstruktiewe terugvoer aan leerders tydens die proses van assessering word deur n aantal studies bevorder, maar min studies fokus op die ondersoek van die gebruik van terugvoerstrategieë in ’n wiskunde-klas, asook die kontekstuele werklikhede wat ’n impak mag hê op die verskaffing van terugvoer aan leerders.

In hierdie navorsingsstudie is ’n gevallestudie in die klaskamers van twee wiskunde onderwysers in ’n primêre skool uitgevoer, ten einde te ondersoek watter terugvoerstrategieë in hul klaskamers gebruik word, asook die faktore wat ’n impak op hul vermoë om konstruktiewe terugvoer aan leerders te gee, mag hê. Die studie ondersoek ook die kontekstuele werklikhede in die klaskamer wat die gebruik van konstruktiewe terugvoer aan leerders om hul prestasie te verbeter, mag strem. Die onderwysers is in hul klaskamers waargeneem en onderhoude is daarna uitgevoer.

Die onderwysers se beplanningsdokumente en die leerders se werkboeke is gebruik om die onderwysers se terugvoerstrategieë te evalueer en daarvolgens praktiese voorstelle te verskaf. Die kwalitatiewe data is gebruik om bevindinge van die literatuurstudie te evalueer en het die navorser in staat gestel om aanbevelings met betrekking tot die verskaffing van terugvoer aan leerders te maak.

KEY WORDS

- **Feedback**
- **Constructive Feedback**
- **Formative Assessment**
- **Mathematics**
- **Social Constructivism**
- **Learning Theories**
- **Problem-Solving**

ACRONYMS

AS	**Assessment Standard**
DoE	**Department of Education**
CASS	**Continuous Assessment**
GET	**General Education and Training**
FET	**Further Education and Training**
LO	**Learning Outcome**
NCS	**National Curriculum Statement**
OBE	**Outcomes-Based Education**
RME	**Realistic Mathematics Education**
ZPD	**Zone of Proximal Development**

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RESEARCH DESIGN AND ORIENTATION

1.1 INTRODUCTION AND PROBLEM STATEMENT

South Africa's participation in international achievement studies in recent years has served as a useful benchmark for learner performance in mathematics. Results from these assessments are an indication of the crisis facing mathematics education in this country.

In both the 1999 and 2003 TIMSS studies, South Africa's performance was extremely poor. Learners attained the lowest average scores in Mathematics when compared to all the other participating countries, including the other African countries that participated. In 1999 the average scale score for South African grade 8 learners was 275 and in 2003 they scored 264 points out of a maximum score of 800. This was well below the international average scale score (IEA 2005: 12; DOE 2009b:87).

South African learners achieved equally dismal results in the Monitoring Learning Achievement (MLA) Project which was conducted in several African countries in 1999, and which measured the competencies of Grade 4 learners in numeracy, literacy and life skills. Out of the 12 participating countries, South Africa scored the lowest average in Numeracy with an average score of 30.2%. Only 1.5% of learners scored 75% or higher on this test (DOE 2009b:82).

In the second Southern African Consortium for Monitoring Educational Quality (SACMEQ) II Project, conducted between 2000 and 2002, which assessed the reading and Mathematics competencies of Grade 6 learners in 14 countries in Africa , South

Africa achieved just under the mean SACMEQ score and ranked ninth in Mathematics (DOE 2009b:85).

South Africa's own systemic evaluation conducted in 2001, 2004 and 2007 which focused on Grades 3 and 6 learners produced similar results. In 2007 Grade 3 learners scored an average of 35% in numeracy. In 2004 the achievement rates of learners in the Grade 6 evaluation were even poorer than those for Grade 3, with learners obtaining an average of 27% for Mathematics. The majority of Grade 6 learners failed to reach the standard required by the National Curriculum with only 12% of Grade 6 learners performing at the Achieved or Outstanding level (DOE 2003:33, DOE 2009b:78).

The analysis of learning achievement against national and international benchmarks as indicated above indicates that an improvement in the quality of learning output remains one of the biggest challenges facing the South African education system. In response to these results the national education department has been vigorous in developing a number of initiatives and programmes aimed at improving learner achievement in Mathematics, including the introduction and implementation of the Foundations for Learning (FFL) Campaign and Annual National Assessments (ANA). It remains to be seen how successful these programmes are in raising learner performance in Mathematics.

1.1.1 The role of assessment in learner achievement

Numerous studies identify assessment as one of the key challenges which impacts on learner achievement. Chisholm, Volmink, Ndhlovu, Potenza, Mahomed, Muller, Lubisi, Vinjevold, Ngozi, Malan and Mphahlele (2000:11) reported on a "lack of alignment between curriculum and assessment policy as well as clarity regarding assessment policy and practice". The Task Team for the Review of the Implementation of the National Curriculum Statement (DOE 2009a:14) also reported on several problems related to various aspects of assessment. It has also been the researcher's experience

as a teacher and as Mathematics Co-ordinator at the Northern Cape Provincial Department of Education Head Office that the assessment practices of teachers appear to have adverse consequences for learners. This is evident from the learner portfolios moderated on a quarterly basis which reflected questionable assessment practices resulting in very low achievement levels of Mathematics learners. The researcher has field experience that attests to what Stiggins (2008a:6) surmises: "The vast majority of teachers and school leaders carry out their assessment practices with neither the confidence nor competence needed to do so productively to support student learning".

A number of research studies propose that strengthening the practice of using assessment for formative purposes results in significant learning gains (for example, Black & Wiliam 1998:3, Sadler 1989, Stiggins 2008a:4). Black and Wiliam (1998:3) posit that for assessment to be formative "the results have to be used to adjust teaching" and this involves finding new ways to enhance feedback to learners. They also declare that this would require new methods of teaching and considerable changes to classroom practice.

The South African National Policy on Assessment and Qualifications for Schools in the General Education and Training Band (DOE 2007a:8) underscores the value of the provision of feedback to learners in the following statement: "Continuous assessment (CASS) is an assessment model that encourages the integration of assessment into the teaching and development of learners through ongoing feedback". The review committee (DOE 2009a:29) also states that "assessment should provide feedback on what learners know relative to what they should know".

Classroom-based evidence of feedback strategies should, therefore, be sought to highlight good practice and identify shortcomings and make recommendations for the use of constructive feedback to learners to improve their performance in mathematics.

1.2 PROBLEM FORMULATION

Extensive evidence, as highlighted by the primary literature consulted in the foregoing sections, demonstrates that the teaching and learning of mathematics in our schools is plagued with problems and inadequacies, which results in low educational achievement. Teachers' assessment practices have also been found to exacerbate poor learner performance rather than serve to provide information on the learners' strengths and weaknesses so as to modify the teaching and learning activities and ultimately improve learning.

The value of positive and constructive feedback to learners during the process of assessment has been widely recognised as one aspect that could contribute to the everyday classroom task of achieving better learning. Hattie and Timperley (2007:87) contend that "[e]ffective teaching not only involves imparting information and understanding to students…but also involves assessing and evaluating students' understanding of this information, so that the next teaching act can be matched to the present understanding of the students. This second part is the feedback part".

Research into classroom-based evidence of feedback strategies is necessary because there are many literature studies enunciating the value of feedback to learners and that provide guiding principles for the implementation of feedback, yet few studies focus on investigating the use of feedback strategies in a mathematics classroom context, or reflect on the contextual realities that may impact on the provision of feedback to learners.

Therefore the study will explore:

- evidence of feedback strategies used in a mathematics classroom context;

- factors that impact on the ability of teachers to provide constructive feedback to learners to enhance learner performance in Mathematics;

- contextual realities at classroom level that may impede the use of constructive feedback to enhance learning.

1.3 GENERAL AIMS AND RESEARCH OBJECTIVES

In this research study, the general aim is to explore, from a theoretical and practical perspective, the use of constructive feedback to enhance learner performance in a mathematics classroom context. The research therefore seeks to:

- review existing research into learning theories, trends in mathematics education and the use of constructive feedback as a way of improving learning and raising standards;

- examine and evaluate evidence of feedback strategies used in a mathematics classroom context;

- reflect on factors that impact on the ability of teachers to provide constructive feedback to learners to enhance learner performance in Mathematics;

- determine the contextual realities at classroom level that may impede the use of constructive feedback to enhance learning; and

- provide recommendations aimed at developing teachers' competence in providing constructive feedback to learners

1.4 DEMARCATING THE FIELD OF STUDY

Leedy and Ormrod (2001:61) maintain that it is equally important to know both what the researcher intends to do as well as what the researcher does not intend to do.

The study provides a brief overview of learning theories with the intention of establishing a link between the feeback strategies that teachers employ and the learning theory that they conform to. Since the phenomenon of constructive feedback falls within the ambit of formative assessment, this study also briefly reviews current literature on how formative assesssment links to constructive feedback.

This research study explores the use of constructive feedback in the mathematics teaching and learning situation, to enhance learner performance in Mathematics. It therefore examines and evaluates evidence of feedback strategies used by mathematics teachers. The study also reflects on the factors that may impact on the ability of teachers to provide constructive feedback to learners. The study further aims to ascertain what are the contextual realities at classroom level that may impede the use of constructive feedback to enhance learning. The study mainly focuses on feedback provided by the teacher. It does not provide an analysis of the different types of feedback and their effects on learning but rather a general discussion of different aspects of feedback which teachers can incorporate into their daily instructional routines. Furthermore, it is not the aim of this study to relate evidence from research studies on the effect sizes deduced from meta-analyses of the use of feedback strategies to improve learning. Rather, the study makes a general argument for improving feedback to enhance learning in mathematics, while highlighting general feedback strategies which teachers should take into account (refer to Hattie & Timperley 2007:85) for a synthesis of a number of meta-analyses relating to the provision of feedback).

Classroom assessment plays a key role in how learners learn and how teachers teach. Feedback is also inextricably linked to teaching and assessment. The study therefore also reflects on the alignment between learning standards, teaching and learning activities, assessment strategies and feedback as implemented by the participants and how these impact on the way learners learn, and the degree to which it allows teachers to provide constructive feedback to learners to enhance their learning.

The study does not focus on formative or summative assessment in general, nor does it focus on the various assessment strategies, types of assessment and their uses. All references to assessment are in the context of how it relates to providing constructive feedback to learners to enhance their learning in Mathematics.

This study is conducted within the field of Curriculum Studies with the aim of exploring the use of constructive feedback to enhance the learning of mathematics.

The research was conducted in a grade 4 and a grade 5 class in a public school in the Umzinyathi administrative district of the Kwazulu Natal Province. The school is a primary school consisting of grades R to 6.

1.5 RESEARCH PARADIGM

Given that this study aims to explore teachers' *understanding* and *experiences* with regards to assessment practices and the providing of constructive feedback, it lends itself to a constructivist paradigm. Guba and Lincoln (1994:113) assert that the aim of a constructivist inquiry is "understanding and reconstruction of the constructions that people (including the inquirer) initially hold, aiming toward consensus but still open to new interpretations as information and sophistication improves". In describing how constructivists perceive reality, Pickard and Dixon (2004:4) talk about a "relativist stance". This terminology is in line with Krauss's contention that constructivists "do not assume that there is a single unitary reality apart from our perceptions. Since each of us experiences from our own point of view, each of us experiences a different reality" (Krauss 2005:760). This is in direct contrast to the "realist ontology" (Guba & Lincoln 1994:113; Pickard & Dixon 2004:4) associated with positivism, which assumes that reality can be understood through "observation and measurement" (Krauss 2005:760).

1.6 METHODS OF RESEARCHING THE PROBLEM

An exploratory and qualitative mode of study is used. The method of investigation entails a literature review and an empirical study. The literature study makes reference to primary sources, such as books and official documents such as policy documents and education gazettes. It also includes a review of secondary sources such as dissertations, theses and journal articles. Journal articles and research papers are sourced from the internet and from online journal databases.

A sample of two teachers from a primary school in the Umzinyathi District in the Kwazulu Natal Province were chosen through purposive sampling. Observations and semi-structured interviews were used as a means of generating data. In addition, the teachers' official records and documents and the learners' books were another source of information. (A detailed description of the research methodology is provided in chapter 4).

On conclusion of the qualitative investigation, the data was analysed and presented. Findings from the investigation were used to provide recommendations for improving the use of feedback to learners to enhance their performance in mathematics.

1.7 ETHICAL ISSUES

McMillan and Schumacher (1998:17) assert that it is primarily the researcher's responsibility to adhere to ethical standards. The steps undertaken by the researcher to ensure objectivity, confidentially and honesty are outlined in section 4.9.

1.8 VALUE OF THE RESEARCH

The findings of this research are intended to augment both current and further research data on the importance of effective and constructive feedback to Mathematics learners. This study is also important for the specific context in which it takes place – South

African schools differ from that of other countries and it is important to consider this phenomenon in a South African context, given its unique issues pertaining to multi-culturalism, language and socio-economic conditions.

Valuable lessons for professional development could be learned from this research that can provoke debates and possibly policy formulation. The study is also intended to suggest ways in which teachers can improve the feedback strategies they employ in their classrooms in order to enhance the learning of mathematics and become reflective practitioners in their daily teaching and assessment of Mathematics.

1.9 EXPLANATION OF CONCEPTS

The following concepts require definition, as they are used repeatedly in this investigation:

1.9.1 Feedback

Sadler (1989:120) posits that feedback is usually defined in terms of “information about how successfully something has been or is being done, and in terms of its effect rather than its information content”.

According to Black and Wiliam (1998:6), “Feedback to any pupil should be about the particular qualities of his or her work, with advice on what he or she can do to improve, and should avoid comparisons with other pupils”.

Hattie and Timperley (2007:81) conceptualise feedback as information provided by the teacher regarding the aspect of the learner’s performance. They further quote Winne and Butler (1994:574) wherein they claim that “feedback is information with which a learner can confirm, add to, overwrite, tune, or restructure information in memory, whether that information is domain knowledge, meta-cognitive knowledge, beliefs about self and tasks, or cognitive tactics and strategies”.

1.9.2 Constructive Feedback

Bee and Bee (1996:3) assert that feedback is constructive when “there are agreed standards of behaviour and performance, and two-way communication about what has gone right as well as what has gone wrong” and when it “provides information about behaviour and performance against objective standards in such a way that recipients maintain a positive attitude towards themselves and their work”.

According to Irons (2008:55) constructive feedback “should be relevant to the formative assessment and to the student learning process”.

Sangster and Overall (2006:123) are of the opinion that “giving constructive formative feedback carries the implication that there will be information available which helps you to improve your work”.

Where the study merely refers to “feedback”, it implies constructive feedback since all references to feedback are in the context of ensuring enhanced learner performance in mathematics. What is key about all references to feedback in this study is that it assumes that it is information about a learner’s performance against objective standards with the aim of enhancing learner performance, in such a way that they maintain a positive attitude towards themselves and their work.

1.9.3 Formative Assessment

Black and Wiliam (1998:2); Earl and Katz (2006:4); Le Grange and Reddy (1998:4) and Falchikov (2005:3) state that assessment is formative if it takes place during teaching, when the evidence is actually used to make adjustments to the teaching process and to provide feedback to learners to improve their learning.

According to Sadler (1989:2) formative assessment “is concerned with how judgments about the quality of student responses (performances, pieces, or works) can be used to

shape and improve the student's competence by short-circuiting the randomness and inefficiency of trial-and-error learning".

1.10 RESEARCH PLAN

The following provides an overview of the chapters included in this study:

In chapter one, the problems related to learner performance in Mathematics and the shortcomings in mathematics instruction and assessment practices is presented. The research problem is outlined and justified and the research procedure is stated.

Chapter two contains the examination of literature sources on learning theories and trends in mathematics teaching.

In chapter three literature sources relating to the provision of feedback are reviewed.

Chapter 4 is a presentation of the research methodology and provides a rationale for the use of a qualitative research methodology. An elaboration of the sampling techniques and data collection methods are provided. Details on the validity and reliability of the study are also presented. Finally, an explanation of the analysis and interpretation of the data is given.

In chapter 5 the research findings are presented.

Chapter 6 provides the analysis and interpretation of the research results.

Chapter 7 presents the conclusions deduced from the literature and the research findings, and recommendations for the use of constructive feedback to enhance learner performance in mathematics.

1.11 CONCLUSION

This introductory chapter highlights the problems in mathematics education currently experienced in South Africa. It refers to the resultant low achievement levels of Mathematics learners. It also points to inadequate assessment practices as being a contributing factor and argues for the use of constructive guidance to learners, so that they can plan the next steps in their learning and in so doing improve learning in mathematics.

A statement and clarification of the problem, and the aims and objectives of the study were established in this chapter. The research design and methods of research were briefly explained. In addition, the researcher relayed the ethical considerations and the value of the study. The relevant concepts used in this chapter and in subsequent chapters were defined, and finally, the framework for the study was set out.

In chapter 2, the researcher reviews existing research into learning theories and trends in mathematics teaching, as it has direct bearing on the provision of feedback to learners.

2

TRENDS IN MATHEMATICS TEACHING AND LEARNING AND ITS IMPLICATIONS FOR PROVIDING CONSTRUCTIVE FEEDBACK ON ASSESSMENT

2.1 INTRODUCTION

"Instructional science in general, and instructional psychology in particular, have undergone tremendous changes over the past decades, and at present important new developments are emerging. Those changes relate to the basic orientation of the field as well as to theoretical and methodological issues and problems" (De Corte 2000:250). New instructional approaches require interactive teaching and learning environments. It demands that teachers know about their learners' strengths and weaknesses in order to adapt their teaching to meet the needs of learners. Central to this is the provision of feedback to learners which will enable learners to gain an understanding of the intended goals and the ways in which they can improve their own learning.

The design of educational programmes is always guided by beliefs about how learners learn in an academic discipline. Teachers have contrasting views on mathematics education. Their underlying belief systems about the nature of mathematical understanding will impact on what learners are taught, how they will be taught and how they will be assessed (Hergenhahn 1982:408; Niss 1993:75). Schoenfeld (1992:23) refers to this as "the epistemological-to-pedagogical link". Hence, teachers who believe that learners learn best through rote learning and repeated practice will design their lessons and assessment procedures differently from those who hold that students learn best through active inquiry and investigation (Niss 1993:75; Garegae 2001:3). Black and Wiliam (1998:9) also assert that teachers' beliefs about learning determine whether

the assessment strategies they employ serves formative purposes. Teachers who believe that knowledge should be transmitted and subsequently learnt, and that it is the teachers' job to explain clearly and reward those learners who are able to regurgitate what they have been told, will not necessarily see value in formative assessment methods. Hargreaves, McCallum and Gipps (2000:30), in addition, posit that teachers' choice of feedback strategies are also influenced by their beliefs about how learners learn. For example, because some teachers believe that children learn through the transmission of knowledge from the teacher, their feedback strategies usually merely entail telling learners whether they are right or wrong.

This chapter provides an overview of various learning theories and discusses particular trends in the teaching and learning of Mathematics as it relates to the provision of feedback to learners. For the purpose of this study, distinctions will not be made between the varying interpretations of theories of learning such as Thorndike's connectionism, Watson's classical conditioning, Skinner's operant conditioning, cognitive and social cognitive theory, realistic or radical constructivism. The study also does not endeavor to present a systematic and detailed analysis or account of the different epistemological and ontological underpinnings of the various learning theories, but places the focus on constructivism as a learning theory and the instructional practices which result from this view. A review of numerous literature studies has brought the researcher to the conclusion that learning theories cannot always be defined into distinct categories, since terms and strategies of different theories have common ground and theories of learning are ever evolving.

2.2 LEARNING THEORIES

A cursory view of behaviorist and cognitive learning theories and its impact on mathematical instructional design and assessment is offered. Thereafter, a contrasting socio-constructivist perspective is presented that blends key ideas from current trends in Mathematics education, in order to argue for improved feedback strategies to improve the learning of Mathematics.

2.2.1 The Behaviorist Learning Theory

For many years, the behaviorist theory of BF Skinner was dominant. The theory of behaviorism claims that there is an immediate response to every effective stimulus and that "[i]t is the business of behaviorist psychology to predict and to control human behavior" (Watson, 1997:14). Much emphasis is placed on what Skinner (1954:86) refers to as "contingencies of reinforcement" – the connection between behaviour on the one hand and the consequences of that behaviour on the other hand, in order to achieve a much more effective control of that behaviour. This emphasis on the study of overt behaviours that can be observed and measured suggests that the teacher has to aim at producing behavioural change in a desired direction. Teachers therefore focus on creating environments that allow learners to behave in accordance with specific objectives. Understanding is therefore measured by observing change in a learner's behaviour through recitation, tests and examinations (Garegae 2001:233; Hergenhahn 1982:408).

These assumptions about learning influence teachers' choice of teaching techniques, which often involves drill and practice which may result in rote memorisation. Learning is considered to be "an accumulation of atomised bits of knowledge that are sequenced, hierarchical, and need to be explicitly taught and reinforced" (Earl & Katz 2006:3). Handal (2003:1) also points out that behaviorist practices "emphasise transmission of knowledge and stress the pedagogical value of formulas, procedures and drill, and products rather than processes. Behaviorism also puts great value on isolated and independent learning, as well as conformity to established one-way methods and predilection for pure and abstract mathematics". Skinner (1954:94) theorises that a task should be broken down into a very large number of very small steps and that learners learn best in a linear step-by-step format. Skinner posits that repetition and constant reinforcement of the step-by-step processes are essential for learners to become competent in a particular field.

From a behaviorist perspective, feedback is based on stimulus-response learning. If a reward or reinforcement follows the response to a stimulus, then the response becomes more probable in the future. Behaviorism is often used by teachers, who reward or punish student behaviors.

2.2.2 The Cognitivist Learning Theory

"While behaviorism focuses on the external behavior of the learner, cognitivism, on the other hand emphasises on the internal mental structures of the same - thus lending itself to abstract information processing rather than actual behaviors" (Geregae 2001:233). Cognitive theorists acknowledge the importance of reinforcement; however they underscore its role in providing feedback about the correctness of responses over its role as a motivator.

Piaget's theory of cognitive development borrows much from the biological sciences (Locke and Ciechalski 1995:14; Von Glasersfeld 1990). He concludes that children adapt to their environments through either *assimilation* or *accommodation*. In Piaget's theory of cognition, this is the first of three basic principles. Assimilation occurs when individuals integrate new information into existing knowledge. The notion suggests that to respond to a new stimulus, the child employs a response already learned. Thus, assimilation is the process by which new environmental stimuli are placed into existing frameworks (Hergenhahn 1982:284; Locke & Ciechalski 1995:14; Mergel 1998:10; Von Glasersfeld 1990). Piaget (1980:43) in his discussions with Bringuier offers the example of an infant who just discovers that he can grasp what he sees. From then on, the child attempts to grasp everything he sees because it is assimilated to the "schemes of prehension". According to Piaget (1980:43) assimilation is just the proof that structures or schema already exist and that external stimuli can only modify behavior to the degree that it is integrated with prior structures. Hence, in accordance with cognitive theory, abstract formal mathematical knowledge such as symbols and computational algorithms can only make sense to learners if it is related to their existing informal knowledge of mathematics. Baroody and Ginsburg (1990:57) state that

“[a]ssimilation and interest go hand in hand” therefore learners will only assimilate new information if it makes sense to them and arouses their interest. It suggests that understanding cannot be imposed upon children. This was first proposed by Piaget when he stated that it is not the environment that stimulates the child, rather the child takes the initiative to respond to those features which are meaningful to him. Learners will therefore only assimilate new information if it makes sense to them and arouses their interest (Baroody & Ginsburg 1990:57; Bliss 2002:28; Montangero & Maurice-Naville 1997:62).

Accommodation is the process by which a child adjusts to new information or internalises stimuli that do not fit any of the frameworks already possessed. When a child is presented with a framework for which no reference exists, the child must create a completely new framework in which to place the new material. Sometimes the child can extensively modify an existing framework. In both cases, accommodation is the result (Baroody & Ginsburg 1990:57; Locke & Ciechalski 1995:14; Siegler 2003:219; Von Glasersfeld 1997). This is described by Hergenhan (1982:284) as a process which “provides a mechanism for intellectual growth”. This is aptly illustrated by Piaget’s (1980:43) infant analogy: if the child sees a large object, for which he needs both hands, or if it is a very small object and he needs to tighten the fingers of only one hand to grasp it, he will “modify the scheme of comprehension” and change his adjustment. Once the child has developed the new framework, the child can assimilate the new experience. Assimilation is always the final stage of the process. The child is always increasing the number of existing frameworks into which new experience can be placed (Locke & Ciechalski 1995:14). Bringuier and Piaget (1980:43) and Mason and Johnston-Wilder (2004:150) assert that assimilation consequentially brings about accommodation because as soon as the scheme of assimilation is applied to a particular situation, it must be modified according to the particular circumstances of the situation. Von Glasersfeld (1997) points out that this second principle provides a procedure for learning and should therefore be of interest to all teachers.

For accommodation and assimilation to take place it would require constant communication between teacher and learners. In order to replace or reconstruct existing ideas learners should receive continuous feedback on their thinking processes. Assimilation and accommodation are also closely related to metacognition and self-regulation in learning as discussed in 2.3.2.2 and 3.3.3. The more the learner is responsible for in the learning process, the deeper and more successful their learning will be.

Piaget uses the term “adaptation” to explain that children seek to maintain equilibrium by balancing the amount of assimilation and accommodation. Equilibrium occurs when assimilation and accommodation are in a specific relationship with each other, and helps to regulate behaviour (Bringuier & Piaget 1980:44). The level of cognitive development will determine the means by which the child will maintain equilibrium (Bliss 2002:24; Bringuier & Piaget 1980:43; Locke & Ciechalski 1995:15; Mason & Johnston-Wilder 2004:150). Von Glasersfeld in Mason and Johnston-Wilder (2004:149) describes Piaget’s concept of adaptation as the organism’s ability to construct a relative “fit” or “viability” with the world as it experiences it. In the cognitive domain it is tied to the attainment of goals and the mutual compatibility of constructs.

Piaget also asserts that, in responding to the environment, the child engages in two types of activity – physical and logico-mathematical. Physical activity is when the child notices attributes of objects, features of situations and so forth, in the environment. This provides him with specific knowledge about the world he lives in. But there is a second logico-mathematical level of activity, which is the basis for the construction of the child’s intellectual structures. Bliss (2002:28) provides the following example to illustrate the point: “A child arranges a row of pebbles in a straight line, counts them and finds they are ten. He rearranges the pebbles in a number of patterns each time finding that the result is ten. What he learns is that the number does not change regardless of the pattern”. Piaget emphasises that it is the child’s actions that are important not the objects. The pebbles could be replaced with any other object. To describe this logico-mathematical activity Piaget also used the term “reflective abstraction” (Bliss 2002:28;

Noddings 1990:8; Von Glasersfeld 1990:63). The child reflects on his or her own activity in a self-regulatory sense and this becomes the main source of growth of the operative structure. According to Piaget the child must make or construct his or her own logical ideas and it is not an addition of externally imported elements (Bliss 2002:28).

Hence the idea of assimilation and schema is also often referred to from a constructivist perspective (Ginsburg & Seo 1999:126; Noddings 1990:9; Piaget 1980:164; Sinclair 1990:20; Steffe 1990:10; Von Glasersfeld 1990:32). Schema can be regarded as the structure that is responsible for the interpretation of the environment (Piaget 1980:225). The "integration of new objects or situations or events into previous schemes" (Piaget 1980:164) leads to the creation of a mathematical environment wherein the *construction* of knowledge takes place. For example, adding and subtracting two and more digit numbers involves only assimilation of the extra digits, at least until an algorithm is presented for dealing with large numbers and large numbers of numbers, such as column addition and subtraction.

In any case, Palincsar (2005:285) asserts that "[v]irtually all cognitive science theories entail some form of constructivism to the extent that cognitive structures are typically viewed as individually constructed in the process of interpreting experiences in particular contexts".

Feedback from a cognitivist perspective focuses on facilitating learning so that learners can create accurate mental representations and connections. Feedback to learners aims to focus their attention on key features of the new information, correct misconceptions, and assist learners to assimilate new knowledge with existing knowledge. As an example, when learners use their existing knowledge about adding whole numbers and apply the same strategy for adding fractions, rather than accommodating to fractions as new objects, feedback to learners must emphasise that only fraction parts that are the same can be added together.

2.2.3 The Constructivist Learning Theory

During the last 20 years, the notion of what it means to learn mathematics has shifted from being defined as the passive and decontextualized acquisition of concepts and procedures to being defined as the active construction of meaning. Constructivists believe that the construction of new concepts is based upon current and past knowledge, experiences, mental structures and beliefs. Learners are thus able to go beyond the information given as they integrate knowledge from their own experiences and new information. This knowledge construction is influenced by their own readiness to learn, their interests and learning styles (Earl & Katz 2006:3; Garegae 2001:233; Jaworski 1996:1; Mergel 1998:8; Powell 1995:3). Donovan and Bransford (2005:219), Ginsburg and Seo (1999:113) and Weaver (1985:2) assert that much of the formal mathematics teachers try to teach learners in schools may be innate, though immature and unstructured, and that we do not take full advantage of this natural propensity of learners to invent or construct their own mathematical ideas and knowledge. They propose that teachers focus on both the child's constructive process and the mathematical content underlying the child's thinking in order to support children's progressive "mathematisation" (Ginsburg & Seo 1999:113) of their self-constructed ideas.

Von Glasersfeld (1990:33) concurs and states that the "the task of education…can no longer be seen as a task of conveying ready-made pieces of knowledge to students, nor, in mathematics education, of opening their eyes to an absolute mathematical reality…". The idea of how a child's learning of new concepts is based on their preconceived ideas and prior knowledge is aptly illustrated by Donovan and Bransford (2005:2) by referring to the children's story "Fish is Fish". In the story the fish, on learning from the frog about the different species he saw in the world outside the water, tries to imagine what a cow, bird and a person look like. The fish then conjures up mental images of these species looking like fish with the attributes of the respective species, for example, it imagines a human being as a fish walking on two legs.

There are several genre of constructivism described in the professional literature. Palincsar (2005:286) suggests that theories of constructivism constitute a continuum characterised by “trivial constructivism” on the one end (the individual as constructing knowledge) and “radical constructivism” on the other end (which assumes that there is no objective knowledge and that knowledge instead develops through dialogue with others). For the purpose of this study the researcher has summarised the following commonalities of constructivism as a learning theory and the instructional practices which results from a constructivist perspective:

- From a constructivist perspective, knowledge is not received from an external source but is actively created by the learner (Jaworski 1996:4; Munari 1998:3; Reynolds & Muijs 2001:11; Wood, Cobb & Yackel 1991:591).

- Knowledge is constructed from previous experience; so new learning should be based on learners’ informal and previous knowledge, resulting in reinforcing or adaptation of that knowledge (Baroody & Ginsburg 1990:57; Beck & Kosnik 2006: 9; Ishii 2003:2; Jaworski 1996:4; Mergel 1998:7; Wood, Cobb & Yackel 1991:591;). This is best stated by Piaget: “A truth learnt is only a half-truth; the whole truth is reconquered, reconstructed and rediscovered by the pupil himself/herself” (Munari 1998:3).

- Postmodern constructivist perspectives reject the notion that the locus of knowledge is in the individual; learning and understanding are regarded as inherently social and cultural activities and tools are regarded as integral to conceptual development (Paliincsar 2005:286). The point of view of learners is valued, therefore collaboration and dialogue are central to this approach wherein learning occurs through “negotiation of meaning” (Handal 2003:1; Jaworski 1996:3; Mergel 1998:7; Steffe 1990:9; Wheatley & Bebout 1990:109; Wood, Cobb & Yackel 1991:591) and the sharing of ideas. It is through this social discourse, sharing their own thinking and reasoning, that learners change or reinforce their ideas. If the opportunity is created for learners to express their

own ideas and hear others' ideas, they can then build a personal knowledge base that they understand, and meaningful classroom dialogue can occur (Powell 1995:4).

- Teachers whose practice is dominated by a constructivist perspective challenges students to reach beyond the simple factual response and higher-level thinking is encouraged. The teacher often asks open-ended questions and allows significant wait time after asking questions. Learners are encouraged to connect and summarise concepts by analysing, predicting, justifying, and defending their ideas (Ishii 2003:2; Powell 1995:4). Learners are encouraged to think independently, posing, answering and analysing their own questions.

- The “autonomy” and initiative of learners are promoted so that they take responsibility for their own learning (attention to meta-cognition and strategic self regulation (Ishii 2003:2; Powell 1995:4)). For this to occur, teachers must provide opportunities for learners to express their own thinking and must listen to them.

- Teaching involves the use of raw data and primary sources and the use of manipulatives and interactive materials are commonplace (Ishii 2003:2; Noddings 1990:16; Powell 1995:4). Noddings (1990:16) contends that this is motivated by Piaget’s theory which suggests that reflective abstraction proceeds from the operations children perform on objects. He however advises that if learners are not given instruction on the use of and do not have a purpose for engaging in the manipulation of objects, there constructions will not be guided by mathematical purpose.

- Learners are involved in real-world settings but teachers should assist them to construct the “abstractions that bind phenomena together” (Powell 1995:4; Mergel 1998:7).

- It is characterised by the use of multiple representations in science and especially mathematics. Multiple representations offer more avenues with which to connect to students' previous conceptions (Ishii 2003:2).

- Awareness of the importance of goals for the learner. This awareness of goals refers to the difference between teacher and learner goals, and the need for learners to understand and value the intended goals (Ishii 2003:3).

The characteristics of a constructivist learning theory as discussed above are illustrated in the following example related to the teaching of the concept of percentage to primary school learners:

Teachers often introduce the concept of percentage to learners without giving them the opportunity to investigate or construct their own meaning of the concept, for example: "*Percentage is used everywhere so we need to know how to use it*" or "*Per cent means something out of one hundred. The words per cent come from the Latin words per centum".* In a constructivist approach, an example of introducing percentages to learners could be to ask the learners how much percent they would have been given for a test if they had 50 questions right out of 100. What percent would they have been given if they had 4 questions correct out of 10? What percent would they have been given if they had 16 questions correct out of 20?. This would then be followed by classroom discussions, using open-ended questions such as: Can they see a pattern? Can they devise a method for calculating percent? In this way learners are given the opportunity to express their own thinking.

An understanding of percentage can be consolidated through the use of base ten blocks where the big block represents 1 whole or 100%, the long block represents 10% or 10 out of 100 and the smaller cubes represent 1% or 1 out of 100. Once the manipulatives have been used to build understanding of the concept the learners can move on to more abstract concepts of percentages.

Learner may use different approaches to calculating percentages of whole numbers. For example, some learners may divide the whole number into 100 equal pieces and then calculate the total for the number of pieces they need. For example, to calculate 10% of 200: 200÷100 = 2 (this represents 1%), therefore 10% = 10 x 2 = 20. Some learners may convert the percentages to fractions and then calculate the fraction of the whole number. For example, 10% = 1/10; 1/10 of 200 = 20. This allows for multiple representations of the learning content and learners are encouraged to think independently.
Furthermore, in a constructivist approach the concept of percentage would be taught in contexts that are related to the learners' real life-world such as interest rates, discount on the sale of goods, weather predictions, and so forth.

2.2.3.1 Social Constructivism

Without intending to trivialise the differences among social constructivist perspectives, the focus of this study is on the social dimensions of constructivism generally speaking. While Piaget's inspiration came from biology and essentially emphasised universal laws of biological origin, which advocates that children act on their environment to learn, Vygotsky placed emphasis on the contribution of culture and social interaction on mental development (Ivic 2000:1; Wertsch & Tulviste 2005:60). For Vygotsky, the human being is characterised by a 'primary sociability'. Social interaction plays a formative and constructive function in the child's development. Certain types of higher mental functions (for example deliberate attention, logical memory, verbal and conceptual thought and complex emotions) cannot be developed without social interaction (Ivic 2000:3).

A social constructivist learning environment facilitates the provision of feedback to learners. For effective feedback to learners the teacher needs to facilitate group and whole class discussion in which the learners are expected to explain their understanding in their own ways and justify their answers. By asking questions and

responding to learners the teacher helps to adjust their thinking (Black & Wiliam 1998:7; Wood, Cobb & Yackel 1991:594).

2.2.3.1.1 The Social Dimension of Classroom Learning

Social-constructivists promote the perspective that mathematics is best learned within a social environment (Ishii 2003:3; Davis, Maher & Noddings 1990:189; Maher & Alsten 1990:149; Pape & Smith 2002:99, Schoenfeld 1992:3). Wood, Cobb and Yackel (1991:590) describe a constructivist epistemology as a "co-ordination of both psychological and sociological perspectives". While the psychological perspective underscores the notion that learners are active constructors of their own knowledge, the sociological perspective emphasises the critical role that social interaction and the negotiation of meaning, involving explanation and justification, plays in learning. Sinclair (1990:24) describes it as "…the interaction between societal presentation and endogenous processes of abstraction…".

The social dimension of classroom learning is also emphasised by Wheatley and Bebout (1990:109): The learner's mathematical knowledge development is a function of the social setting within which they operate and it is through class and group discussions that their ideas are authenticated. Sinclair (1990:22) maintains that "science is essentially a social factor" and hence social interaction is central to the constructivist view of knowledge. He asserts that there are epistemological and psychological reasons why social interaction is essential for the construction of knowledge. Epistomological, because for knowledge to be "objective" and to verify the correctness of our knowledge, we need to share it with our peers; and, psychological because we largely interact with other human beings and in this way we reflect on our own actions and understanding.

The most significant basis of this *social constructivist theory* is contained in Vygotsky's theory of the Zone of Proximal Development (ZPD). Vygotsky defined the concept of the Zone of Proximal Development (ZPD) as the distance between a child's "actual

developmental level as determined by independent problem solving" and their "higher level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Daniels 2005:5; Wertsch 1988:67). This concept refers to the gap between what a person is able to do independently and what they can do with the help of someone more knowledgeable or skilled than themselves. According to Reynolds and Muijs (2001:11) this brings to the fore the role of teachers, adults and peers in children's learning. By providing children's thoughts with so-called scaffolds, they can help bring the child's knowledge to a higher level by intervening in the zone of proximal development. Scaffolding involves providing the learner with hints or strategies or offering encouragement for problem solving in order to allow the student to better approach the problem in the future. Some children are able to learn more in the zone of proximal development than others.

This theory is evident in Lawler's (1990:48) contention that when a learner with an "inferior comprehension is engaged socially with a more comprehending…" learner, "social demands push at the boundaries of comprehension" of the learner who does not understand. In the experience of the researcher, this kind of interaction can be advantageous, since both the learner acting as mentor and the one being mentored, can benefit. However, it is a situation which should be carefully managed by the teacher to ensure that one learner does not overwhelm the other which could result in the learner with the lower comprehension feeling inferior and becoming even more reticent.

According to Nicholas (2008:137) "social interaction is critical to learning in the zone of proximal development" and it is through feedback, suggestions and guidance from adults or competent peers that learners are supported to accomplish a task. Furthermore, Bandura and Cervone (1983:102) posit that when learners are given consistent and accurate feedback "they will regularly set goals near the upper limit of their zone of ability" so that they can monitor and improve their own learning.

2.2.3.1.2 Social Interaction through Language

Vygotsky also maintained that human activities take place in cultural settings and that our culture helps shape our cognition. He emphasised the importance of cultural tools (which could be any technological tool or any symbolic tool which aids communication) that people assimilate in order to influence their own mental functions. Thus for Vygotsky the power of human intelligence is "reinforced by the tools and aids provided by culture" (Ivic 2000:4).

It is in Vygotsky's emphasis on the socio-interactional origins of individual mental functioning that the notion of dialogue features most prominently for him (Cheyne & Tarulli 2005:234). According to Vygotsky, it is through socio-cultural interaction that the child is introduced to language, which in the beginning serves as a tool for communication and social interaction. As opposed to Piaget, Vygotsky did not think that "maturation" in itself could result in advanced thinking skills. He believed that it was children's interaction with others through language that most strongly influenced the level of conceptual understanding they could reach (Reynolds and Muijs 2001:11). Through these social interactions and dialogue, the child moves towards more individualised thinking. When the child receives help through interacting with others, he or she learns new and better strategies to use in the future, should they encounter a similar problem. The co-constructed dialogues thus lead to internalisation, which in turn leads to independent thinking. Furthermore, the newly acquired skills (such as language), which are of a social origin, start to interact with other mental functions such as thought and this brings about new functions such as verbal thought. Vygotsky believed that egocentric and inner speech results in the individualised activity of self-mastery (Cheyne & Tarulli 2005:127; Ivic 2000:4). Social interaction creates opportunities for learners to *talk* about their thinking, and this talk encourages reflection. Through verbalising what they are doing, learners examine their mental operations which in turn provides opportunities for them to reflect and to devise new and often more viable strategies (Murray, Olivier & Human 1998:171).

Von Glasersfeld (1990:36) purports that “there is an inherent and inescapable indeterminancy in linguistic communication”. In describing how babies learn new words, he illustrates that the meanings that children attach to spoken words are often only partially compatible with that of adults. By being aware of this “inherent subjectivity in the interpretation of … language”, teachers would then be cognisant of the fact that the instructions they give to learners are subject to different interpretations. Therefore, when learners respond contrary to what teachers expect, it does not imply that they are incorrect or that they are unable to construct logical conceptions, but could be that their response makes logical sense to them based on their own views of the situation. In these situations, it is unproductive to simply tell learners that they are wrong, and it would be more beneficial to try to infer the learners’ conceptual structures so that the teacher can then guide the learning processes of learners. Teachers have to know what learners are thinking in relation to the topic at hand and “the only way this can be achieved is through communication” (Leino 1990:45). This is in line with what Thalheilmer (2008:25) suggests when he advocates for the provision of “corrective feedback” to learners (this idea is expounded in 3.3.2.1). Stephens (1990:234) suggests that varied forms of communication should be encouraged in classrooms. He asserts that “[t]hrough classroom discussion…children learn how other people think mathematically, but written work … is a powerful medium for communicating mathematical ideas and interpretations”.

Steffe (1990:9) observes that teachers’ beliefs about the nature of mathematics and about their role and the learners’ role in the classroom are such that discussions about mathematics are “almost non-existent”. Black and Wiliam (1998:7) agree and advocate for more opportunities for learners to express their understanding. They also posit that in many instances the way in which teachers manage classroom dialogue causes the future learning of learners to be inhibited.

Communication (and particularly classroom dialogue as an aspect of feedback) is further discussed in 3.3.4.

2.2.3.2 The Practical Implementation of a Constructivist Approach

Constructivist influence has extended beyond just the research and scholarly community: it has had an impact on a number of national curricular documents and national education statements (Matthews 2000:3; Wood, Cobb & Yackel 1991:590). In South Africa, Outcomes-Based Education (OBE) forms the foundation of the curriculum (DoE 2002:1). A key design feature of the curriculum is the learning outcomes that "encourage a learner-centred and activity-based approach to education" (DOE 2002:1). The pedagogical approach encouraged by the Revised National Curriculum Statement (NCS) is closely related to constructivist practices given that it advocates the use of instructional strategies such as problem solving, co-operative learning, exploratory work, participatory learning, and application of mathematics to real-life situations. Literature provides various definitions of OBE, yet generally the approach it espouses focuses on learner-centred education, and that is aligned with the constructivist principle that the learner has to construct meaning. From a philosophical, ontological and epistomological perspective, the researcher postulates that OBE learning assumes constructivism, although Vithal and Volmink (2005:8) are of the view that "[i]n contrast to constructivism, outcomes-based education may be characterised as a strong pedagogy based on a weak epistemology".

The value of constructivism is that it allows us to be ingenuous and critical in our thinking about the teaching and learning situation. In order to teach effectively we need to reflect on how learners are learning; what it is that they understand, what misconceptions they have and what their mistakes tell us about their understanding and about their mathematical constructions (Noddings 1990:14-18).

Weissglass, Mumme and Cronin (1990:281) caution that it is not easy to change from traditional instructional approaches. Furthermore, it is a huge task to implement constructivist approaches and much time and resources are required. However, when implemented correctly it is rewarding for teachers, learners and society in general.

Cobb (1990:16), on the other hand, asserts that although the link between education and constructivism is quite credible, there is very little documented evidence of its practical implementation other than pronouncements in curriculum documents and vision statements. He also emphasises a need for empirical research that documents the conditions required for constructivist approaches to be successful. Jansen (1998:9) in referring to the curriculum reform in South Africa agrees in the following statement: "The proliferation of Green and White Papers, and corresponding Bills and Acts, has not been matched by visible changes in the schools".

2.3 TRENDS IN MATHEMATICS EDUCATION

"There is considerable nationwide interest in improving students' understanding of mathematics, combined with an emerging consensus about the essential elements of mathematics instruction. In addition, research has provided valuable insights into how children learn. Together these factors are opening the way to substantial and enduring progress in school mathematics" (Kilpatrick & Swafford 2002:3). The traditional approach assumed that learning facts and algorithms would naturally result in successful application in appropriate situations. This, however, no longer holds true. The teacher can no longer assume that mathematical knowledge presented through curriculum and instruction will be transferred directly to the mind of the child (Ginsburg & Seo 1999:114; Davis, Maher & Noddings 1998:188).

Numerous studies have provided evidence that children are active in structuring and reinventing mathematical knowledge. This requires a radical change in traditional mathematics education. Various research studies in mathematics teaching and learning emphasise the creation of powerful learning environments which allows learners to construct mathematical knowledge for themselves; the use of heuristic procedures; the attainment of mathematical problem-solving and reasoning skills and attitudes and its application in real-life situations; and the acquisition of metacognitive attributes and skills (Davis, Maher & Noddings 1998:188; Ginsburg & Seo 1999:114; Verschaffel *et al*. 1999:196).

2.3.1 The use of real-world contexts in the teaching and learning of mathematics

A shift from the traditional decontextualised acquisition of knowledge, to the importance of creating learning environments which connect conceptual processes and practice to authentic everyday experiences which have meaning to learners, is evident in many research studies (De Corte 2000:254; Maher & Alsten 1990:148; Von Glasersfeld 1990).

Verschaffel *et al.* (2006:54) in quoting Lerman (2000) refers to "the social turn in mathematics education research", which underscores the social and cultural nature of learning mathematics within realistic settings. A key issue which this view espouses is the creation of instructional and learning environments which provide opportunities for the construction of mathematics meaning in socio-cultural contexts, and the use of out-of-school arithmetic contexts to enhance school mathematics. If we want learners to learn mathematics that is both meaningful to them and also useful in everyday situations we cannot perceive mathematics as something that is decontextualised as it is always embedded in a particular cultural context. Zlatan (2005:29) pertinently points out that "…mathematics is not a subject domain of universal validity but rather a culture dependent interpretational means. Mathematics is still considered to be a body of knowledge, but this knowledge is a social category, which is socially distributed, transmitted by social means, and is inextricably linked to other elements of human culture". As already pointed out in 2.2.3.1, constructive feedback is enhanced in an interactive, co-operative and social classroom setting.

This emphasis on context in mathematics teaching and learning has many similarities with the theoretical perspective of Realistic Mathematics Education (RME) developed by Freudenthal (1991). In RME, children learn mathematics by means of doing mathematics, and solving every day life problems (contextual problems) is an essential part of learning. The teaching-learning situation is highly interactive and the learners' informal solution strategies are also taken into account. Other key principles are that learners should be given the opportunity to reinvent mathematical concepts through

mathematising with the guidance of the teacher (Fauzan, Slettenhaar & Plomp 2002:1; Kwon 2002:2).

Schoenfeld (1992:19) suggests that to become mathematically proficient we need to consider mathematics less as an "instructional process" focusing on the teaching of specific skills and knowledge, and more as a "socialisation process" where social traits such as gender roles, ethnicity and culture play a role. Acknowledging that various types of knowledge occur in various social settings and creating a link between learners' informal knowledge and experiences and their formal mathematics helps to direct learners thinking in mathematically productive ways (Donovan & Bransford 2005:231; Ishii 2003:2).

Zlatan (2005:13) postulates that although context is a word frequently used in mathematics education, its meaning is often not clear. Teachers often understand contextualisation of mathematics as "using words from outside mathematics in a mathematics class" and believe that it is mainly important for motivational purposes and to apply mathematics to real-world situations. He points out that this narrow understanding does not take into account the fact that the context may be crucial in helping learners to build mathematical knowledge and to "relate mathematical knowledge properly to their beliefs, their values, to their cultural background and foreground as well as to their professional activity".

This is in line with Cobb's (1990:201) contention when he discusses "contextuality of cognition" applicable to researchers and to mathematics learners. He interprets *context* as "the cognising subject's own construction" and he asserts that there is a distinction between context and the settings that the observer (in our case the teacher) creates in the subject's (the learner's) environment. Wheatley and Bebout (1990:107) agrees by saying that "the setting in which learning takes place, as well as the context established by the learner, is crucially important".

Cobb cites an example of a setting as being a mathematics task (however this may be structured) which the teacher asks the learners to complete. The context wherein the

task is completed may “differ radically” (Cobb 1990:201) from learner to learner – some might be focused on the problem-solving at hand, whereas another might merely be focused on trying to remember the teacher’s instructions, and are therefore engaged in a different mathematical activity. In structuring the context, the purpose, as well as the goals and needs involved, are key motivating forces. If the learner regards the application of a procedure prescribed by the teacher as the main purpose, then other activities seem irrelevant. Von Glasersfeld (1990:32) agrees when he refers to the biologist Jakob von Uexküll (1993) who held that “what an organism experiences as environment necessarily depends on the organism’s ways and means of perceiving and acting”. Let us use the assessment example in chapter three related to teaching the topic of the interrelationships between surface area and volume as an illustration. The teacher (in this case the researcher who has used this task with a class of grade eight learners from different schools) might have assumed that she is creating an authentic context by incorporating real-world problem-solving activities, but Cobb (1990:201) would describe this as a “situation or setting”.

Depending on the classroom experiences which these learners are normally exposed to, some might experience the context as the teacher intended, whereas for others the context which they created for themselves would be that of trying to figure out what theoretical activity they would be expected to complete. Learners’ understanding is therefore influenced by their own conceptual constructs and by a continual process of assimilation and accommodation. In creating learning environments or contexts for learners, the teacher therefore has the task of first inferring how learners would construct certain concepts, and then create the kinds of environments which would allow learners the opportunity to either assimilate or accommodate their own understanding to the required conceptual model and the expectations and goals of the teacher. This can only be achieved through constant communication with learners to ascertain their level of understanding and providing feedback to learners on their progress.

Hiebert, Carpenter, Fennema, Fuson, Human, Murray, Olivier and Wearne (1996:16) make a valuable point when discussing the use of real-life problems as a context for problematising mathematics: Whereas it provides a legitimate context, it is merely one context and we must not be restricted to it for reflective inquiry. They argue that problems and tasks which are contextualised entirely in mathematics can also provide opportunity for reflective inquiry. They site an example of a grade 2 class discussing how to find the difference between 62 and 37. Whether learners regard this otherwise routine computation as an opportunity for inquiry depends on the culture of the classroom as well as the mathematical ideas embedded in the activity. According to them it is irrelevant to distinguish between "real-life" problems and "school" problems. What determines whether problems are relevant and important is whether the learners have made the problem their own and in doing so, “what kind of residue is likely to remain”. Donovan and Bransford (2005:243) and Gainsburg (2008:216) concurs and advises that the use of real-world contexts should not result in merely a series of activities in which the mathematical ideas are not sufficiently prominent and not connected enough to the standard math notations and vocabulary.

Cobb (1990:202) refers to the experiential, cognitive and anthropological perspectives of a context. In structuring an *experiential context*, the purpose should be to infer how learners experience mathematics or mathematical concepts. In doing so we need to consider both their “knowledge in action” (that which we assume the learners know and are able to do with that which they know) as well as the “objects of knowledge” (that which the learner will discover, observe and reflect on). With regards to structuring *cognitive contexts* (here the author only refers to mathematical cognition), he advocates that the purpose should be to infer how the learners have the mathematical experiences which they have. However, we should also acknowledge that their mathematical and social cognitions are interdependent since learners interpret classroom events in terms of their beliefs about their own role and the teacher’s role. Consequently, they accept certain obligations for their own activity and have unspoken expectations for the activities of others. This co-ordination of mathematics and social-cognitive context is possible if we reconsider our idea of context. In considering the *anthropological*

context, Cobb (1990:207) asserts that the purpose should be to identify aspects of the classroom culture by analysing social norms, for example, the way a learner responds to the teacher.

Cobb (1990:206) rightfully points out that we "typically talk of students doing mathematics in a context as though they first create and then get on with the business of acting in it". He quotes Bateson (1973) who maintained that "[i]t is important to see the particular … action as part of the … context not as the product or effect of what remains of the context after the piece which we want to explain has been cut away from it". Gainsburg (1998:212-215) agrees that the majority of teachers believe that learners can only master tasks with real contexts after they have learned the relevant mathematics using traditional methods. They are of the opinion that realistic contexts are unsuccessful for teaching new mathematical concepts or skills. These teachers thus believe that only the "mathematically advanced" learners are capable of handling these kinds of problems. There primary goal therefore becomes the transmission of skills and knowledge. To them it is less important to develop the learners' ability to solve real problems.

2.3.2 The role of problem-solving in Mathematics

In advocating for the design of effective teaching-learning environments, research studies and curriculum standards convey an ever-increasing focus on the importance of mathematical reasoning and problem-solving skills. For example, this is advocated in the Revised National Curriculum Statement Grades R-9 Schools in South Africa (DOE 2007b:5) and the Curriculum and Evaluation Standards for School Mathematics in the USA. In contrast to the basic-skills curricula of the 1970s, with its emphasis on acquiring the mechanics of mathematics, recent reform recommendations place a heavier emphasis on connections of mathematics to the real-world; and real-life problems are recommended as appropriate contexts for learning and assessment (Hiebert *et al*. 1996:14).

Problem-solving in essence implies doing mathematics in context as advocated by proponents of Realistic Mathematics Education (see 2.3.1). In RME, children learn mathematics by means of doing mathematics, and solving every day life problems (contextual problems) is an essential part of learning. The teaching-learning situation is highly interactive and the learners' informal solution strategies are also taken into account.

Hergenhahn (1982:428) surmised three decades ago that trends in learning theory would "see an ever-growing concern with the application of learning principles to the solution of many human problems". It is critical that learners see the intention of a task as the need to solve a problem. If learners do not identify a problem they cannot attempt a solution and would be prone to see the intention of the task as "behavioural" where they see the task as an end in itself. In order to achieve this, problems should be relevant, should focus on learners' interests, and it should use learners' previous knowledge as a point of departure (Ishii 2003:2).

2.3.2.1 Learning through problem-solving

The mathematician best known for his conceptualisation of mathematics as problem-solving, and for his discussions of problem solving strategies in mathematics, or heuristics, is Pólya (Schoenfeld 1992:16).

Polya (1957:6) identifies four phases in solving a problem and with each phase he identifies a number of pertinent questions which are helpful in discussing problems with learners:

(a) Firstly, understanding the problem. Here Polya (1957:6) suggests that the learner should understand the verbal statement of the problem and should be able to state it fluently. The learner should also identify the principal parts of the problem: the unknown, the data and the condition. It is also important to have learners consider whether it is possible to satisfy the condition.

(b) The second phase is to devise a plan. Polya (1957:8) asserts that this is the main achievement in solving a problem but states that this is very difficult for one who has no knowledge of mathematics.

(c) The third phase is carrying out the plan. According to Polya (1957:12) this phase is much easier than the previous one provided the learner does not forget his plan. This may be the case if the learner did not devise his/her own plan but simply receives it from the teacher. The teacher therefore has the role of ensuring that the learner checks each step carefully.

(d) The fourth phase is looking back. This step not only ensures that there are no errors but helps to consolidate learners' knowledge and develop their ability to solve problems.

Polya (1957:3) contends that there are two aims to applying this method of problem solving, which is, to help the learner to solve the problem and to develop the learner's ability in order to solve problems independently.

Murray, Oliver and Human (1998:170) posit that a problem-centred learning approach to mathematics teaching involves learners who construct their own knowledge and as a result they attempt to establish individual and social procedures to monitor and improve the nature and quality of their constructions: "[O]ur version of a problem-centred learning approach reflects the belief that subjective knowledge (even if only in young children) should be experienced by the students as personal *constructions* and not re-constructed objective knowledge. (When we aim at children creating their own knowledge, as opposed to reconstructing existing objective knowledge, we do not imply that children are actually creating knowledge that does not already exist as objective knowledge; we do state that the children in this approach assume that they are creating *their* knowledge as new)".

Freudenthal (1991:45) disagrees with the use of the term “problem-solving” which according to him is exemplified as having to solve other people’s problems (the teacher, textbook authors, researchers) according to methods which they had in mind. He is also not in favour of the term “discovery learning” as to him this implied that the learner has to “uncover what was covered up by somebody else”. Nonetheless, his description of the learning of mathematics as “invention” which “embraces content and form, fresh discovery and organisation” is similar to the notion of the construction of knowledge through active inquiry and social interaction. According to Freudenthal (1991:45) “guided reinvention” happens when an instructional environment is created for the learning process.

According to Murray et al. (1998:171), problem-solving is regarded as the “*vehicle* for learning”. They contend that it is essential to distinguish sharply between learning *to* solve problems and learning *through* solving problems. This implies that you do not first learn the mathematical computations and then apply them to problems but rather the problems or tasks are the starting point, and as a result of working on these problems learners would be left with a “residue of mathematics”. Cai (1995:12) concurs that in teaching through problem solving, the focus is on “conceptual understanding, rather than on procedural knowledge”.

This is in line with the principle of “problematising mathematics” proposed by Hiebert *et al*. (1996:14). They argue that the reason why learners’ knowledge acquired in the classroom does not transfer well to the world of work, is that conceptions of problem solving are characterised by “a distinction between acquiring knowledge and applying it”. The distinction suggests that computation procedures should be acquired first and then applied to solve problems. By making the distinction, educators have separated mathematical activity into two artificial categories and then have created equally artificial methods to bring them back together

Hiebert *et al*. (1996:14) assert that allowing mathematics to be problematic will result in classroom activity that encourages participation. During such activity the teacher bears

the responsibility for developing a social and intellectual community of learners that problematises mathematics and shares in searching for solutions, through examination and discussion of the methods used to achieve solutions. In creating these opportunities for problematising mathematics, teachers have to rely on their knowledge of the subject as well as knowledge of learners' thinking, in order to select appropriate tasks linked to learners' experience, ideas and skills. Problem-posing has been found to be a successful way of learning mathematics, but only if the problems are well-designed and well-sequenced. More importantly, though, is that the classroom culture should fully support learning. Tasks that are relatively routine and contained entirely in the domain of mathematics (such as the 62 minus 37 example of Hiebert *et al.* 1996) can result in reflective inquiry because of the shared expectations of the teacher and the learners. Even typical real-life problem situations may not be useful if the classroom culture does not inspire critical inquiry (Hiebert *et al.* 1996:16; Murray *et al*. 1998:184).

The researcher is in agreement with De Corte (2000:254), Freudenthal (1991:48) and Ginsburg and Seo (1999:113) who advocate for a balance between allowing learners to discover or reinvent mathematics on the one hand, and systematic instruction and guidance on the other. Ginsburg and Seo (1999:113) contend that despite the positive influence of constructivist practices, "it has resulted in the unfortunate tendency to downplay the role of … mathematical content". Donovan and Bransford (2005:242), Hiebert *et al*. (1996:16) and Noddings (1990:15) agree that learners would make very slow progress if there is too much focus on their own time-consuming methods that are not easily generalisable. They can benefit from the information which the teacher holds, and can be helped to attain more generalisable and efficient methods provided that it does not undermine the learners' own inquiry. If a teacher learns through a diagnostic session that learners are making a certain kind of error over and over, it seems perfectly reasonable to show them how to do the procedure correctly and to provide whole classes with drill and practice at appropriate times.

2.3.2.2 The importance of metacognition in the solving of mathematics problems

Many researchers have identified metacognitive thinking as being integral to the problem solving process and crucial to problem solving success (Darr & Fisher 2004:2; De Corte 2000:254; Donovan & Bransford 2005:238; Fae Ho & Hedburg 2005:241; Schoenfeld 2007:190; Stacey, 2005:342; Verschaffel *et al.* 1999:196).

Verschaffel *et al*. (1999:196); and De Corte (2000:253) point out that the majority of mathematics learners do not acquire the necessary aptitudes to approach mathematical application problems efficiently and effectively. Verschaffel *et al.* (1999:196) attribute this to what they term "insufficiencies in the domain-specific knowledge base" as well as "shortcomings in the heuristic metacognitive, and affective aspects of mathematical competence". Donovan and Bransford (2005:2380); Muir, Beswick and Williamson (2008:230) and Verschaffel *et al*. (1999:196) refer to learners' inability to apply simple heuristic strategies like making a drawing or a table, decomposing the problem into parts or guessing and checking. Learners also do not often apply metacognitive self-regulatory activities such as analysing the problem, monitoring their solution process and evaluating the outcome. Furthermore, their beliefs and attitudes towards mathematics impact on their problem solving performance and is an important factor in problem solving behaviour. For example, if a learner believes that mathematics only involves numbers and operations, then they often focus only on the manipulation of the numbers in a problem with little or no thought to the problem itself (Muir *et al.* 2008:231; Schoenfeld 2007:190; Stacey 2005:342; Verschaffel *et al*. 1999:197).

Schoenfeld (2007:190) also highlights the importance of metacognition in the solving of mathematics problems. According to Schoenfeld (2007:190) research on metacognition encapsulates three categories of intellectual behavior: (a) Knowledge about your own thought processes, that is, your ability to describe your own thinking. This is important because learners' study skills partially depend on their ability to evaluate what they are capable of learning. Also, if they do not have a grasp of what they know they cannot be efficient problem-solvers; (b) Control or self-regulation, which relates to learners' ability

to keep track of what they are doing and how they use the information from these observations to guide their actions; and (c) Beliefs and intuitions about mathematics, which is similar to the above assertions by Verschaffel *et al*. Schoenfeld (1992:67) notes that the once "sharply delineated distinction between the cognitive and affective domains" is now becoming increasingly blurred.

Schoenfeld's assertions are similar to the model provided by Nicol and MacFarlane-Dick (2004:2) which illustrates that self-regulatory skills are essential for feedback to be effective. A key feature of the model (see Fig. 2.1) is that the learner occupies a central place in all feedback strategies. They point out that the learner should be active in all feedback processes and should monitor and regulate their own performance in order to reach the desired goal. In doing so, they monitor their own performance not only in relation to the goal, but also in relation to the strategies used to reach those goals. The model shows that the feedback cycle starts when a task is set by the teacher. The learners' prior knowledge and motivational beliefs influence their engagement with and interpretation of the task. The learners then formulate their own task goals and use their own strategies to achieve the goals. Internal feedback happens when the learners monitor their own progress against the goals which they have set for themselves. This may lead to them re-interpreting the task or adjust their own goals, change their methods or even their beliefs. External feedback, on the other hand, could serve to enhance, concur or conflict with the learner's own interpretation of the task (Nicol & MacFarlane-Dick 2004:3).

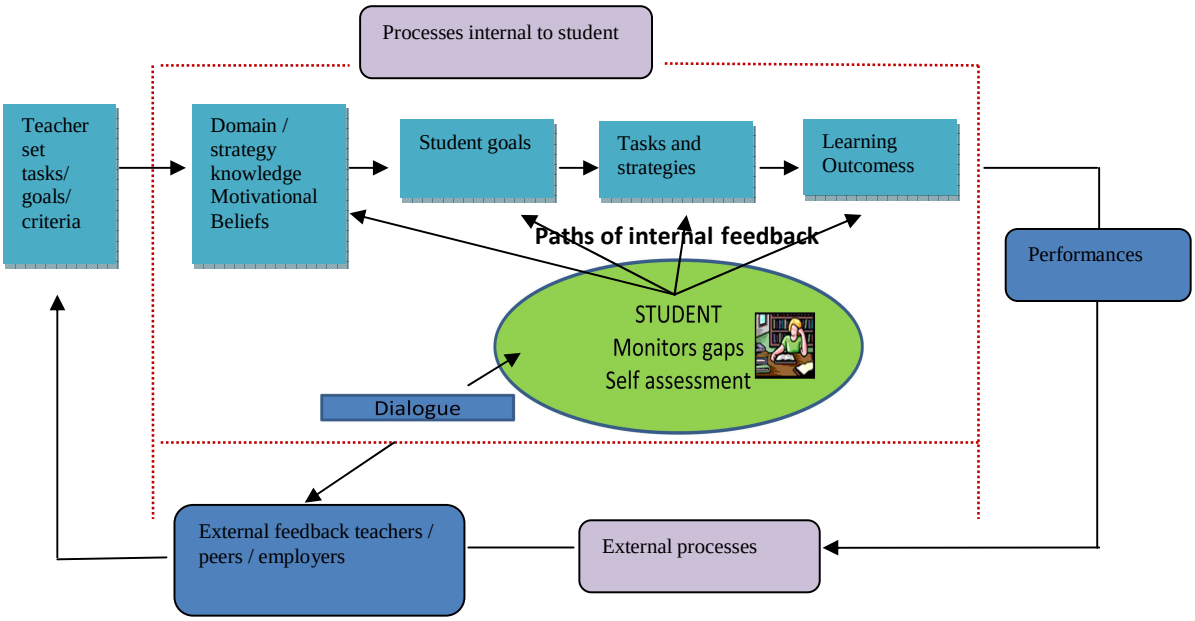


Fig. 2.1: A model of formative assessment and feedback (taken from Nicol & MacFarlane-Dick 2004:3)

Swan (1993:35) also asserts that learners often engage in mathematical activity without being aware of what they have learned, and that "working through tasks becomes a substitute for working on ideas". He suggests practical tested ideas which teachers can use to increase the "quantity and quality of reflective activity" so that learners will become more responsible for their own learning. These include having 11 to 12 year old learners working on extended projects using pre-determined criteria. The teacher then uses the same criteria to assess the learners' work. The key element here is that "considerable discussion and negotiation" follows between learner and teacher so that both parties become aware of the areas of strength and support needed. They also suggest a type of showcase portfolio wherein the work the learner is most proud of, together with the self-assessment tool, is kept. He cites another example of thirteen to fourteen year old learners being asked to devise their own test at the end of a unit (this strategy is also suggested by van den Heuvel-Panhuizen and Gravemeijer (1993:62)). The learners were asked to devise questions which have varying difficulty, is interesting and which they can answer, and to supply their own memoranda. Learners were thus forced to revise the work and reflect on the most important concepts and skills. The

results were often that the tests were harder than what the teacher would have designed and the learners performed better than expected.

The notion of self-regulation and how it relates to feedback is explored further in 3.3.3.

2.3.2.3 Other factors that influence learners' ability to solve problems

Learners' inability to solve context-related mathematics problems can also be attributed to a number of external factors. Learners are typically exposed to "standard" problems with straightforward calculations rather than complex problems requiring learners to devise real-life solutions and develop conceptual understanding (ARG 2006:8; Verschaffel *et al.* 1999:197; Wood, Cobb & Yackel 1991:588). Furthermore, the instructional methodologies used often focus on teaching learners standard procedures demonstrated by the teacher and are not aimed at teaching learners valuable heuristic and metacognitive strategies.

The classroom culture which learners find themselves in also influences what and how learners learn mathematics. Daily classroom rituals and practices such as continuous drilling and rote memorisation of procedures and the use of specific procedures to find the "right answer", give learners a particular perception about what mathematics is. On the other hand, if they see mathematics as relevant to their life-world, something which makes sense and fits together and which they are capable of understanding, they become positively disposed to the subject (Donovan & Bransford 2005:20; Kilpatrick & Swafford 2002:16; Verschaffel *et al.* 1999:197).

This is where most mathematics classrooms are lacking, however. Most problem-solving tasks are usually disconnected from real-world experiences and learners tend to disregard their mathematical knowledge when solving real-world problems. Consequently, they cannot solve mathematical problems which they would otherwise easily solve in realistic contexts (Cai, Mamona-Downs & Weber 2005:218; Gainsburg 2008:200).

Learners should be given the opportunity to apply multiple strategies to solve given problems if they are to become proficient in mathematics problem solving. By discussing several methods in the classroom learners would begin to understand how and why different methods work and they would consider the efficiency and reliability of the respective methods. This serves as a form of scaffolding as learners would move from their own conceptual understanding to more useful and abstract approaches and begin to see that doing mathematics is not merely about routine procedures but involves their own reasoning and strategy development (Donovan & Bransford 2005:223).

Cai *et al*. (2005:218) assert that the reasons why teachers typically do not expose learners to multiple problem solving strategies are related to their "affective, cognitive, and pedagogical concerns". Research studies confirm a general consensus that teachers feel inadequately prepared to deal with open-ended problems. They usually doubt their ability to explain the various concepts required and believe that multiple methods and heuristics will serve to confuse learners. This actual or perceived limitations in teachers' mathematical knowledge results in them sticking to traditional teaching approaches focused on the practicing of routine exercises and algorithms (Cai *et al*. 2005:218; Fae Ho *et al.* 2005:239).

Despite problem solving currently being a fundamental goal in many curriculum documents, this goal appears to be increasingly elusive (Stacey 2005:341). In its report (DOE 2009a:49), a task team appointed by the South African National Minister of Education to review the Implementation of the National Curriculum Statement in South Africa, the task team concluded that "in relation to Mathematics, both at GET and FET levels, problem-solving methods are advocated, but there is little guidance as to the mechanics of such an approach".

Smit (1997:23), in his response to Hiebert *et al.*, expresses his reservations pertaining to the problematising of mathematics. His main concern is that learners are not only exposed to numerical and quantitative concepts (as illustrated in the examples by Hiebert *et al.)* in mathematics, and this could give rise to numerous challenges: "If we

cannot address the problems that stem from the diversity of students' mathematical experience, students' limited capacity to express their ideas, and teachers' limited capacity to respond, we should not delude ourselves that school mathematics can be organised by students' problematising the subject. We have much more work to do if we want to pursue this vision seriously".

Fae Ho and Hedburg (2005:239) explain this by relating it to Howson and Malone's (1984) contention that the curriculum may be viewed from three different perspectives: the "*intended* curriculum, the *implemented* curriculum and the *attained* curriculum". Thus, while it is *intended* that problem solving *should* be the central focus of the curriculum, the role of the teacher will determine its effective implementation and ultimately the degree of success attained.

2.4 CONCLUSION

The reform in mathematics education that is being strongly advocated implies a considerable change from traditional practices that underscore the transmission of knowledge to a practice that emphasises inquiry and discovery learning, and the creation of rich learning environments that engage learners and provide opportunity for exploration and authentic problem-solving.

The research has highlighted the characteristics of effective learning processes which De Corte (2000:254) describes as a "constructive, cumulative, self-regulated, goal-oriented, situated, collaborative, and individually different process of knowledge building and meaning construction". These characteristics, which are the focus of numerous literature studies, denote the necessity for reform in mathematics education that emphasises a change in teaching practice and the creation of authentic learning environments that offer ample opportunities for collaboration and feedback. The principles underpinning formative assessment and feedback are aligned to the principles of a socio-constructivist theory and are in keeping with trends in mathematics education as outlined in this chapter. The emphasis on "social interaction, dialogue and

negotiation of meaning" (Handal 2003:1), as well as problem-solving skills and self-regulatory processes have a distinct correlation to the provision of feedback as espoused in the next chapter.

3

CONSTRUCTIVE FEEDBACK FOR ENHANCING LEARNER PERFORMANCE

3.1 INTRODUCTION

The purpose of this chapter is to review current literature on the use of constructive feedback for enhancing learner performance in Mathematics. Several important aspects are explored, relating to the provision of constructive and effective feedback.

The study examines how feedback should be structured in order to assist learners to plan their learning and to alter the gap between their current level of understanding and the desired level; and the various strategies of providing feedback that can be employed. It also discusses how classroom dialogue is a key component of the provision of feedback so that learners are active participants in the process of learning. The ways in which feedback can affect the motivation and self-esteem of learners are also discussed. An important aim of providing feedback to learners is to encourage self-regulated learning, hence this concept is also examined in this chapter.

The whole notion of constructive feedback to support learning is futile if it is detached from good assessment tasks that challenge learners to “reason critically, to solve complex problems, and to apply their knowledge in real world contexts” (Shepard 2000:9). It implies that this philosophy should also be reflected in classroom routines and teaching methodologies. It is thus also necessary to look at ways in which the intended learning outcomes, classroom instruction and assessment processes should be aligned to effective feedback strategies.

As a starting point this chapter will describe constructive feedback to learners as a key element of formative assessment or assessment for learning, and will reflect on the general principles of formative assessment as it relates to feedback as a tool for enhancing learning and raising standards.

There are a number of key factors that jointly and separately impact on the provision of feedback to learners. These factors are discussed in this chapter and are schematically represented in Figure 3.1.

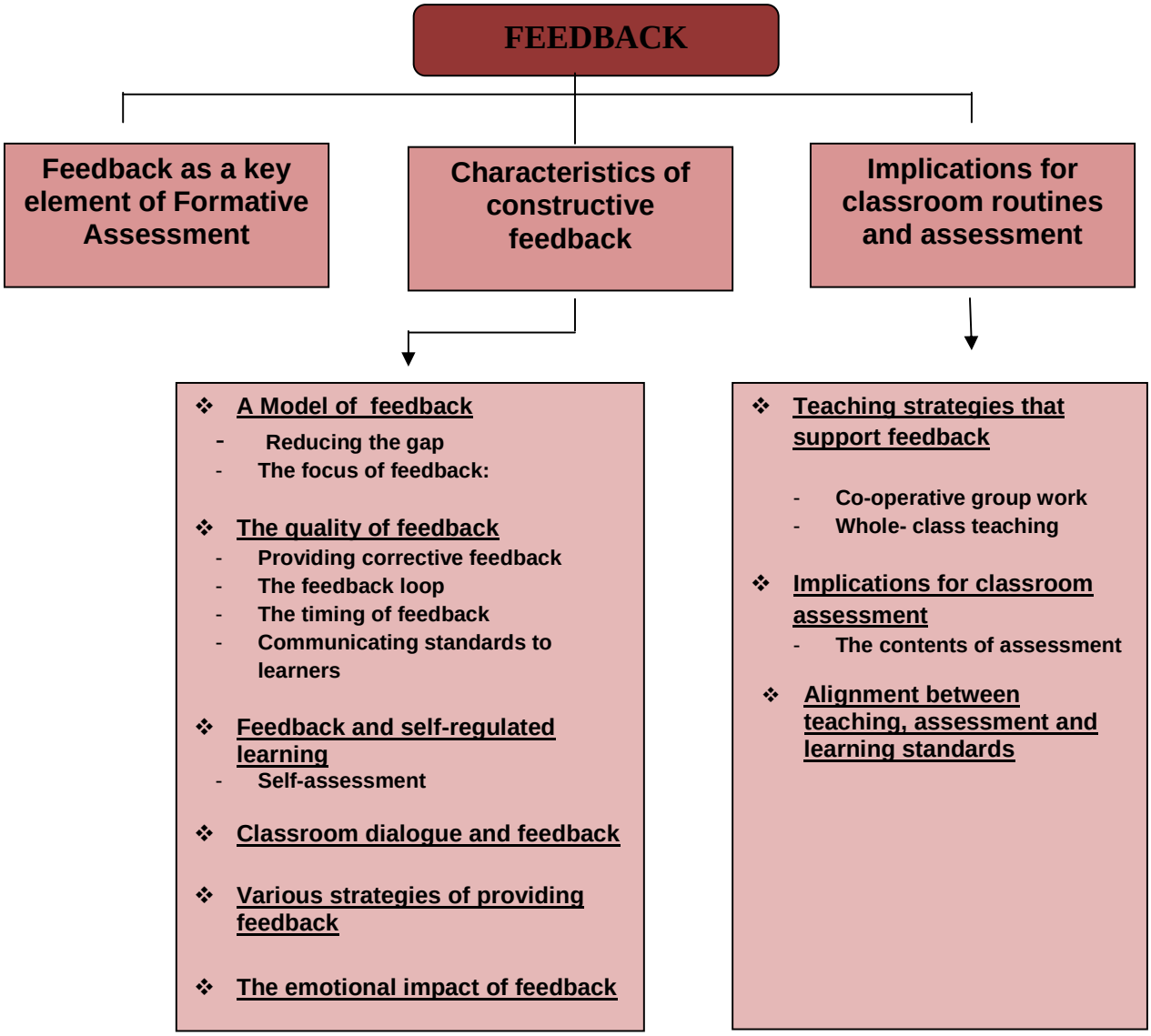


Fig. 3.1: Factors that impact on the provision of feedback to learners

3.2 FORMATIVE ASSESSMENT AND THE PROVISION OF FEEDBACK

In 1998, professors Paul Black and Dylan Wiliam of Kings College, London, compared the classroom to a 'black box' (Black & Wiliam 1998:1). According to them, government initiatives focused on the box's input and output, but not what went on inside it. Although lip service was paid to the process of teaching and learning, the emphasis was still on 'summative assessment' – the recording of data for certification and evaluation.

According to the Assessment Reform Group (ARG 2002:2) formative assessment is an essential professional skill for all teachers. This includes the knowledge and skills to plan for assessment, to observe learning, to analyse and interpret learners' evidence of work, to give feedback to learners and to support learners in self-assessment.

A number of curriculum documents emphasise the importance of formative assessment by teachers. Black and Wiliam (1998:5) cite the 1988 Education Reform Act of England and Wales in this regard. In South Africa, the National Assessment Policy (DOE 2007a:8) advocates for continuous assessment (CASS) which "encourages the integration of assessment into the teaching and development of learners through ongoing assessment. It is a model of assessment that is used to determine a learner's achievement during the course of a grade, provide information that is used to support the learner's development, and enable improvements to be made to the learning and teaching process". However, Black and Wiliam point out that these formal commitments to formative assessment are not always on par with the actual priority given to it.

The recent launch of the Foundations for Learning Campaign in South Africa, with its focus on standardised assessment, bears testament to the notion that in South Africa, there appears to be much emphasis on external assessment appraisals. In her 2008 address at the launch of this campaign, the then Minister of Education, Ms. Naledi Pandor refers to these external assessments as "non-negotiables". In a statement on the progress of the review of the National Curriculum Statement, the minister of basic education, Mrs Angie Motshekga announced the following directives which implies a

distinct shift in focus from formative assessment to external summative assessments (DOE 2010:1-4):

- A reduction in the number of projects for learners.
- Eradication of portfolio files of learner assessments.
- Regular, externally-set assessments at grades 3, 6 and 9 in literacy (in home language and first additional language) and numeracy/mathematics.
- The weighting of continuous assessment and end of year examinations in grades 7-9 will be changed from 75% continuous assessment and 25% end of year exam to 40%: continuous assessment and 60% end of year exam.
- Clear targets have been set for improvement in learner achievement on the Annual National Assessments (ANA) by 2014. The Minister has set a target of improving numeracy and literacy attainment levels of grades 3 and 6 from the current average attainment levels of between 27% and 38% to at least 60% by 2014.

It is not the intention of this study to denigrate the value of summative external assessments. The researcher recognises the efficacy of such assessments, which Braun, Kanjee, Bettinger, and Kremer (2006:5) underscores in the following statement: "publicly available data enable policymakers to craft effective policies and students and parents to better choose among educational options. It allows individuals, communities, and countries to track the quality of schools and educational systems". Rather, the researcher's views are in accordance with that of Stiggins (2008b:2) in his Assessment Manifesto, wherein he campaigns for a balance between formative and summative assessment and between "large-scale" and classroom assessments.

Black and Wiliam (1998:1) advocated formative assessment**,** or "assessment for learning". Based on an extensive review of literature, they concluded that enhanced formative assessment is a common feature of various interventions which resulted in improved learner performance. Formative assessment is characterised by an interactive learning environment where teachers gather evidence of their learners'

progress through a range of activities, questioning, observation, and discussion (this is characteristic of the socio-constructivist approach discussed in 2.2.3.1). This evidence is then used to adapt teaching strategies to meet the needs of learners and enhance learning. The learners' work is interpreted by both the teacher and learner to determine the progress toward the particular goal and how the learner can be helped to further learn. The emphasis is not on what level or grade the learner achieved. Learners are involved in the assessment process, assessing themselves and reflecting on their own work. This implies that learners should know the goals and standards they are working towards, so that they can ultimately take responsibility for their own learning (see discussion on the OBE principle of clarity of focus in 3.3.2.4). This relates to Nicol and MacFarlane-Dick's (2004:3) description of the learner as being central to feedback processes and taking responsibility for their own progress, as discussed in 2.3.2.2**.**

The Assessment Reform Group (ARG 2002:2) describes the process of formative assessment as "seeking and interpreting evidence for use by learners and their teachers to decide where the learners are in their learning, where they need to go and how best to get there". Black and Wiliam (1998:2) contend that assessment is only *formative* when the information gathered is used to adapt the teaching to support the learner's development.

An important aspect of "assessment for learning" captured in the principles outlined by the Assessment Reform Group (ARG 2002:1) is that of good feedback. To enhance learning, teachers should ensure that learners receive constructive guidance about how to improve, in order to plan the next steps in their learning. It is important to highlight the learner's strengths and advise on how to develop them, make them aware of the areas they need to concentrate their efforts and provide opportunities for learners to improve upon their work. Stiggins (2008b:5) supports this by referring to "descriptive feedback". Stiggins (2008a:1) posits that in order to ensure "universal student mastery of essential standards" there are seven specific actions related to assessment which should be taken. One of these is that we should "rethink our feedback strategies".

Providing feedback to learners is therefore central to the process of formative assessment (ARG 2006:11; ARG 2008:16; Black & Wiliam 1998:2; Chambers 1993:17; Maree & Fraser 2008:34; Niss 1993:7). Black & Wiliam (1998:3) emphasise that important features of formative assessment which must be improved to achieve "significant learning gains" include new ways to enhance feedback between teacher and learner; and new modes of pedagogy which require significant changes in classroom practice.

3.3 CHARACTERISTICS OF CONSTRUCTIVE FEEDBACK TO LEARNERS

For feedback to be constructive and effective, teachers would need to focus on several important aspects. Although this study does not intend to provide an exhaustive analysis and discussion of the various ways of providing feedback, a number of pertinent features relating to the provision of effective feedback to learners are discussed in this section.

To start with, the research has chosen the framework in which feedback can be considered provided by Hattie and Timperley (2007:86) (see Fig. 3.1). The model focuses on important features relating to the provision of effective feedback, namely, ways of reducing the gap between the learner's current and desired understanding, and the levels at which feedback should be directed in order to influence its effectiveness.

3.3.1 Hattie and Timperley's Model of Feedback

Hattie and Timperley (2007:86) assert that the main purpose of feedback "is to reduce discrepancies between current understandings and performance and a goal" (see Fig. 3.2). According to Hattie and Timperley (2007:86) effective feedback must answer three questions: Where am I going? (the goals); How am I going? (What progress is being made toward the goal?); and Where to next? (What do I need to do to impove?). The level at which the feedback operates will determine how effectively answers to these questions will reduce the gap. Hattie and Timperley (2007:86) contend that

because some feedback is more effective than others at reducing the gap, it is important that the feedback is targeted at the appropriate level. These levels include the level of task performance, the level of process of understanding how to do a task, the regulatory or metacognitive process level and the self or personal level.

3.3.1.1 Reducing the gap between current and desired understanding

Although there are many possible ways for learners to try to reduce the gap between current and desired understandings in response to feedback, they are not always effective in enhancing learning. Those likely to be effective include the following:

(a) Learners can increase their effort, particularly when the effort leads to tackling more challenging tasks rather than just doing "more." Furthermore, learners are more likely to increase effort when they have an understanding of the intended goal, when they are committed to achieve it, and when they have confidence in achieving success.

(b) Learners can develop effective error detection skills. Error detection is a powerful skill, provided learners have some understanding about the task. Learners can also seek better strategies to complete the task or they can seek more information in order to solve problems (Hattie & Timperley 2007:86).

3.3.1.2 The Focus of Feedback

According to Hattie and Timperley (2007:90) the focus of feedback is critically important. They identify four major levels at which feedback could be directed in order to influence its effectiveness (the researcher substituted the examples from Hattie and Timperley with mathematics related examples):

(a) Feedback can be about a task or product, such as how well the task is being performed and whether answers are correct or incorrect; acquiring more or different information, or building more knowledge. This level of feedback may

include directions to acquire more, different, or correct information, such as "*You need to look at the value of the tenths*" (in comparing decimal fractions). Hattie and Timperley (2007:91) say that this type of feedback is often referred to as "corrective feedback" and that about 90% of teachers' questions are aimed at this level. However, teachers often combine corrective feedback with information at the self-level, which reduces the effectiveness of the corrective feedback. Feedback at the task level is also more powerful if it addresses learners' misunderstandings rather than a lack of the necessary knowledge (in which case further instruction is more effective than feedback). It is more effective to focus feedback on simple rather than complex task performances. Also, too much feedback at the task level could result in learners focusing on the immediate goal using trial-and-error methods and less on the strategies needed to attain the goal which involves higher level responses (Hattie & Timperley 2007:91). Thalheilmer (2008:45) concurs that such short and specific feedback "may not support learners in being able to generalise to broader circumstances".

(b) Feedback can be aimed at the process used to complete a task. This kind of feedback is more directly aimed at the processing of information, or learning processes requiring understanding or completing the task. For example, a teacher or peer may say to a learner, "*Try to solve the problem by using the problem-solving strategies we talked about earlier*". Feedback information about the processes underlying a task can act as a cueing mechanism and lead to more effective information search and use of task strategies, provided the cues assist learners in rejecting incorrect ideas and provide direction for searching and strategising (Hattie & Timperley 2007:93). According to Hattie and Timperley (2007:93), referring to Balzer (1989), feedback at the process level appears to be more effective for enhancing deeper learning than at the task level. However, feedback is most effective when the two are combined.

(c) Feedback to students can be focused at the self-regulation level, including greater skill in self-evaluation or confidence to engage further on a task. For example, "*You already know your multiplication tables. Check to see whether you have calculated correctly*". Hattie and Timperley (2007:94) identify six aspects of feedback at the self-regulation level that affects the effectiveness of feedback: the capability to create internal feedback; the ability to self-assess; the willingness to invest effort into seeking and dealing with feedback information; the degree of confidence in the correctness of the response; the attributions about success or failure; and the ability to seek help.

(d) Feedback can be personal in the sense that it is directed to the "self," which is too often unrelated to performance on the task. Examples of such feedback include "*You are a great student*" and "*That's an intelligent response, well done*." Feedback about the self as a person usually contains little task-related information and is rarely converted into more engagement, commitment to the learning goals, enhanced self-efficacy, or understanding about the task. Praise, punishment, and extrinsic rewards, that direct attention away from the task to the self, are least effective for enhancing achievement due to its low information value to achievement and learning. However, praise directed to the effort, self-regulation, engagement, or processes relating to the task and its performance (for example, "*You're really great because you have diligently completed this task by applying this concept*") has greater effects because it can assist in enhancing self-efficacy and thus can be converted by learners back into impact on the task (Hattie & Timperley 2007:96).

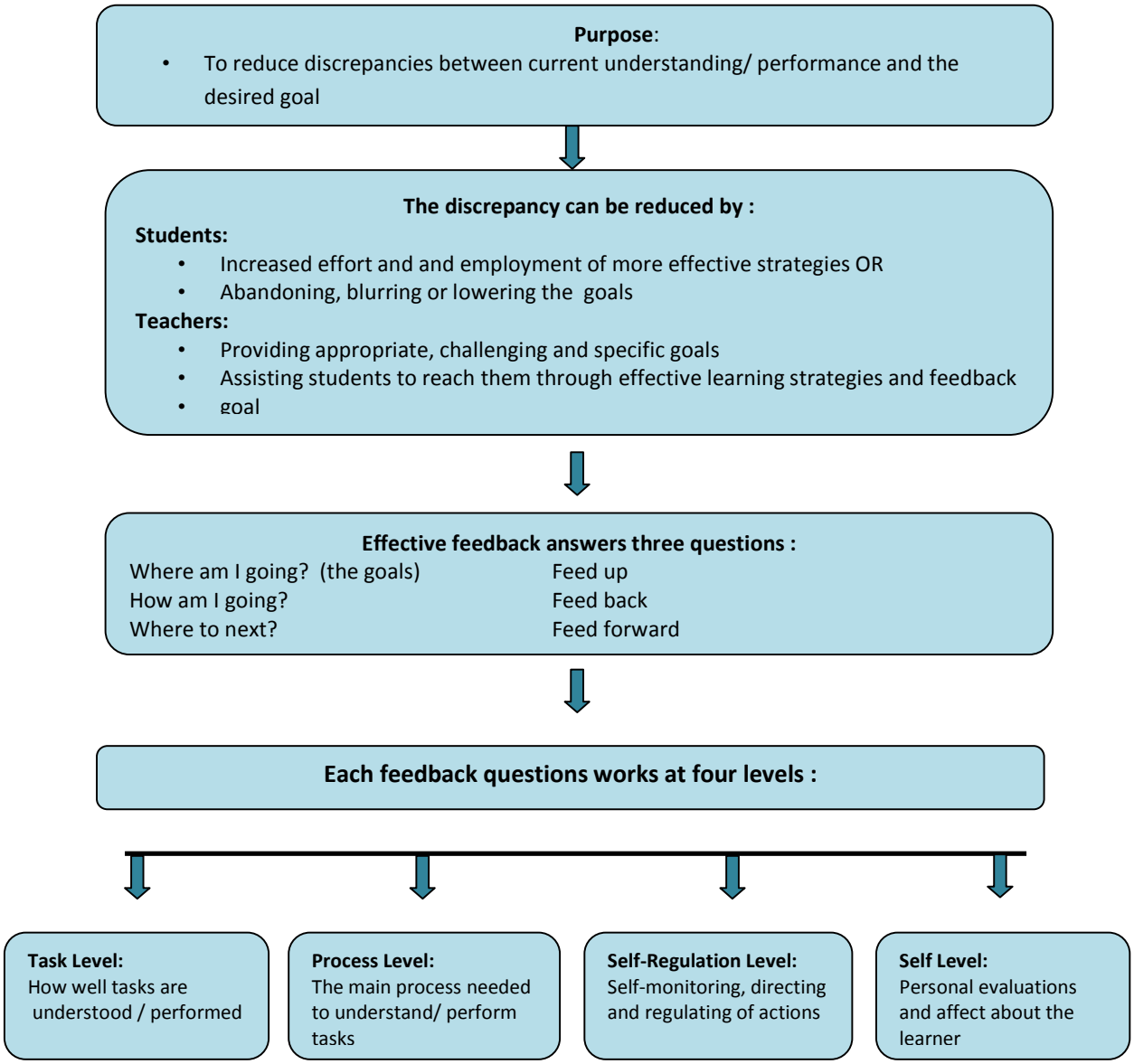


Fig. 3.2: A model of feedback to enhance learning (taken from Hattie & Timperley (2007:86)).

It is interesting to note that the levels at which feedback can be directed as described here are similar to the aptitudes of learning described by Verschaffel *et al*. (1999:196) as referred to in 2.3.2.2, namely content knowledge, heuristics, metacognition and the "self". The shortcomings in learner aptitudes highlighted by Verschaffel *et al* can thus be improved through focused feedback.

In addition to the features of effective feedback provided by Hattie and Timperley as discussed above, there are various other aspects that impact on the quality of the feedback provided.

3.3.2 The Quality of the Feedback

The researcher has identified the following aspects which have an effect on the quality of the feedback provided to learners, and which are discussed in this section:

- Providing corrective feedback
- The feedback loop
- The timing of feedback
- Communicating the desired standards to learners

3.3.2.1 Providing corrective feedback

If the aim of providing learners with feedback is to assist them to improve on prior performance, then the information they receive should be useful and should provide guidance on how to improve. Test scores and aggregates do not provide this guidance. Teachers should know where learners are in terms of achieving the required standard and they should know what comes next in the learning. They should be able to pinpoint the learners' achievements and advise them how to improve on these, and give guidance in terms of how areas of weakness can be addressed (ARG 2002:2). Stiggins (2008b:4) summarises it succinctly when he says that "the question is not: Who is mastering standards? Rather, it is: How is each student doing on her or his journey up the scaffolding leading to each standard?"

Thalheilmer (2008:25) suggests that feedback should be focused on correcting misconceptions by giving learners “specific corrective information”. This feedback should help them develop suitable “mental models” of the concepts to be learned. He suggests that teachers should not waste learners’ time with additional conflicting or partial information. They should also not be provided with verbatim repetitions of the original learning material.

Thalheilmer (2008:25) has the following practical suggestions for providing corrective feedback:

(a) Mistakes are typically not random. If teachers can figure out the misconceptions learners have, they can provide them with better feedback. Teachers should attempt to anticipate the reasons the learners misunderstand the concept and provide specific corrective feedback.

(b) Learners may need more extensive feedback when they are building understanding than when they are supporting retrieval of that which they have already learned or are developing fluency. For example, learners are given a pre-question before the teacher even introduced the concept. The teacher asks them a question, and then gives them feedback by introducing the topic. The researcher developed this example for a grade 8 or 9 class as a case in point, substituting the example provided by Thalheilmer (2008:25) with a mathematics-related example:

TASK:

Make two shekeras. These authentic African musical instruments are completely handmade of calabash gourds and shells.

Your "gourds" should not be bigger than 10cm in diameter and should be approximately 10cm in height (the shakeras  diameter including the handle, should not be longer than 15cm)

Working as a member of a group:

A. Design and construct the following two containers to hold the two shekera's which your group has made.

- **A rectangular prism in which the two shakera's lie side by side.**
- **A square-based prism in which the two shakera's will be stacked on top of each other.**

1. Determine the dimensions (measurements) of the shakera's (length, breadth, height), in order to determine the size of the container
2. Use a pair of compass and a ruler and pencil to design the nets of the containers (don't forget to add flaps for pasting).
3. Design and cut out the nets
4. Construct the container; show the dimensions on the outside of the container. You may decorate your container as you like.

B. Determine the following for each of your containers:

1. Total surface area (the amount of cardboard used to manufacture the container). Show all calculations.
2. The volume of the containers. Show all calculations.
3. Make a proposal on which of the containers you think should be used to hold the shakeras, explaining why you think it is the best choice (consider cost-effectiveness).

In this task, the teacher is teaching the topic of the interrelationships between surface area and volume. The teacher has never introduced the topic before and most of the class is unlikely to know much about these concepts except for basic perimeter and area formulae. To introduce the topic, the teacher gives them the problem as outlined above. They attempt to solve the problem. Because the learners have very little knowledge of the concepts, the teacher will have to give them extensive feedback throughout the process to help them understand all they need to understand to solve the problem. Here is a short list of the kinds of information they may need to learn:

- What is perimeter, area, surface area, volume?
- How to use mathematical instruments to design nets.
- How to build models of 3D solids.
- Calculating surface area and volume and making comparisons.

In a task as the one above, learners will need extensive feedback, providing the correct response, throughout the process of solving the problem. Thalheilmer (2008:27) contends that to help the learners build understanding it is often helpful to provide the correct response with a simple explanation of why the response is correct. On the other hand "…learners may require worked examples, graphical animations, or simply more time to fully process the learning material".

Important to note is that this kind of instructional support is beneficial when learners are in the process of building understanding of complex tasks or problem solving, or when they have difficulty retrieving what they have learned. However, after they understand the concepts, any feedback that "short-circuits retrieval is generally counterproductive", that is, learners should first be given the opportunity to demonstrate their understanding before feedback is given (Thalheilmer 2008:28).

3.3.2.2 The feedback loop

Sadler (1989:120) contends that feedback "can also be defined in terms of its effect rather than its information content". This means that, whereas it is important that the feedback information should concisely describe to the learner how they can improve in order to attain the desired goal, the information is useless unless the learner understands it and is able to use it to "close the gap between the actual level and the reference level of a system parameter" (Hattie & Timperley 2007:82; Ramaprasad 1983:4). This is also referred to by Bandura and Cervone (1983:102), Nicol and MacFarlane-Dick (2004:3), Hattie and Timperley (2007:86), Du Toit and Du Toit (2004:4-5) and Kramer (2005:25) in 2.2.3.1.1, 2.3.2.2, 3.3.1.1 and 3.3.2.4 respectively.

Hattie and Timperley (2007:82) further posit that new skills cannot be learned simply through being told about them. Learners should be given the opportunity to test their understanding of the feedback, while being supported by the teacher. The "feedback loop" cannot be completed if the learner cannot use the feedback to modify or improve their performance. Feedback is not only about informing learners about correctness; when it is "combined with more a [sic] correctional review, the feedback and instruction become intertwined until the process itself takes on the forms of new instruction" (Kulhavy 1977 in Hattie & Timperley 2007:82).

Thalheilmer (2008:13) also emphasises the importance of this feedback loop when he refers to giving learners "retrieval practice" (giving learners practice retrieving information by means of questions, problems to solve, simulations, tasks, hands-on practice and so forth). He posits that the ultimate goal of education is to help learners retrieve what they have learned - at an appropriate time and situation in the future. He cites various studies including that of Jones (1923-1924) and Roediger and Karpicke (2006) which prove that retrieval practice supports future retrieval (though none of these studies provided learners with feedback). However, further research shows that when the retrieval practice was difficult, that is, when learners were required to answer

complex or open-ended questions, “feedback was critical in helping them benefit from retrieval practice” (Thalheilmer 2008:14).

Figure 3.3 illustrates Thalheilmer’s (2008:17) assertion of how feedback works in context. It typically comes after learners have been presented with learning events and after they have been given a retrieval practice opportunity. The “feedback loop” is completed because learners are given the opportunity to demonstrate their understanding of the feedback through later learning events.

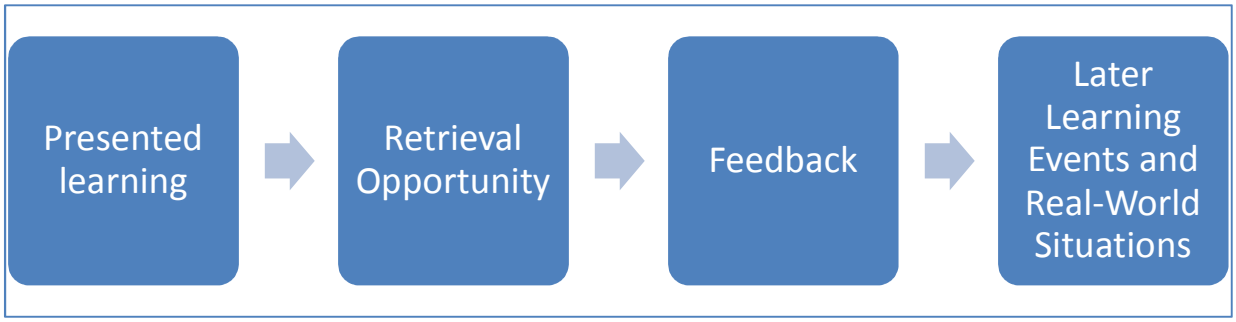


Fig. 3.3 Feedback in Context (taken from Thalheilmer (2008:17)).

3.3.2.3 The timing of feedback

Research studies differ on whether feedback should be provided immediately or should be delayed. Valuable arguments can be made for both approaches, depending on the context in which the feedback is provided.

Thalheilmer (2008:35) contends that because of the power of retrieval to strengthen memory, we should not create opportunities for learners to reinforce inappropriate memory traces. When learners make mistakes in answering questions or practicing a skill, they should receive feedback before they attempt to re-answer the question or re-attempt the skill as they are likely to continue incorrectly if not given corrective feedback. Immediate feedback thus prevents this problem since it provides feedback before learners have additional opportunities for revision or practice. On the other hand, according to Thalheilmer (2008:38) delayed feedback essentially produces a

“spaced learning” opportunity and has the same advantages as spaced learning. This requires more effort in cognitive processing which results in improved learning. Spaced learning also provides learners with a range of repetition contexts and this “helps learners develop additional retrieval routes to the information stored in memory”. Furthermore, when delayed feedback is processed it is more likely to be processed at a deeper level than immediate feedback.

In deciding between immediate and delayed feedback, Thalheilmer (2008:37) has the following suggestion: “In general, the more likely our learners are to re-engage learning concepts after they have been involved in retrieval, the more helpful it may be to provide immediate feedback to prevent reinforcement of misconceptions. If re-engagement is unlikely, delayed feedback may be preferred”.

Hattie and Timperley (2007:98) relates the timing of feedback to the level at which the feedback is directed. For example, if feedback is directed at the task level, then immediate feedback can result in faster rates of acquisition; if feedback is directed at the level of processing the task, immediate feedback can detract from the learning of routine procedures and the associated strategies of learning.

3.3.2.4 Communicating standards to learners

In 2.3.2.2 it is argued that one of the conditions for learners to move from feedback to self-monitoring is that the learners should have an understanding of the goal. Similarly, one of the characteristics of effective learning processes as described by De Corte (2000:254) and referred to in 2.4, is “goal-orientated” learning. Learners can only assess their success in achieving their purpose when they have a clear picture of the targets they are meant to attain (Black & Wiliam 2008:7; Clarke 1992:1). This then implies that the teacher should clearly articulate the desired standard to the learners. This is what Hattie and Timperley (2007:86) refers to as “feed up” (see fig. 3.1). Feedback cannot lead to reducing the gap if the goal is not clearly defined. Feedback is also often not related to the criteria for success (Hattie & Timperley 2007:89). This idea

speaks to the principle of “Clarity of Focus” which is one of the four defining principles of Outcome-based Education (OBE) as espoused by Spady, who is often referred to as the father of OBE (Du Toit & Du Toit 2004:4-5; Kramer 2005:25). Similar to the above assertions, Spady posits that “clear, measurable and observable outcomes” should be the focus of learning (Kramer 2005:25).

Sadler (1989:126), however, contends that although most teachers are able to recognise quality work when they see it, it is often difficult for them to describe what they are looking for. She asserts that teachers’ ability to make good qualitative judgments about learners’ work “constitutes a form of guild knowledge”, as they are better at comparing a range of quality which exists amongst learners’ work than making an isolated judgment of quality. This, according to Sadler (1989:127), is disadvantageous to the learner as it only serves to compare learners with their peers. It also does not serve formative purposes as the concept of the required standard remains with the teacher. The learner remains dependent on the teacher for making judgments about his or her work and is not encouraged to take responsibility for his or her own learning.

Sadler (1989:127) suggests two approaches which teachers can use to specify the expected standard: (a) descriptive statements and (b) providing learners with exemplars.

(a) Providing learners with descriptive statements of the desired standard

This is also commonly referred to as “Criterion-Referenced Assessment or Testing” (Lapp, Flood, Brock & Fisher 2007:74; Maree & Fraser 2008:10, DOE 2005:11). Criterion-referenced assessment measures learners’ performance against pre-determined criteria at a designated level of quality, the extreme ends being mastery and non-mastery (Lapp *et al*. 2007:74; DOE 2005:11; Sadler 1989:127). This is contrary to “norm-referenced assessment” which is done by comparing a learner’s performance with the performance of others, or with the typical performance of the learner. Norm-

referenced tests are typically interpreted in statistical terms including percentile rankings, scores and grade levels. Lapp *et al* (2007:75) say that the basic difference between the two types of assessment lies in what the test results are referenced to (or compared with) and provides the following comparison between the two:

Test Feature	Norm-Referenced	Criterion-Referenced
Test design	Design is related to subject matter information and process skills.	Design is related to specific instructional performance objectives
Item Preparation	Designed to determine variances among students	Designed to measure individual competency on a given task
Item types	Many types are used (multiple choice, true-false, completion)	Many types are used (multiple choice, true-false, completion)
Item difficulty	Moderate; designed to determine a middle range	Wide variance, but with adequate instructional preparation, responses are generally correct
Interpreting results	A student's accomplishments are compared with those of a norm group by computing his or her subscore or total test score	A student's achievement on a specified performance item is determined by comparing his or her response to the correct one
Test use	Used to determine a comparative score between one pupil and a normative group and to determine global student achievement	Used to diagnose student strengths and needs and to evaluate an instructional program

Table 3.1 Comparison of norm-referenced and criterion-referenced tests (adapted from Lapp *et al* (2007:75)).

Criterion-referenced assessments reflect competencies within a well-defined specified performance domain. It should therefore provide descriptive information regarding a

learner's level of competence on a specific task or against a particular standard which are established before the learners attempt the task (Killen 2007:342; Lapp *et al* 2007:74). Killen (2007:343) points out that a difficulty of using criterion-referenced assessment is defining suitable criteria to describe performance. Some educators may set low criteria while others may set inappropriately high criteria. In addition, it lends itself to subjectivity as different assessors may make different judgments of the same performance.

Nonetheless, when learners are given clear pre-determined criteria for achievement, they are provided with ongoing feedback about their progress towards the expected standards. A study by Andrade and Du (2005) regarding student's use of rubrics to support their own learning and academic performance, suggests that the students involved in the study saw much value in getting rubric-referenced feedback on drafts of their work. The students also claimed to use these criterion-referenced assessment rubrics to self-assess and revise their work, and more importantly for this study, to reflect on external feedback. The researcher developed the following assessment tool to assess a task relating to collecting, organising and interpreting data to illustrate an example of criterion-referenced assessment by means of a rubric:

CRITERIA	Not Achieved 1	Partially Achieved 2	Achieved 3	Exceptional Achievement 4
Designing questionnaire	Questionnaire is unstructured. Questions are poorly articulated and off the point.	Questionnaire not logically structured and contains unnecessary details. Questions are poorly articulated. Not all questions relate to problem.	Questionnaire is focused and to the point. Well structured questions related to the research problem.	Questionnaire is focused and to the point. Insightful questions related to the research problem. Questions allow conclusions and predictions to be made about the situation.
Sampling and Collecting Data	Chose inappropriate sample (too big/too small) for investigation. Data collection procedure is totally unplanned and data is incomplete.	Chose inappropriate sample (too big/too small) for investigation. Data not systematically collected and incomplete.	Chose appropriate sample for investigation. Data systematically collected and complete.	Chose appropriate sample for investigation and shows clear understanding of random sampling. Devises and implements a systematic procedure to collect complete data.

Table 3.2 Example of a criterion-referenced assessment tool

(b) Providing learners with exemplars that illustrate the desired standard

According to Sadler (1989: 129) learners benefit from having exemplars because they provide a concrete reference level of the desired standard. However, teachers might be concerned that providing learners with exemplars may stifle their creativity and result in them slavishly copying the exemplars, Sadler (1989:129) argues that even if some learners do copy, they may learn something valuable in the process and it could serve as a starting point for developing their own ideas. In any case, they need to be presented with more than one exemplar of good quality (for a single standard) in order for them to appreciate the concept of quality. She does, however, acknowledge that

“[s]tudents develop a concept of a reference level more readily in some learning contexts than in others”.

The importance of learners’ occupying a central role in all feedback processes is highlighted throughout this study (see 2.2.2, 2.2.3.1.1, 2.3.2.2, 3.3.1.1, 3.3.1.2, 3.3.2.4). In 3.3.3 the study highlights how feedback provides learners with the opportunity to assess their own progress and ultimately improve their self-regulatory skills.

3.3.3 How feedback can bring about self-regulated learning

The South African National Curriculum Statement builds the Learning Outcomes for the General Education and Training Band for Grades R-9 on critical and developmental outcomes that envisage learners who play an active role in their own learning and assessment and in all feedback processes (DOE 2002:1).

To achieve this, Sadler (1989:121) states that feedback to learners plays a pivotal role and should take into account three elements: (a) the learners should have an understanding of the desired goal or standard (again this is linked to the OBE principle of “clarity of focus” as discussed in 3.3.2.4; the importance of explaining the desired standard to learners as discussed in 2.2.3.1.1, 2.3.2.2, 3.3.1.1 3.3.2.2 and 3.3.2.4; as well as the need for learning processes to be “goal-orientated” in order to be effective as posited by de Corte (2000:254) referred to in 2.4); (b) compare their actual level of achievement with the desired standard and (c) engage in some form of action to attempt to close the gap between the two. In order for learners to improve, they must appreciate what high quality work is and have the skills to self-assess (Nicol & Macfarlane-Dick 2004:2; Sadler 1989:1).

Learning is enhanced when learners are encouraged to engage in self-reflection, to review their experiences of learning, and to apply what they have learned to their future learning. It is through developing their skills of self-assessment that teachers help learners to take charge of their own learning and to learn to recognise their own

expertise. A continuous cycle of feedback and adjustment provides learners with the opportunities to assess their own work against a range of *understandable* criteria and not to only depend on the teacher's judgment about their abilities. It also serves cognitive processes as learners become more interested in the criteria and the substantive feedback than in the awarded grade or mark. When learners acquire these skills, they then want to learn and they want to engage in discussion with their teachers and peers about work, and this type of self-reflection is essential to good learning (Anderson 1993:103; ARG 2002:2; ARG 2008:16; Black & Wiliam 2008:7; Earl & Katz 2006:5; Shepherd 2000:30 and Stiggins 2008b:9). De Corte (2000:254), as discussed in 2.4, agrees that effective learning is a "self-regulated" process of developing knowledge and constructing meaning.

Extensive literature exists documenting the value of self-regulated learning and the structure and function of self-regulatory processes. These studies all agree that self-regulated behavior is associated with academic achievement (Darr & Fisher 2004:1; Donovan & Bransford 2005:12; Pape & Smith 2002:100; Zimmerman 2002:64). According to Zimmerman (2002:65) "[s]elf-regulation is not a mental ability or an academic performance skill; rather it is the self-directive process by which learners transform their mental abilities into academic skills. Learning is viewed as an activity that students do for themselves in a *proactive* way rather than as a covert event that happens to them as a reaction to teaching".

Nicol and MacFarlane-Dick (2004:3) contend that teachers can improve their learners' capacity for self-regulation by providing them with self-assessment tasks. This provides learners with "formal and structured" opportunities to monitor themselves and judge their progress towards the goals and encourages them to reflect on the processes and the products of learning.

According to Hattie and Timperley (2007:94) "[s]elf-assessment is a self-regulatory proficiency that is powerful in selecting and interpreting information in ways that provide feedback". They also refer to Paris and Winograd's (1990) contention that there are two

major aspects of self-assessment namely self-appraisal and self-management. Self-appraisal relates to learners' capacity to review and evaluate their abilities, knowledge, and cognitive strategies through a variety of self-monitoring processes. Self-management is the monitoring and regulating of their ongoing performance through planning, correcting mistakes, and using correction strategies.

Stiggins (2008b:8) surmises that involving learners in self-assessment and reflection is directly linked to the self-motivation and confidence developed in learners, as it gives each learner "a strong sense of control over her or his own academic well-being". Clarke (1992:44) rightfully contends that "one of the most constructive and empowering educational goals we might frame would be to equip students to monitor their own progress. In this way learners take ownership of the evaluation process and their learning becomes a subject of mutual interest and discussion (Clarke 1992:44; Shepherd 2000:12). Hence, an important component of effective teaching is encouraging self assessment so that learners move from responding to feedback that someone else provides to actively seeking feedback in order to assess their own levels of thinking and understanding.

To facilitate the management of self-assessment in classroom situations the teacher can provide learners with a self-assessment sheet with a list of criteria at the start of the topic or lesson. Learners can then monitor their progress by recording the tasks they have completed and understood. An adapted example of such a self-assessment sheet is illustrated in figure 3.6 (Clarke 1992:44).

Name: _____

Linear Algebra, Graphs and Simultaneous Equations

Tick the following boxes once you have

(i) completed the tasks

(ii) understood the working involved

Tasks	Finished Task	Understood Task
"Backtracking" – algebraic equations		
Linear Algebra – being able to write what a linear equation is and how to solve it		
Linear Algebra – solving them and using the calculator		
Transpose formulas – geometry problems		
Project and Report		
Understanding how graphs work – introduction to distance-time graphs		
Graphs – "tell me a story"		
The graph of $y = mx + c$		
Practice drawing graphs		
Solving Simultaneous Equations		
Application of Simultaneous Equations		

Fig. 3.4: Example of a Self-Assessment Sheet (Adapted from Clarke (1992:44)).

Hattie and Timperley (2007:94) claim that when learners have the metacognitive skills of self-assessment, "they can evaluate their levels of understanding, their effort and strategies used on tasks, their attributions and opinions of others about their performance, and their improvement in relation to their goals and expectations… [m]ost

important, students know how and when to seek and receive feedback from others". Sadler (1989:122) concurs that the goal of many instructional systems is to "facilitate the transition from feedback to self-monitoring". De Corte (2000:254) also contends that there should be a good balance between external regulation and self-regulation.

The value of communication within a social constructivist classroom environment has already been underscored in 2.2.3.1.2. The following section builds on this and discusses the importance of classroom dialogue as it relates to feedback.

3.3.4 Classroom dialogue as an aspect of feedback

If learners are to be active participants in the process of learning, much more emphasis should be placed on the opportunities which teachers provide for learners to talk about their learning, and about the teacher's teaching.

Chambers (1993:20) remarks that the goal of many teachers seems to be getting the learners to understand how they, the teachers, think rather than trying to understand how the learner thinks. Listening to "student discourse" is described as one way to "develop an accurate description of student thinking" (Chambers 1993:20). Providing learners the opportunity to communicate their understanding is important for the interaction needed to support formative assessment and facilitate feedback to learners. It is through dialogue that the teacher gets a sense of the learners' reasoning and understanding or lack thereof, and he/she can then guide their thinking accordingly (Black & Wiliam 1998:7; Donovan & Bransford 2005:12; Ginsburg, Jacobs & Lopez 1993:158; Shepherd 2000:11 and Warloe 1993:152). It is also through dialogue that learners conceptualise their own understanding and make sense of things. When learners articulate their thinking they reflect on the problem and the strategies they used to solve it, which leads to understanding and to self-regulated learning (Fennema *et al*. 1999:188 in Pape & Smith 2002:99). Chambers (1993:20) further contends that teachers can learn to "orchestrate discourse" by focusing on the learners' solution strategies rather than on the answer.

The teacher has an important responsibility of establishing norms for collaborative dialogue, observing, interacting and providing feedback where necessary to ensure "meaningful negotiation of mathematical viewpoints and solutions" (Wood & Yackel, 1990:245). Noddings (1990:15) concurs and purports that if conducted well, such a session gives the teacher many opportunities to reassure learners that they are doing some things right, that their thinking has some power and that their errors are correctable. They state that such methods can be used to create effective mathematical environments. In these settings, teachers view their role as facilitators, drawing on their knowledge of mathematics and their knowledge about the way learners learn, to facilitate meaningful discussion and debate in solving problems, and to ascertain and work with learners' preconceptions (Donovan & Bransford 2005:228; Steffe 1990:10). Von Glasersfeld (1990:37) asserts that "language is not a means of transporting conceptual structures from teacher to student, but rather a means of interacting that allows the teacher here and there to constrain and thus to guide the cognitive construction of the student".

Freudenthal (1991:95) and Wood, Cobb and Yackel (1991:606) also stress the importance of the role of the teacher during group and whole class interactions. The role of the teacher is not to impose his or her methods but to create opportunities for learners to negotiate meaning and construct their own mathematical understanding. The mere act of verbalising their learning processes will result in improved learning and the teacher may pick up on keys to guide learners in the right direction.

In describing what they term "conceptual splatter in peer dialogues", Easley and Taylor (1990:225) contend that we need to understand how primary learners think creatively in solving real problems, and the kinds of social situations we as teachers create which will either promote or suppress such thinking. They describe classroom settings in first grade mathematics classes wherein learners are presented with story problems and problems about mathematical concepts. Learners are allowed sufficient time in groups to discuss the problem and present their solutions to the class. In the dialogues between learners which they recorded it is evident that learners are able to form and

apply numerous mathematical ideas in solving problems which they have not been explicitly taught. They suggest that if this approach can be maintained for at least the first three grades, learners are given the opportunity to discuss and conceptualise many algorithms which they would otherwise be expected to memorise and most probably poorly understand.

This is of course a daunting proposition for most teachers and rightfully so. This kind of free dialogue wherein diverse ideas are entertained and explored could become chaotic in the presence of even the most experienced teacher. It again comes down to the fact that most teachers do not have the necessary skills to deal with such situations in classrooms.

Easley and Taylor (1990:225) agree with this and assert that some teachers would steer away from open-ended problems and prepare lessons which will guarantee predictable discussions, whereas others will welcome this dialogue but yet try to guide it back to standard forms of arithmetic. They are adamant, however, that these contexts allow learners to make rapid progress and that teachers can learn valuable mathematics in observing learners tackle challenging problems by pooling their diverse ideas and discussing various approaches.

The quality of the dialogue is also a factor to consider. Hodgen (2007:2) is of the opinion that teachers often only focus on “low level” questions, requiring learners to recall facts and procedures. Learners are not expected to think, reason and communicate critically. Cooney, Badger and Wilson (1993:240) describe a study which they conducted with 201 teachers in order to examine the teachers’ assessment practices. According to their study the majority of teachers used what they term “level one and level two” questions to test learner’s understanding of mathematics. Black and Wiliam (2008:7) suggest that it is because teachers lack the “flexibility or the confidence” to deal with unconventional responses from learners, so they steer learners to giving specific answers by asking closed-ended questions, so that teaching can proceed smoothly.

Research supports the notion that asking higher order questions leads to enhanced learner performance. Clarke (1992:34) asserts that classroom questioning should not be “all one–way traffic” and highlights the importance of encouraging learners to ask more questions. He suggests practical ways that teachers can structure this question-asking in order to get learners to monitor their own learning through internal dialogue which focuses on thoughtful questions. For example, the teacher can divide the class into groups and ask each group to list (a) what they know about the topic, and (b) questions they would like answered. Pape and Smith (2002:99) also emphasise the importance of teachers creating environments wherein learners critically talk about their own and others’ mathematical reasoning. Through this kind of discourse they are exposed to “strategies used by their more sophisticated peers and to ways of thinking that may be different from their own” (Pape & Smith, 2002:99).

Another aspect to consider is the extent to which teachers dominate classroom discourse, not providing adequate opportunity for learners to respond and participate actively. Reynolds and Muijs (2001:44) assert that wait time should be shorter for lower level factual questions than for open-ended, higher level questions and that prompting learners after the acceptable wait time is equally important. A number of studies underscore the importance of the wait time, that is, the time a teacher pauses after asking a question. Studies differ on the exact time a teacher should wait for a response from learners, but what they have in common, is the notion that teachers typically do not provide adequate time for learners to think and formulate a response in order to give feedback on their learning processes. Teachers either ask and answer their own questions, or ask the type of questions that can produce an immediate response from learners. The result is that learners do not even attempt to think about a response or that only a few learners in the class are called on all the time (Black & Wiliam 2008:8; Clarke 1992:32; Hodgen 2007:2; Wood, Cobb & Yackel 1991:606).

Clarke (1992:32) draws attention to the following positive effects of increased wait time, adapted from Rowe (1973):

- Children gave longer responses and the contributions of “slow” children increased.
- Children initiated more responses that were appropriate and also asked more questions
- Children gave more explanations, demonstrating speculative thinking.
- Children made more and better connections among observations and references.

As Black and Wiliam (2008:8) assert, classroom dialogue should be a “thoughtful and reflective” process. Its purpose should be to provide all learners with the opportunity to think and articulate their ideas, reason critically and enhance their understanding. In addition to using classroom discourse to promote the provision of feedback, there are numerous other strategies which teachers can employ in order to effectively provide feedback to learners.

3.3.5 Using various strategies to provide feedback

If learners are given only marks or grades, they do not benefit from the feedback on their work. If learners are only awarded a quantitative score they perceive the purpose of assessment as being summative, to rank the class in order of ability so that they can be compared to their peers (Black & Wiliam, 2008:8; Stiggins, 2008b:3; Swan 1993:26). Hence, the form of reporting and providing feedback must be consistent with the purpose of the assessment (Swan, 1993:26). Thus, the way in which feedback on test results is provided to learners so that they can identify their own strengths and weaknesses is a critical feature. Black and Wiliam (2008:8) note that “a good test can be a learning as well as a testing occasion”. By analysing test results, teachers can diagnose learning difficulties and misconceptions and can provide feedback accordingly. If a test is given at the end of a module, it cannot serve formative purposes. Black and Wiliam (2008:8) note, however, that too often “[t]he collection of marks to fill up records is given greater priority than the analysis of pupils’ work to discern learning needs”.

Class work and homework exercises can also be used as an invaluable opportunity to provide constructive feedback to learners provided the tasks are clear and relevant to the learning goals (Black & Wiliam 2008:8). Maree and Fraser (2008:34) suggest that teachers could make provision for learners to hand in draft copies of their work, and then write comments on or discuss these with the learners. In this way learners develop their work with the teacher, as opposed to just handing in a completed product.

A study conducted by Darr and Fisher (2004:8) in a grade 7 class to explore how a learning and teaching environment could support self-regulated learning, involved encouraging mathematics learners to report and explain their thinking by keeping a journal. The written feedback by the authors, who read the journals after each session, encouraged further reflection by the learners. Learners were given time to respond to the feedback, which often asked questions about what they had written or requested them to clarify their thinking or provide further examples. Feedback from the journaling in turn was used to initiate discussion about learning on a whole class or group bases. They assert that the journals provided learners the opportunity to reflect on their thinking and enabled the teacher to gain insights into the strategies used by learners.

Classroom discussion, observation of activities, marking of written work, can all be used to provide feedback to learners, but it is then important to look at, or listen carefully to, the talk, the writing and the actions through which learners demonstrate their understanding (Black & Wiliam 2008:7). Ginsburg *et al.* (1993:158) refer to Piaget's *clinical interview* method which they term "flexible interviewing" as a different way of assessing learner's thinking and understanding. Like Darr and Fisher (2004:8) they also contend that this meaningful dialogue between teacher and learner provides the opportunity both for revealing valuable information about (the learner's) thinking processes as well as providing meaningful feedback to learners and encouraging them to reflect on their own understanding.

Feedback can also be provided by means of report cards. Maree and Fraser (2008:157) suggest that report cards can assist in improving learning if learners are

provided with “accurate feedback about the state of their learning”. The Revised National Curriculum Statement Grades R-9 (DoE 2002:100) states that report cards should give a description of the strengths, developmental needs, or areas of support required by the learner. It should also be linked to the Learning Outcomes and Assessment Standards. These comments will allow parents, learners and other educators to gain an understanding of what support the learner needs.

Whichever feedback strategies are employed, it is important to note that the learner’s emotional response to any form of feedback plays a vital role in whether the learner can and will use this feedback to improve or self-correct.

3.3.6 The emotional impact of providing feedback

“Feedback is one of the most powerful influences on learning and achievement, but this impact can be either positive or negative” (Hattie & Timperley 2007:81). The emotional impact that assessment has on learners plays a significant role in their achievement (ARG 2002:2; Stiggins 2008b:3).

It is widely agreed that providing constructive feedback that focuses on the learner’s progress toward the desired standard, rather than on the learner self, is more productive. As already mentioned in 3.3.5, if learners are merely provided with a mark or grade, the assessment is mainly judgmental and learners are focused on comparing themselves to others rather than using the feedback to improve. Feedback is counter-productive when it results in learners feeling that they are not good enough, and impacts negatively on their confidence and enthusiasm to learn. Feedback is more constructive when it focuses on what the learner does well rather than highlighting failure. Learners’ mistakes and misconceptions can be addressed if the feedback is focused on their work, providing guidance on how they can improve (ARG 2002:2; ARG 2006:8; Black & Wiliam 1998:6; Hattie & Timperley 2007:86; Stiggins 2008:6).

Black and Wiliam (1998:6) are of the opinion that a classroom culture which focuses on external rewards such as gold stars, grades or rankings, results in learners being more focused on obtaining the best marks than how they can improve. Thalheilmer (2008:44) concurs that giving learners extra acknowledgement when they are correct or words of sympathy and encouragement when they are wrong generally has no learning benefits. It is the corrective feedback and information that has the benefits. Thalheilmer (2008:44) cites research studies by Dweck (1986); Elliott & Dweck (1988) and Dweck & Leggett (1988) that shows that focusing learners' attention on how well they are doing instead of what they need to learn, could result in them wanting to take shortcuts to "look good" as opposed to focusing on what they need to learn by utilising effective learning strategies. This could then impact negatively on future learning.

Hattie and Timperley (2007:98) point out that praise can be effective, provided it is accompanied by feedback about the task. Essentially, only providing learners with grades indicating their failure, instead of feedback that diagnoses incorrect mental models and corrects misconceptions, is detrimental to their learning. Hattie and Timperley (2007:104) state that "…the major discriminator is whether [the feedback] is clearly directed to the task, processes …and not to the self level". Stiggins (2008b:8) concurs: "If all students are to succeed, they must have continuous access to credible evidence of their own academic success at mastering prescribed achievement standards".

If the feedback strategies propagated in this study are to be implemented in classrooms as part of formative assessment, then classroom instruction and assessment practices should change to be consistent with and support this social constructivist pedagogy.

3.4 IMPLICATIONS OF THE PROVISION OF FEEDBACK FOR CLASSROOM ROUTINES AND ASSESSMENT

Feedback has no effect in a void; to have an effect, there must be a learning context to which feedback is addressed (Hattie & Timperley 2007:82; Thalheilmer 2008:6). It is

one component of the entire teaching process. Feedback happens after a learner has responded to initial instruction, when the learner receives information about some aspect of his or her performance. It is most effective when it addresses the learner's misconceptions rather than a total lack of understanding. Under the latter circumstance, it may even be detrimental to learners. "If the material studied is unfamiliar or abstruse, providing feedback should have little effect on criterion performance, since there is no way to relate the new information to what is already known" (Hattie & Timperley 2007:82).

Hence, feedback is a futile exercise if the instruction and assessment which precedes it is not aligned to the achievement of standards.

3.4.1 Teaching strategies that support the provision of feedback

There are a wide range of factors which determine how effectively teaching takes place. Reynolds and Muijs (2001), for example, summarise a number of American and British research studies which examine the ways in which teachers' actions in the classroom affect learners' achievement, particularly in English and Mathematics. This research spans various topics which includes, inter alia, teacher effectiveness, classroom management, homework, higher order thinking skills, effective planning, and so forth.
"The attributes of a successful mathematics student have come to include the ability to devise problem-solving strategies, to assess the relevance of different procedures to applied contexts, to work productively with others, coordinating individual efforts to achieve a group goal" (Clarke 1992:1). The critical role that social interaction and communication plays in learning; the attainment of mathematical problem-solving and reasoning skills; and its application in real-life situations are discussed at length in 2.2.3, 2.3.1 and 2.3.2 respectively.

Given the increasing emphasis on learning as a social as well as a cognitive activity and the importance of an interactive environment to support the provision of feedback, as discussed in 2.2.3 and 2.2.3.1, the effective use of co-operative group work and whole

class teaching as teaching strategies to facilitate the provision of feedback are discussed in this study.

3.4.1.1 Co-operative Group Work

Substantial research has resulted in co-operative learning becoming accepted as one of the best practices in education (Cohen, Brody & Sapon-Shevin 2004:3; Galton & Williamson 1992:14; Johnson & Johnson 1993:154). Learners are likely to achieve more if they work together in co-operative groups to achieve a common outcome than when they work individually. It has also been found that learners' self-esteem and motivation is improved by working with their peers. Furthermore, there are considerable cognitive benefits to working collaboratively and it is likely to contribute to enhanced achievement (Galton & Williamson 1992:30; Cohen, Brody & Sapon-Shevin 2004:3).

For effective feedback to learners the teacher needs to facilitate group and whole class discussion in which the learners are expected to explain their understanding in their own ways and justify their answers. According to Johnson and Johnson (1993:155) "…feedback is institutionalised into the basic structure of cooperative learning". An important element of co-operative group work is allowing the group to reflect on their own progress. This not only develops co-operative and self assessment skills, but also ensures that learners receive feedback on their progress, both from their peers and the teacher (Zakaria & Iksan 2007:36).

Noddings (1990:18), on the other hand, rightly points out that simply having learners work in groups does not ensure that it will result in acceptable mathematical results. We have to ensure that the group is engaging in mathematical activities. Furthermore, "groupwork is not a pedagogical panacea in any case". In a review of research into effective teaching conducted by Reynolds and Muijs (2001), they concluded that the group work that is done is mostly children *sitting* in groups and there has been very little group collaborative work. There are also a number of drawbacks to working in small co-operative groups, such as some learners not participating in the group and relying on a

few to do the work; the fact that learners can be unkind and disrespectful to one another; and some learners may lack participation, communication and listening skills (Noddings 1990:18; Reynolds & Muijs 2001:54). These problems can, however, be managed by employing effective strategies. Reynolds and Muijs (2001:54) suggest that learners should be explicitly taught communication skills, such as paraphrasing, before group work is used, and that teachers can initiate class rules pertaining to talking and listening during group work.

Teachers should be knowledgeable about the different strategies of engaging learners in co-operative group work and fostering collaboration in classroom activities, and how feedback to learners can be facilitated through the use of this teaching strategy. In the report of the task team appointed to Review the Implementation of the National Curriculum Statement in South Africa (DOE 2009a:25), group work was identified as being particularly problematic in the transition from GET to FET. The task team proposes that teachers begin to understand when it is appropriate to use group work as a teaching strategy.

This study does not provide a comprehensive review of the research on co-operative group work. However, there are numerous literature studies documenting the factors which need to be taken into account to ensure the successful use of co-operative learning as a teaching strategy (see Cohen *et al*. 2004; Galton & Williamson 1992; Johnson & Johnson 1993; Reynolds & Muijs 2001).

3.4.1.2 Whole Class Teaching

Reynolds and Muijs (2001:7) concluded that the “whole class teaching situation” is still the setting in which most challenge takes place for learners, but found that it is hardly being used in classes. Their findings highlight that “teachers were spending much more time communicating with individual children than they were doing whole class teaching or facilitating collaborative group work”.

Whole class teaching lends itself to classroom discourse which supports the provision of feedback to learners. Teachers who employ whole class teaching strategies (where the teacher interacts with the learners, lecturing, explaining, asking questions, demonstrating and so forth as opposed to giving learners individual assignments to work on) were more prone to asking more challenging questions and providing feedback, and learners would pay more attention and concentrate more on their work. Ross, Morrison and Dempsey (1993:180) also contend that it is when teachers interact with learners in a classroom setting that feedback is most commonly delivered. However, they point out that due to high teacher-pupil class ratios the frequency and quality of feedback to learners is extremely inadequate.

Having said this, it does not mean that teachers should spend the entire lesson teaching the whole class. Individual or group practice remains an essential part of the lesson if student learning is to be maximised, as students have to have the opportunity to consolidate their learning. De Corte (2000:254), as discussed in 2.4, also acknowledges that individual learning is an important component of effective learning processes.

3.4.2 Implications of the provision of feedback for assessment in the classroom

According to Hattie and Timperley (2007:101), assessment should provide teachers and learners with “feedback information” relating to the task, the processes involved in the task and about the learners’ self-regulation to improve. This is opposed to the traditional understanding of assessment as merely serving the purpose of assessing learners’ levels of proficiency. If teachers see the purpose of assessment as the latter, the benefits of feedback from such assessment are often reduced.

Assessment can perform the function of providing learners with information about how and what they understand, the strategies they need to improve, and about taking responsibility to understand the required standards. However, assessment activities

and questions are seldom structured to provide effective feedback to learners and teachers (Hattie & Timperley 2007:101).

3.4.2.1 The Contents of Assessment

An important factor which promotes effective assessment is the quality of the assessment task and activities itself, whether formal or informal. Niss (1993:18) agrees that the task "occupies a dominant position in the teaching and learning of mathematics…" as it is an "organisational vehicle for the exercise of mathematical activity…" In his assessment manifesto, Stiggins (2008b:6) lists the following attributes which a quality assessment activity should encompass:

- They must be designed to serve a specific predetermined purpose.
- Designed to specifically fit into each purpose and target context.
- Communicate their results effectively.
- Be sensitive enough to detect and accurately reflect changes that evolve over time.

Shepherd (2000:1) refers to Graue (1993) who observed that assessment and instruction are often visualised as "curiously separate in both time and purpose". According to Shepherd, Graue noted that the approaches to classroom assessment, which are based on exemplars of standardised tests, are incompatible with and actually impedes the use of more socio-constructivist approaches to teaching. She maintains that traditional assessment practices, clouded with beliefs in "scientific measurement" are still prevailing today. This is in direct contrast to the emerging socio-constructivist pedagogies, which support formative assessment practices involving learners actively through self and peer assessments and the construction of knowledge. Figure 3.7 provides and illustration of the above assertions from Shepherd (2000:5):

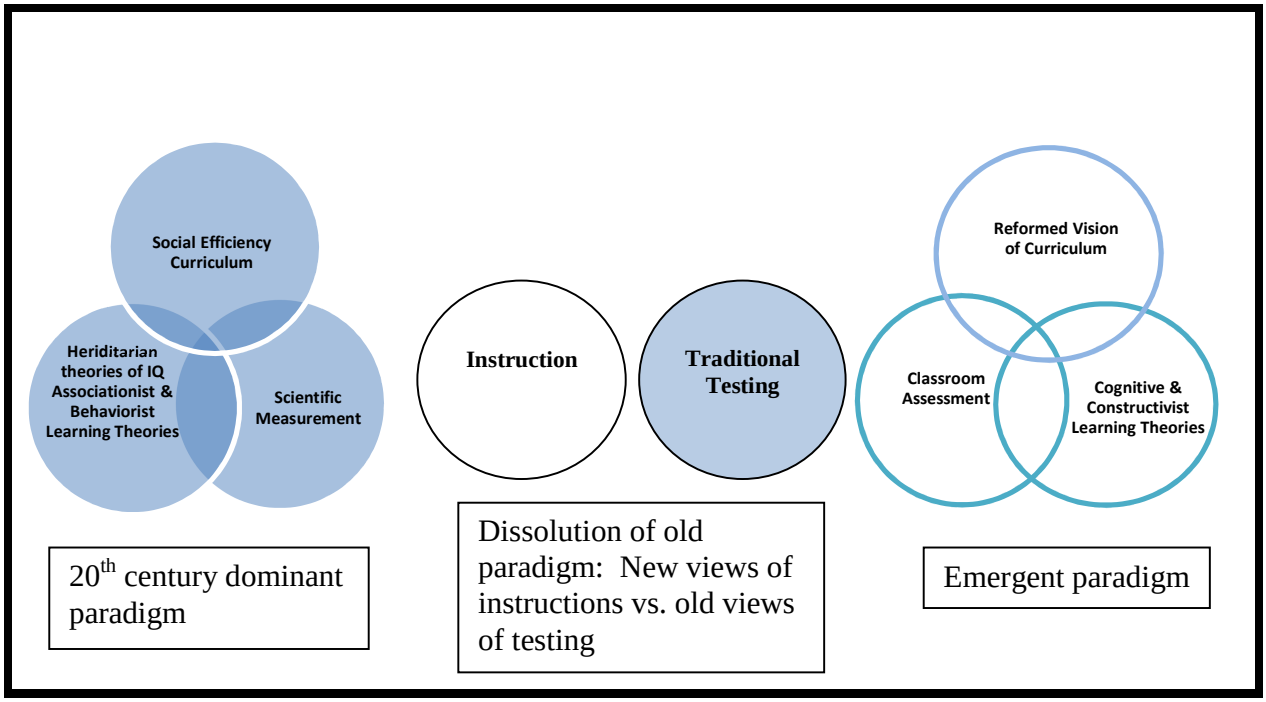


Fig. 3.5: **New views of instruction versus traditional views of testing (taken from Shepherd (2000:5)).**

According to Shepherd fundamentally the problem is that teachers are beginning to change their teaching strategies in line with new social constructivist philosophies, but their assessment strategies are incompatible, still rooted in philosophies of "scientific measurement" focusing on memorisation and recall of facts. Galbraith (1993:79) also refers to this "lack of consistency" between the respective approaches to learning and assessment.

According to Black and Wiliam (1998:4) and Clarke (1992:2), assessment is often still used solely for the purpose of grading learners, is not integrated with learning activities and does not support learner's construction of knowledge. Furthermore, assessment items still mainly test rote skills as opposed to problem-solving strategies in real-life contexts. Niss (1993:19) and Swan (1993:26) support this notion saying that the focus of attention is often too narrow and only designed to test facts and standard techniques mastered and the correct performance of computations based on formulae.

Shepherd (2000:7) (and others like Swan 1993:26) suggests that “the contents of assessment should match challenging subject matter standards” and “a broader range of assessment tools is needed” and that there is a need for “expanding the armamentarium for data gathering” The relevance of this perspective is also captured in policy documents. As a case in point, the South African National Policy on Assessment and Qualifications for schools in the General Education and Training Band (DOE 2007a:7) determines that assessment should:

(a) be authentic, continuous, multi-dimensional, varied and balanced;
(b) take into consideration the diverse needs of learners and the context. Various assessment strategies should therefore be used;
(c) be used as an on-going integral part of the learning and teaching process. This means that assessment should be used to inform and evaluate teaching and learning;
(d) be accurate, objective, valid, fair, manageable and time-efficient;
(e) take many forms, gather information from several contexts, and include a range of competencies and uses;
(f) be free from bias and sensitive to gender, race, cultural background and abilities;
(g) in the main, be criterion-referenced; and
(h) be transparent so that learners and teachers have a clear understanding of what the expectations are for any assessment task and what knowledge, skills, values and attitudes are being assessed.

Furthermore, the “challenging subject matter standards” referred to by Shepherd are evident in the Assessment Standards prescribed in the South African National Curriculum Statement, that describe the knowledge, skills and values that learners need to demonstrate to achieve the Learning Outcomes in each grade. The problem is that teachers are struggling to ensure that these prescribed assessment standards and assessment practices are realised into successful classroom practice.

This situation is described by Du Toit and Du Toit (2008:4) who suggest that behaviorist approaches is on one end of a continuum and constructivist approaches at the other

end. They go on to say that “the position in which educators find themselves on the continuum will definitely influence the way in which they teach, assess and structure a teaching-learning environment” (Du Toit & Du Toit 2008:4). Black and Wiliam (1998:9) also attribute teachers’ assessment practices to the nature of their “beliefs about learning”. Teachers who hold the view that knowledge can be transmitted and learned and that good teaching entails clear explanations and rewards for those who are receptive to those explanations, see no need for formative assessment. The ideological viewpoint from which teachers operate and how this impacts on teaching, assessment and feedback is also discussed in 2.1.

Stiggins (2008a:7) argues that teachers rarely have the opportunity to learn sound assessment practices because assessment training for teachers “remains nearly nonexistent”. There is a need for pre-service and in-service professional development that extends teachers’ understanding and skills of assessment for different purposes (ARG 2006:12; Stiggins 2008a:7).

In South Africa, a similar call is made by the task team appointed to review the implementation of the National Curriculum Statement (DOE 2009a:55). Their findings concluded that teachers were of the opinion that newly qualified teachers were not sufficiently trained in their respective fields of specialisation and that both new teachers and more experienced teachers “are not confident about assessment”.

Teachers are also confused by the contradiction between the call for alternative methods of assessment and institutional demands to improve the standardised test results to which they are held accountable. Hence, the nature of classroom assessment is often dictated by external assessments (ARG 2006:11; Mayer & Alsten 1990:162). As a case in point, in South Africa there is an increasing emphasis on external assessments as discussed in 3.2, whereas the National Assessment Policy (DOE 2007:5) describes assessment as “a continuous planned process of identifying, gathering and interpreting information about the performance of learners”. Biggs

(2003:4) agrees that many quality assurance procedures result in “quantitative expressions of learning”.

3.4.3 Alignment between teaching, assessment and learning standards

There is a distinct shift from the traditional disconnect between the contexts of learning versus that of assessment. Teachers should plan for assessment as part of teaching and learning and it should not be a separate activity. The content of assessments should match learning standards; therefore a broader range of assessment instruments is needed which are based on learning goals and which directly connect assessment to ongoing instruction. Biggs (2001:2; 2003:1) emphasises this distinctly in what he terms “constructive alignment”: The constructive aspect refers to the idea that learners construct their own knowledge, whereas the alignment aspect speaks to the teachers’ role of creating learning environments that supports this knowledge construction. The key is that all components in the curriculum - the intended outcomes, the teaching methods used and the assessment tasks are aligned to each other. All are aligned to the learning activities addressed in the desired learning outcomes.

Biggs (1999:64; 2003:2) describes four steps in setting up an aligned system of teaching, learning and assessment:

(a) Defining the Intended Learning Outcomes – according to Biggs (2003:2), it is imperative that teachers have clear objectives describing what they want their learners to achieve. These objectives should be stated clearly, detailing the topics and the level at which learners should understand them. They should also stipulate what learners need to be able to do to demonstrate this understanding. Biggs (2003:2) advises that in order to do this it is helpful to use appropriate verbs to describe learners’ required performance. He distinguishes between high level verbs (such as hypothesise, reflect, solve) and low level verbs (such as describe, identify, memorise). To ensure alignment, it is important that the same

verbs are reflected in the teaching and learning activities and in the assessment tasks.

(b) The next step is to choose the teaching and learning activities that are likely to lead to the achievement of the identified learning outcomes. The learners should execute the verbs described in the objectives (Biggs 1999:64; 2003:2). According to Biggs (1999:60), a "surface approach" to designing learning activities should be discouraged and a "deep approach" should be encouraged. A surface approach refers to activities that are pitched at a low cognitive level. These activities result in "fragmented outcomes" that have no meaning to the learners. A deep approach refers to activities that are structured to achieve the intended outcomes.

(c) The teacher now has to assess the learners' work in order to determine to what extent they have achieved the intended objectives. It is important to ensure that the assessment tasks reflect the intended learning outcomes.

(d) The last step involves arriving at a final grade. Biggs (2003:5) asserts that there are two ways to deduce this. Firstly, through a marking process that converts qualitative data into quantitative numbers and secondly, making holistic judgments using specified criteria (see discussion on criterion referenced assessment in 3.3.2.4). According to Biggs (2003:4) the intended learning outcomes "cannot sensibly be stated in terms of marks obtained". If our objectives and assessment are to be aligned, then the learners' achievement should be stated in terms of the intended learning outcomes.

Biggs (1999:64) refers to this as a "fully criterion-referenced system" wherein all the components have the same objectives and they support each other. Figure 3.7 illustrates Biggs' (1999:65) assertions.

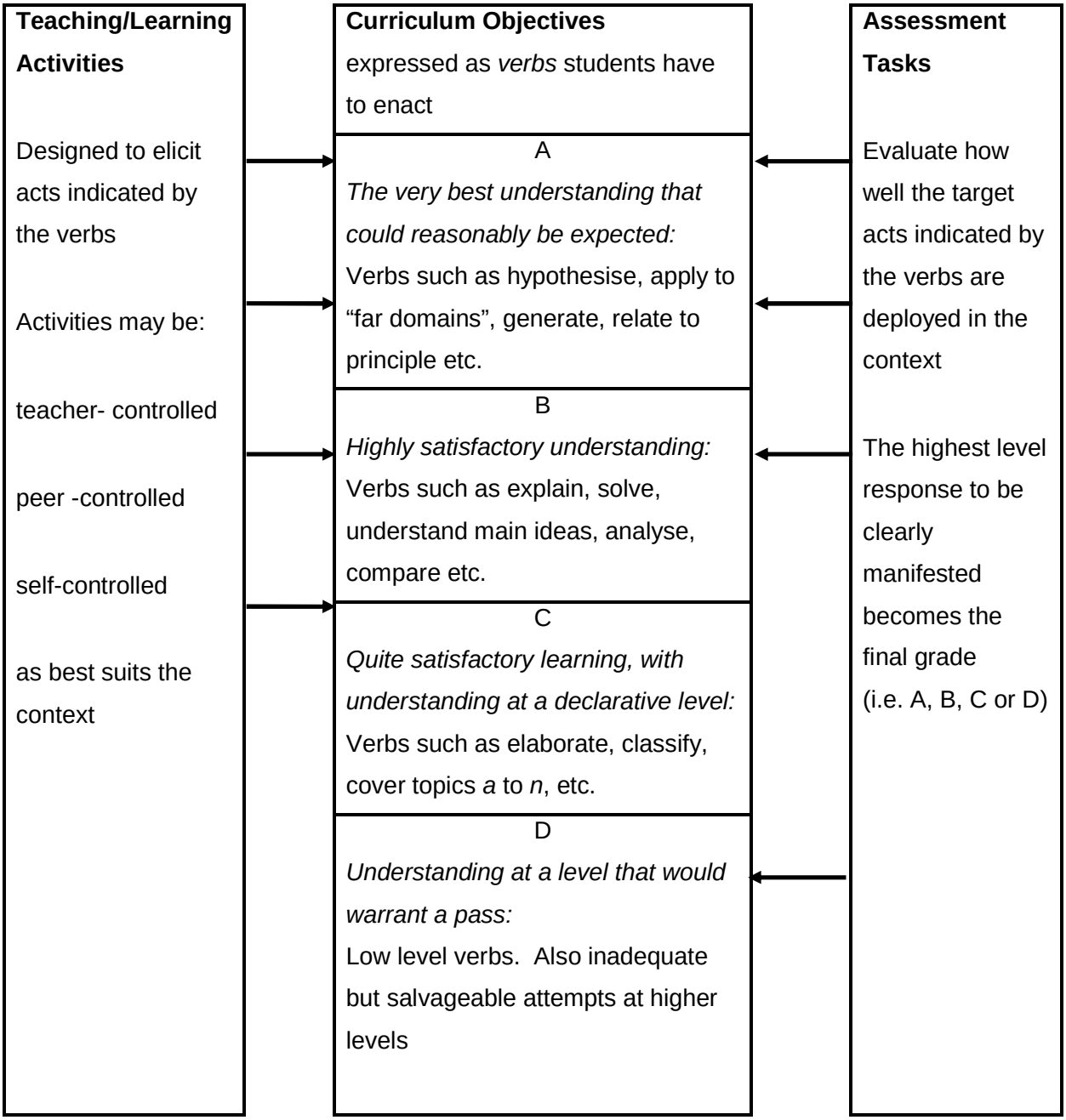


Fig. 3.6: Constructive alignment: Aligning curriculum objectives, teaching/learning activities and assessment tasks (taken from Biggs (1999:65)).

This system of alignment between objectives, teaching/learning activities and assessment tasks supports effective feedback to learners. It clearly speaks to "the

"provision of corrective feedback" and "communicating standards to learners" as discussed in 3.3.2.1 and 3.3.2.4 respectively. Race, Brown and Smith (2005:12) highlight this link clearly when they state that "constructive alignment is about ensuring that assessment, teaching, learning and feedback are all in harmony with each other, and that feedback links well to students' evidence demonstrating their achievement of the intended learning outcomes". It makes it possible for learners to receive direct and useful feedback regarding their achievement of the intended outcomes. They provide a diagrammatical representation (see Fig. 3.9) of the alignment between the intended learning outcomes, the learners' evidence of achievement, assessment processes and feedback to learners (Race, Brown & Smith 2005:13).

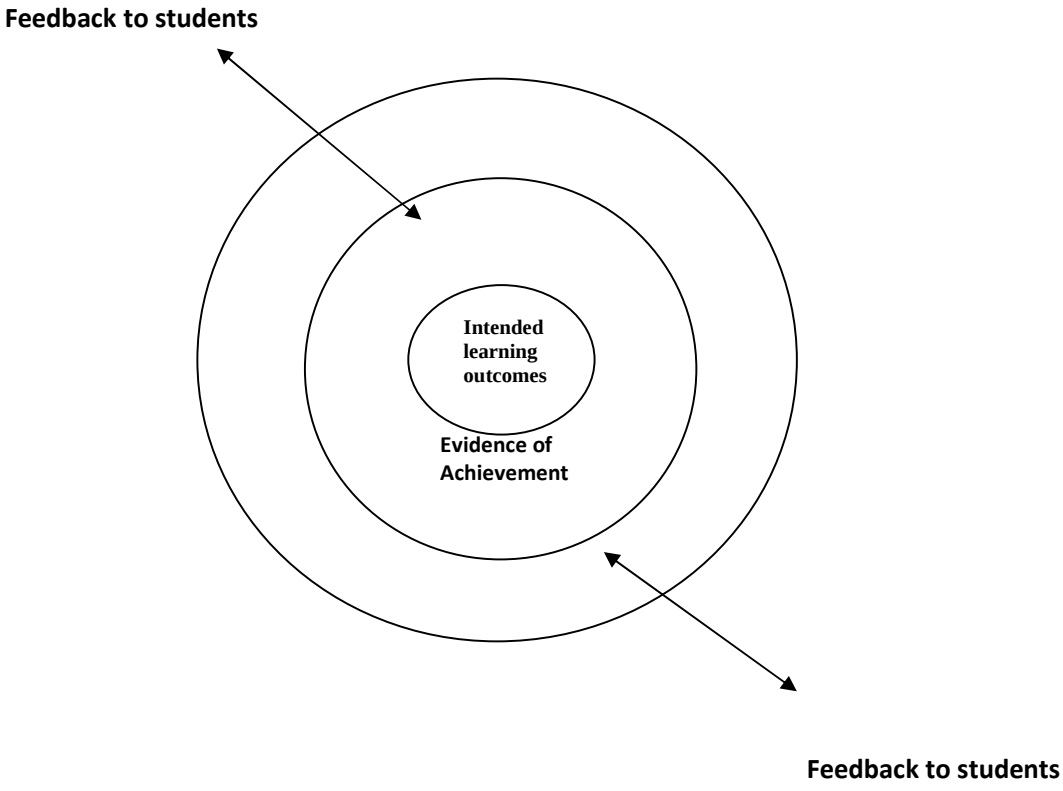


Fig. 3.7: Linking learning outcomes, evidence of achievement, assessment criteria and feedback (taken from Race, Brown & Smith (2005:13)).

The concept of alignment between teaching, learning and assessment and the importance of assessment instruments yielding information to inform further learning

and teaching is also emphasised in a number of other research studies (ARG 2002:2; Chambers 1993:25; De Corte 2000:254; Ishii 2003:2; Mergel 1998:7; Niss 1993:21). The South African National Policy on Assessment and Qualifications for Schools in the General Education and Training Band (DoE 2007a:6) also provides that "[a]ssessment is an integral part of teaching and learning and should be planned for when developing learning programmes, work schedules and lesson plans". This planning should include a clear understanding of how information gathered will be used by both teachers and learners, and strategies to ensure that learners understand the required standard, how they will be assessed, how they will receive feedback and how they will be helped to improve. So the basis for the development of effective assessment and feedback practices is the verification of the quality of the learning experience upon which it will rest.

However, the Task Team for the Review of the Implementation of the National Curriculum Statement (DOE 2009a:16-31) in its report calls for " … greater alignment in curriculum processes". It also states: "Curriculum standards specify the intended knowledge for learning. Assessment Standards exemplify the level of cognitive demand and the progression of learning over time. LTSM and training provides support and the means by which these may be enacted in the classroom. It is crucial that these different elements of the curriculum process be tightly coupled, and that there is clear alignment between the requirements of each" and "there is also a problem in the alignment of assessment with intended learning as encapsulated in the National Curriculum Statement documents".

3.5 CONCLUSION

This chapter provided a conceptual analysis of feedback and its effect on learning and achievement. Feedback is recognised as a key element of formative assessment and classroom instruction aimed at improving learner performance and raising standards.

The level at which feedback is directed determines its efficacy. Feedback can be directed at the task level, the process level, the self-regulation level or it can be directed to the self (Hattie & Timperley 2007:90). For feedback to be effective it should provide learners with specific information aimed at correcting any misconceptions, and should advise learners on how to improve. The feedback therefore comes after learners demonstrated some skill or understanding of knowledge. Feedback is futile if learners are not given the opportunity to demonstrate whether they understood the feedback and have corrected the misconception. It is also widely accepted that test scores and grades do not provide learners with the information they need to improve their learning. Furthermore, when feedback only focuses on the negative, it results in learners feeling less confident and discourages them.

The teaching and learning situation which plays out in classrooms on a daily basis provides teachers with a range of valuable opportunities to provide constructive feedback to learners. Effective assessment and feedback practices should be based on successful learning experiences. Planning for assessment, how learners will receive feedback in order to improve, and the teaching and learning situations that will be created, is therefore an integrated process. Alternative methods of assessment are required to ensure that the required outcomes are assessed. The value of classroom dialogue should also not be underestimated as a means of determining learners' understanding and providing feedback to guide their thinking.

Feedback should be linked to the learners' evidence of achievement towards the intended learning outcomes. It is therefore crucial that there is alignment between the intended learning outcomes, the teaching and learning activities, assessment processes and feedback.

However, the ultimate aim of many instructional systems is to mould learners towards self-efficacy (Sadler 1989:122). Self-regulation, reflection and self-assessment are thus significant skills to develop if learners are to be in command of their own learning.

In subsequent chapters this study seeks to determine whether current teaching and assessment practices, and more specifically feedback strategies used by the participants in the study, are in accordance with these trends, and if not, what the areas for improvement are.

4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

The foregoing chapters comprised a literature review of trends in mathematics teaching and learning, as the instructional approaches teachers employ have direct bearing on the provision of feedback to learners. Moreover, the use of feedback as a strategy to enhance learning in mathematics was reviewed. This chapter provides a description of the empirical course of the research, and the research instruments used to gather data.

4.2 DESCRIPTION OF RESEARCH METHODOLOGY

According to Sikes (2004:231) "methodology refers to the theory of getting knowledge, to the consideration of the best ways, methods or procedures, by which data that will provide the evidence basis for the construction of knowledge about whatever it is that is being researched, is obtained. Methodological work is, therefore, philosophical, thinking work".

4.3 QUALITATIVE APPROACH TO THE STUDY

The emphasis in this study is on human interaction with a phenomenon, and in view of the fact that the research problem is "exploratory and interpretive" in nature (Leedy & Ormrod 2001:112), suggests a qualitative approach. McMillan and Schumacher (1998:15; 2006:315) posit that qualitative research is based more on constructionism, which assumes reality is multi-layered and is socially constructed through individual and collective perceptions or views of the same situation. Denzin and Lincoln (2000:3) and Kelly (2006:287) emphasise the naturalistic approach of this method, saying that it

involves studying things in their “natural setting”, attempting to “make sense of”, or to interpret feelings, experiences, social situations or phenomena as they occur in the real world and in terms of the meanings people bring to them.

Moreover, Mason (2001:4) describes qualitative research as:

- “Grounded in a philosophical position which is broadly ‘interpretivis’ in the sense that it is concerned with how the social world is interpreted, understood, experienced and produced.

- Based on methods of data generation which are flexible and sensitive to the social context in which data are produced.

- Based on methods of analysis and explanation building which involves understanding of complexity, detail and context”.

This mode of inquiry can also be described as being interactive. McMillan and Schumacher (1998:35) describe an interactive mode of inquiry as “an in-depth study using face-to-face techniques to collect data from people in their natural settings”.

The research methods utilised in this study are in keeping with the constructivist research paradigm guiding the study, in order to preserve the principle of “coherence” (Durrheim 2006:38; Sikes 2004:235; Terre Blanche & Durrheim, 2002:36). Sikes (2004:236) cautions that researchers should ensure that the methodologies and procedures they use are in concurrence with their ontological position in order to be able to make a convincing case that the data collected legitimately answers the questions posed. The constructivist research paradigm and the qualitative research methods that are used in this research study are consistent with the interpretive nature of the phenomenon being explored.

4.4 SAMPLING TECHNIQUES ADOPTED IN THIS STUDY

A sample of two teachers from a primary school in the Umzinyathi District in the Kwazulu Natal Province was chosen through purposive sampling. The researcher's reasons for using purposive sampling is best described by Kumar (1999:162) when he says that a researcher " … goes to those people who in his or her opinion are likely to have the required information and be willing to share it". McMillan and Schumacher (1998:176) use the term "purposeful sampling" but also contend that "qualitative researchers are more interested in selecting cases that are information rich". To this end, teachers were identified who were willing to avail themselves for interviewing and allow the researcher to enter their classrooms to observe their lessons. Admittedly, the researcher was restricted to a large extent, given the fact that she had to relocate to another province in the middle of doing the research, and was therefore not familiar with any of the schools or teachers in the area. Teachers were therefore reluctant to accommodate a stranger in their classrooms.

Nonetheless, this sample size is appropriate as it is not the sole intention of the study to formulate generalisations, but rather to "shed light on the phenomenon under investigation" (Leedy & Ormrod 2001:102), and to gather useful knowledge that could be used by policy makers and other stakeholders to make informed decisions pertaining to the use of constructive feedback to enhance learning in mathematics.

To its merit, and in an attempt to address reliability and validity issues that may be raised in relation to a small sample size, it must be noted that the sample (the classrooms and school chosen for the research) is representative of a large cross section of schools in Kwazulu Natal and in South Africa as a whole, in terms of the socio-economic status of the learners, class sizes, language issues and so forth. Although the findings are not representative in a statistical sense, the research highlights many of the problems which most teachers experience and suggests issues that are likely to be transferable to similar contexts. However, as already pointed out, it is not the purpose of this qualitative research to generalise the patterns of the

population on the basis of the findings pertaining to the sample. Hence, it can only be surmised that, where appropriate, findings from this research could be applicable to other areas with similar circumstances.

Terre Blanche and Durrheim (2002:381) posit that in selecting a sample "there are no hard and fast rules, and decisions about the number of cases are also determined by constraints imposed on the researcher".

4.5 CASE STUDY

Krauss (2005:764) describes qualitative data analysis as having a "...naturalistic proclivity for direct observation ... and ... face-to-face interaction". Guba and Lincoln (1994:111) have a similar contention when they say that "[t]he variable and personal nature of social constructions suggests that individual constructions can be elicited and refined only through interaction *between and among* investigator and respondents". Therefore, as part of a qualitative mode of inquiry, this research entails a case study which also incorporates elements of a phenomenological study. Denzin and Lincoln (2000:439) assert that case studies are of value for enhancing existing theory and suggesting phenomena for further investigation, as well as helping to establish the limits of generalisability. Case studies can contribute to public policy setting and reflection on human experience. Leedy and Ormrod (2001:153) describe a phenomenological study as a study that attempts to understand people's perspectives of a particular situation.

The fieldwork took place in two classrooms: one grade 5 class with 33 learners and one grade 4 class with 34 learners. The case study provided an opportunity to examine the phenomenon in a classroom setting and determine how practicable information about feedback from the literature translates into existing classroom practice. The researcher spent an extended period of time in the field observing and talking to the participants in an attempt to understand their perspectives on the use of feedback to enhance learning. Details about the context in which the case is found, were recorded, including

information about the physical environment and any historic, economic and social factors that are relevant to the situation.

As part of the case study the researcher collected extensive data on which the investigation is focused, as described in Section 4.6.

4.6 DATA COLLECTION METHODS

According to Leedy and Ormrod (2005:98) "[m]easurement instruments provide a basis on which the entire research effort rests".

Observations and interviews were chosen as the main instruments of measurement. Classroom observations and semi-structured interviews with the teachers took place over a period of fourteen weeks. One interview was conducted with the principal in order to garner information pertaining to the profile of the school. The data gathered from the school principal is discussed in sections 6.2.3.2 and 6.2.3.3. The focus of the observations and interviews was informed by the literature study and attempted to source any data that would shed light on the research objectives. The fieldwork proved to be quite challenging when the public servants' strike forced the researcher to abandon the fieldwork for a period of time and to resume when the strike was terminated.

4.6.1 Observations

The constructivist paradigm on which the research is based reflects an epistemological position which suggests that knowledge can be generated by observing or participating in real-life settings (Mason 2001:61). Therefore, observations are an appropriate means of generating data.

The researcher arranged with the teachers to observe lessons on days that were convenient for the teacher. Participants were visited in their classes to observe the

mathematics lessons and related assessment practices of teachers. The researcher assumed the role of a non-participant observer in the classroom. During observations, the researcher positioned herself so as to observe the teacher and the learners without interrupting the classroom activities.

Observations were focused, looking out for particular kinds of interactions. The idea of "selectivity and perspective in observation" as suggested by Mason (2001:67), was applied, focusing on teaching and learning activities in general and more specifically focusing on the degree to which constructive feedback was provided to learners in an attempt to enhance learning.

Observations were recorded in the form of field notes and audio recordings. Field notes comprised the observation date and time, a running record of the description of activities, and other information related to the observations (such as interruptions in and outside the class, problems with recording devices, and so forth). The data obtained from the audio recordings were complemented with the researcher's field notes in order to compile comprehensive data of classroom observations. This would ensure completeness of the verbal interaction and provide material for reliability checks (McMillan & Schumacher 2006:355). The researcher transcribed the audiotapes of classroom observations with verbatim transcriptions of the teachers' and the learners' statements. After completing the transcriptions, the researcher compared it with field notes to ensure that it provided good descriptions of all interactions and statements important for the study.

4.6.2 Interviews

According to Denzin and Lincoln (2000:42) "[a]n in-depth interview is often characterised as a conversation with a goal. The researcher may use a general interview guide or protocol but not a set of specific questions worded precisely the same for every interview. Rather there are a few general questions, with considerable latitude to pursue a wide range of topics". Krauss (2005:760) concurs: "Rather than

approaching measurement with the idea of constructing a fixed instrument or set of questions, qualitative researchers choose to allow the questions to emerge and change as one becomes familiar with the study content". This describes the approach to the interview method utilised in this study.

4.6.2.1 Administration of the Interviews

The interviews were conducted in the school library at a convenient time for the teachers. The teachers willingly agreed to these interviews despite the other duties they had, such as marking of books and assessment tasks, meetings and other school activities. The interview with the principal was conducted in his office. The interviewees were given the assurance that the discussion would be treated as confidential.

The teachers and the principal were asked for permission to allow the researcher to record their responses with an audiotape so that the researcher could replay the interviews and fill in the gaps in handwritten notes. The use of the audiotape ensured that the information recorded in the notes and the tape could be compared and corrected wherever there was some uncertainty or ambiguity. If any part of the questions was not very clear to the respondents, the researcher gave a further break down, and probed the participants to elaborate where responses were vague.

4.6.2.2 Construction of the Interview Guide

In keeping with a qualitative mode of inquiry, the researcher based interview questions on a general framework of key ideas elicited from the literature study. As alluded to in 1.6, the interview schedule designed for the study was semi structured to provide flexibility and allow the researcher to illicit detailed responses. The interviewer would however still adapt these conditions according to the circumstances of the field.

In this study a "loose interview format" as described by Mason (2001:71), was developed. The interview format was based on key topics and relevant questions

related to the research phenomenon. This interview format provided adequate flexibility, but also some kind of guide or prompt for the interviewer about the key issues and questions with which the study was concerned. The researcher did not use a script of questions during the interview, but rather a set of index cards to take into each interview. As recommended by Mason (2001:72), these notes were not in a particular sequence, so that they could be drawn upon at any time, in relation to the specific context of the interview in progress. A flow chart of a possible interview structure was also developed. An example of the interview format and the flow chart is attached as Appendix A and Appendix B. Figure 4.1 ilustrates an overview of the planning and preparation procedure for qualitative interviews (Mason 2001:72):

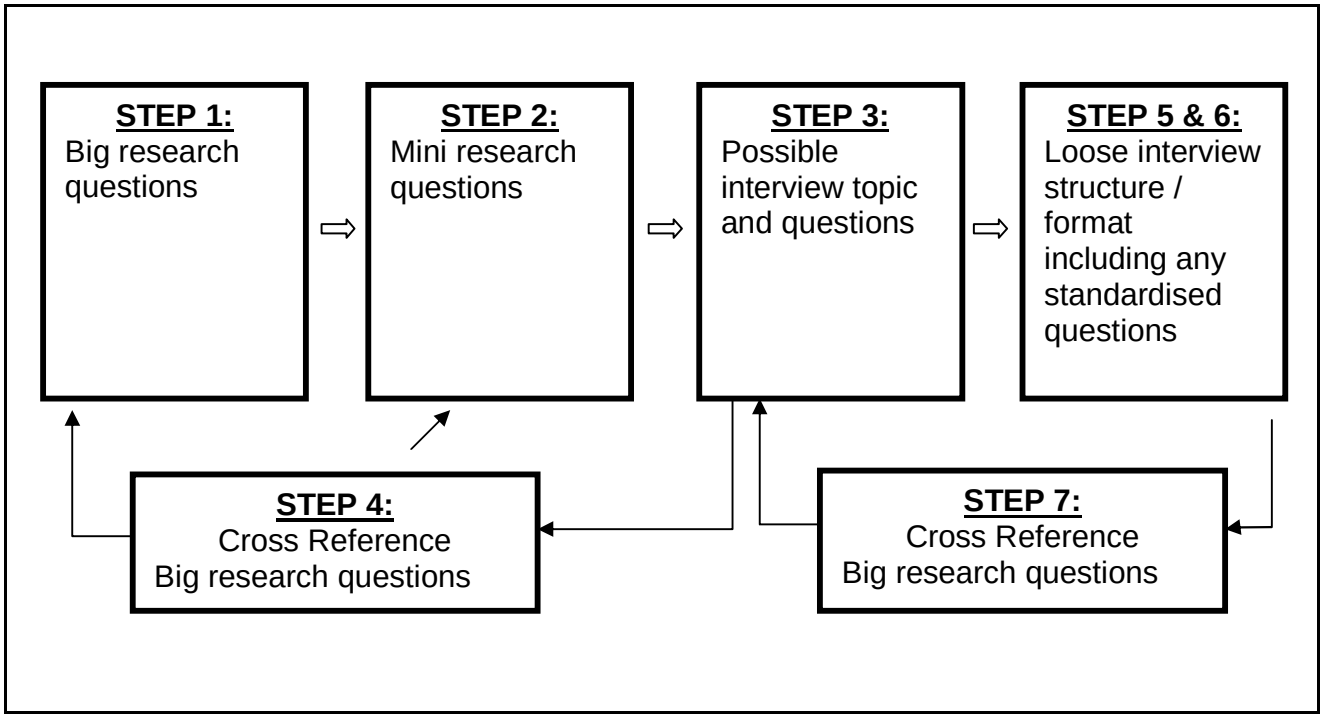


Fig. 4.1 Overview of planning and preparation procedure for qualitative Interviews (taken from Mason (2001:72)).

4.6.3 Written documents and visual material

The teacher's planning documents, assessment tasks and learner responses were collected for analysis and corroboration with observation and interview data. According to Terre Blanche and Durrheim (2002:35) as well as Durrheim (2006:39) interpretative research should emphasise "rich experiential data", and this study was designed to produce this kind of data.

4.7 RELIABILITY OF RESEARCH RESULTS

Terre Blanche and Durrheim (2002:63) describe reliability as "the degree to which the results are repeatable". However, they go on to say that in an interpretive and constructivist research study, it is expected that the results will not be repeated since reality is not seen as stable or unchanging. Therefore in the place of reliability they posit that constructivist studies should be "dependable". Dependability refers to the degree to which the reader can be convinced that the findings did indeed occur as the researcher says they did. In this study dependability is achieved through rich and detailed descriptions that show how opinions and conclusions are rooted in and developed out of contextual interactions.

Pickard and Dixon (2004:6) and Guba and Lincoln (1994:114) refer to Guba's "criteria of trustworthiness" which could be used to judge the quality of constructivist inquiry. These are "credibility, transferability, dependability and confirmability". This study meets the criteria for credibility which according to Pickard and Dixon (2004:6) is "shown by prolonged engagement with the research participants, persistent observation of those participants, and triangulation of the techniques used to study those participants and their context…"

In constructivist inquiry, the goal is to allow for "transferability of the findings" rather than wholesale generalisation of those findings (Kelly 2006:381; Niss 1993:75; Pickard & Dixon 2004:6). The multiple data collection methods and the rich reporting of the

analysis of the data as described above, allows for transferability of the findings. Dependability and confirmability of the findings emanating from this study are established by ensuring that the constructions "…can be traced back to the raw data of the research and ensuring that constructions can be seen to have emerged directly from the data, thereby confirming the research findings and grounding them in the evidence" (Pickard & Dixon 2004:6). To this end, all the interviews and observations were taped with an audiotape and the tapes have been kept securely as a quality assurance measure, to be submitted if necessary to verify that the transcripts were accurate.

4.8 VALIDITY OF THE STUDY

The use of "Methodological Triangulation" (Denzin & Lincoln 2000:443, Terre Blanche & Durrheim 2002:431) in this research study can be upheld as a claim to validity. The fact that multiple sources of data are collected, which reveals common themes, contributes to the validity of the conclusions drawn from the data. Denzin and Lincoln (2000:443) endorse this when they say that triangulation is "a process of using multiple perceptions" for "verifying the repeatability of an observation or interpretation". In addition, the instruments developed in this study were informed by the literature review and based on the objectives of the study, which therefore meets the requirement of "construct validity" (Welman & Kruger 2001:135). Welman and Kruger (2001:135) assert that "the instrument we use to measure the variable must measure that which it is supposed to measure"; if it is to meet the requirement of construct validity. Therefore, care was taken to ensure that the interview questions were developed so that the intended constructs rather than irrelevant constructs are measured. This implies that the interview questions were formulated in such a way that the data gleaned from these would give an indication of the participants' ideas, beliefs and practices pertaining to the use of constructive feedback to support learning in mathematics. The observations, research questions and their responses are linked to literature and theory of education in order to further ensure that the findings would be given added validity.

4.9 OBSERVATION OF ETHICS

As far as possible, the researcher strove to observe ethical conventions of research in this study.

Guba and Lincoln (1994:115) assert that "[e]thics is *intrinsic*" to the constructivist paradigm"…because of the inclusion of participant values in the inquiry". Because the aim of the research is uncovering and improving initial constructions, it is in the interest of the inquirer to reveal their intention. He further contends that the "…hermeneutical methodology itself provides a strong but not infallible safeguard against deception" (Guba & Lincoln 1994:115). The researcher informed participants of all aspects of the research. The purpose of the research was explained to the participants in detail and respondents were prepared beforehand for the type of questions they would be asked in the interviews.

When referring to "Codes of Ethics", various authors cite the principle of "informed consent" as a major determinant of ethicality which must be applied in any research study (for example Denzin & Lincoln 2000:138; Leedy & Ormrod 2001:158; Mason 2001:58; McMillan & Schumacher 1998:196, Terre Blanche & Durrheim 2002:72). Participants must willingly agree to participate and their agreement must be based on complete information. In this research, the teachers who participated in the study signed letters of agreement to participate. Furthermore, great care was taken to ensure that participants were not inconvenienced in any way, both during the interviews as well as the classroom observations. Appointments were made beforehand to suit the participants' work schedules.

To ensure confidentiality and anonymity of respondents, they were given the designations Teacher A and Teacher B respectively. All personal and identifiable information as well as the data that were provided by the participants will be protected.

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

4.10 ANALYSIS AND INTERPRETATION OF THE DATA

Detailed descriptions of each lesson, the transcribed interviews, copies of the teachers' planning, and the learners' assessment tasks and workbooks formed the data sources for interpretation and analyses.

Phenomenology is a theoretical view point which contends that it is through direct interaction with various phenomena that human beings interpret them and attach meanings to different actions and or ideas and in the process construct new experiences. Therefore, researchers have to develop "empathic" understanding to know the beliefs and viewpoint of individuals so that they can replicate in their minds feelings, intentions and thoughts that are behind the action of others (Dash 2003:46; Terre Blanche & Durrheim 2002:399).

Terre Blanche and Durrheim (2002:401) refer to an "emic approach" (understanding from within the context) and an "etic approach" (outside perspectives and the use of theory), and advocates for the use of "derived etics", a combination of the two approaches. They further refer to "descriptive and interpretive hermeneutic functions" which should be employed in order to create insightful accounts.

This philosophy is thus applied in interpreting the data. The researcher agrees that both an immersion in the context and distanciation is needed to gain understanding of the phenomenon. Data was interpreted both "literally" and "interpretively" (Mason 2001:109). The data is read literally to the extent that it documents a literal version of the evidence of feedback observed and found in the learners' books. It is also read interpretively as it involves the researcher's interpretation of what the data represents and what can be inferred from the data.

The first step in data analysis was for the researcher to familiarise and immerse herself in the data by reading through field notes and transcripts of interviews numerous times. By identifying the main ideas that underlie the material, the researcher then generated themes, bearing in mind the research questions. The researcher preferred to code the data by using a word processor and highlighting segments of text in different colours, then using the cut-and-paste function to group text that pertained to particular themes. This is an acceptable method described by Terre Blanche and Durrheim (2002:143). This was not a linear process as the themes tended to change in the course of coding. The researcher also found that bits of data were applicable to different themes. These were pasted under all relevant themes and the researcher made provisional notes underneath on how the data will be used.

On completion of the analysis and interpretation of the data the narrative was read and scrutinised to identify any contradictions, over-interpretations or prejudices that may have influenced the interpretation of the data, as cautioned by Terre Blanche and Durrheim (1999:143). As far as possible the researcher tried to remain objective, but suspects that her own inclination towards a constructivist paradigm may have some influence on the way data was perceived and interpreted.

4.11 CONCLUSION

The focus of Chapter 4 was on discussing the context in which the research was undertaken and the research methodology employed in this study. The use and choice of qualitative research methodology was presented and elucidated. The rationale behind the use of observations and interviews as a means of gathering data is explained. Furthermore, issues pertaining to data analysis, reliability, validity and ethics were also discussed. In Chapter 5 the research findings are presented.

5

RESEARCH FINDINGS

5.1 INTRODUCTION

This section reports on the key findings of the study. It is structured according to the following categories: biographical data of the school and the profile of teachers involved in the study; classroom observations and teacher responses to interview questions. Categories derived from literature as well as those that emerged from the observations guided the researcher to determine what aspects of classroom practices to focus on. In general, three aspects were the focus of the observations: the nature of the classroom practices and teacher instruction; the learning environment created for social interaction and the opportunities they provide for the provision of feedback; and feedback provided to learners during the course of a lesson.

Mathematics lessons were observed and the teachers were interviewed about specific teaching and assessment decisions. Literature on feedback, formative assessment, learning theories and trends in mathematics teaching, as discussed in chapters one to three, was the primary source of the details used in the construction of the interview guides and as the focus of classroom observations. The interview questions were loosely structured and compiled according to the example provided by Mason (2001:71) (see 4.6.2.2). Questions were asked pertaining to the teachers' pedagogical practices; opportunities created for effective communication and classroom discourse; feedback strategies currently used; assessment strategies employed by the teacher; teacher training received; and the profile of the school.

It is not feasible to describe every observation and interview in detail in this study. However, in this section, all information regarded as important to the study is described

in as much detail as possible. As a quality assurance measure and to ensure validity and dependability of the research, all audiotapes and field notes are kept securely by the researcher, as described in paragraph 4.7. To ensure anonymity of participants, the teachers involved in the study are referred to as Teacher A and Teacher B respectively.

5.2 BIOGRAPHICAL DATA AND CONTEXTUAL FACTORS

5.2.1 School Background and Context

The school is situated approximately 90 km from where I reside. A visit to the school required that I leave my home at about quarter to seven in the morning. During the winter months visibility on the roads was normally problematic due to heavy mist and fog. About 20km from my hometown I pass a coal mine, but the rest of the fifty minute drive takes me past rural areas with crops and cattle visible from time to time.

The small, quaint town where the school is situated has a population of approximately 13 547 people. It is situated in the Umzinyathi District of Kwazulu-Natal, South Africa. The main economic activity in the area is coal mining while sheep and cattle ranching are also practiced. The neighboring residential areas are African townships.

The school building is a modest two-storey building. Although the outward appearance is not particularly attractive, the grounds and reception area are neat. The school is a former Indian school within the ex-House of Delegates Education Department. As a result of the repeal of the Group Areas Act in 1991 and the official desegregation of schools in 1995, there has been a strong influx of black learners into this school over the past decade. The school now has a multiracial learner population of approximately 20% Indian learners and approximately 80% African learners. The school is situated in a working to middle class still predominantly Indian area. The Indian learners live in the community where the school is situated, while the majority of the African learners live in surrounding townships.

The school has a male principal and a female deputy principal. It caters for learners from grades R to grade 6. The staff comprises 16 teachers in total.

5.2.2 Teacher Profiles

Teacher A is an Indian, English-speaking female in her fifties. The teacher also speaks Hindi. She has a four year teacher's diploma. Her highest qualification in Mathematics is at the level of matric. The teacher has 34 years of teaching experience in the primary school in the Foundation Phase and Intermediate Phase. She has taught mathematics for one year.

Teacher B is an Indian, English-speaking male in his twenties. He has a four year teacher's diploma. His highest qualification in Mathematics is at the level of matric but he indicated that although he did not specialise in mathematics the subject formed part of the course for the first three years of his teacher training. The teacher has 4 years of teaching experience in the primary school in the Intermediate Phase. He has taught mathematics for one year.

5.3 CLASSROOM OBSERVATIONS

The following descriptions summarise the activities observed during the lessons of Teacher A and Teacher B:

As I entered Teacher A's classroom the learners greeted me enthusiastically. The classroom is neat. It has clean brick walls. A large portion of the wall is covered with wall charts and pictures. One side of the wall has only Mathematics charts (Addition and subtraction, Multiplication, Fractions). Two bright yellow A4 sheets have the words "Maths Wall" and "Our Maths Information" written on it. The wall is lined with wooden shelves on one side. On the shelves there are colourful little boxes, bottles and tins that are painted and decorated, which looks like items which learners have made for technology. One wall chart displays all the learners' names and there are varying

numbers of gold stars pasted next to each name. I learned later that the gold stars were awarded to learners who do well on the mental test written at the start of each lesson. The teacher obviously makes a concerted effort to create a physical atmosphere conducive to learning. The classroom seating was organised in a conventional row setting.

For all the lessons observed, Teacher A started the lesson by giving learners a mental test, which generally consisted of basic calculations involving two or more operations such as “2 x 9 + 8”. The teacher read the problem while the learners write in their test books. The teacher then collected the books from each learner and tied the books with a rubber band to mark later.

Teacher A generally introduced the topic for the day by referring learners to the particular topic in the textbook or stating what the topic for the day is, for example, “*Today, you are going to draw a bar graph*”. The teacher immediately started to demonstrate the topic of the day and the procedures involved in a step by step format. In all the lessons observed, the teacher made use of teaching aids which she had made herself (for example graph paper drawn on an A4 sheet, fraction parts drawn and coloured, shapes drawn and coloured to demonstrate tessellations).

The learners were required to look at the blackboard while the teacher explained and demonstrated. Teacher A placed much emphasis on repetition and constant reinforcement. The learners were expected to repeat word for word what the teacher regards as important for them to know. The teacher read any information or questions aloud and the learners repeated it a number of times. Teacher A generally addressed any questions to the entire class and the class provided answers in unison. In isolated cases the teacher asked individual learners for a response.

In one of the lessons observed (tessellations) the learners were seated in groups. However, the format of the lesson remained the same. The teacher demonstrated what tessellations are, and then the learners were required to do their own tessellating

patterns using cut out shapes. During this activity the learners were more talkative and noisy. Some learners were quick to build their tessellating patterns while some learners copied the patterns of the others in the groups. The teacher used one of the learner's patterns to demonstrate the correct way to the rest of the class. In dealing with the learners, the teacher spoke clearly and slowly and tried to simplify content as much as possible.

Once the teacher had completed the explanation and demonstration, the learners were required to do a similar activity in their books. The learners worked on the activity individually. The teacher checked on the learners as they work on the activity, and explained again if there were learners who did not understand what they had to do.

Teacher A provided very little feedback to learners during the course of the lessons, neither to affirm positive behaviour nor to correct misconceptions. The teacher did, however, often provide feedback to learners by repeating the learners' correct answers. In the few instances where learners did make mistakes or provide incorrect answers, the teacher immediately corrected them or refered the question to another learner, as in the following example:

Teacher: Modes of transport. Now on this side here, what can we write? [Pointing to vertical axis]. Kanye?
Kanye: Modes of transport.
Teacher: No. This is types of transport [pointing to horizontal axis]. What are these? What does each block represent? [pointing to vertical axis and addressing the whole class].
Learners: Children.

Although the example above is indicative of the general trend in Teacher A's class, I would be remiss not to mention one incident which occurred in the final lesson that was observed. In this lesson, the teacher was teaching learners about measuring the capacity of liquids. Rather than merely redirecting the question to another learner as

she commonly did, the teacher actually probed the learner who provided an incorrect answer and assisted him in making sense of the concept, as is illustrated in the following excerpt:

Teacher: One litre can fill how many 500ml bottles? More hands should be going up. One litre can fill how many 500ml bottles? Here's one litre and here's half a litre [shows the litre and 500ml bottles] How many of these can fit into a litre bottle?
Learner: Two.
Teacher: Two, right. One litre can fill how many quarter litres? How many of these can go into this? [shows the litre and 250ml bottles]
Learner: One.
Teacher: How many 250 ... Siyabonga think. It must fill this bottle [shows one litre bottle]. How many of the 250 ml fills this one? [picks up 500ml bottle]
Learner: Two.
Teacher: Two will fill this one. So how many will fill this bottle here [shows one litre bottle]
Learner: Four.
Teacher: Right.

Teacher B's classroom is somewhat less attractive. The walls have obviously not been painted for a while. The ceiling is broken in places. The classroom is however sufficiently spacious and tidy. There were no papers strewn on the floor. There are a number of wall charts covering one section of the wall (road safety, a few science charts, a chart depicting the South African flag and the class timetable). However, none of the charts related to mathematics. The learners were also seated in straight rows, two at a desk.

In teacher B's class, classroom instruction generally followed a regular sequence of events. The lessons started with recitation of multiplication tables, after which learners had to complete a speed test. The teacher usually wrote a few sums on the board and gave learners a specified time (usually approximately five minutes) to complete. The

teacher immediately wrote the answers on the board and instructed the learners to mark their own work with a pencil. The teacher walked around to all the learners to check whether they had marked their work. The teacher then instructed learners to take out their homework books and again walked around the class to check each child's book to see if they had done the homework. Teacher B reprimanded all the learners who had not attempted to do the homework. The teacher then wrote the answers to the homework exercise on the board. In some lessons the teacher elicited the answers to the exercise from the learners. The learners were then again instructed to mark their own work with a pencil. The teacher again walked around the classroom checking each learner's book to ensure that they had marked the corrections to the homework exercise. The teacher then wrote the homework for that day on the board and instructed learners to copy the exercise. The teacher then wrote the answers to the previous day's class work on the board and instructed the learners to mark their work and do the corrections in their class work books which he referred to as "the big book". Teacher B again moved between the learners to check whether they were marking correctly and doing the corrections, while he reprimanded the learners who did not do it correctly.

Teacher B generally introduced the lesson by referring the learners to the relevant page in the textbook, for example, "*Today, we're doing problem-solving that is on page 79*". The teacher then read the exercise in the textbook together with the learners. During a lesson on "problem-solving" in the textbook, which required learners to find answers to problems stated in words, the teacher read through each problem and lead learners to the answers. After this, the learners were required to complete the same exercise in their class work books.

Teacher B's approach to a lesson on multiplication of two digit numbers involved demonstrating the algorithm step by step. The learners were instructed to look at the board. The teacher revised the algorithm meticulously asking individual learners to recall the steps. The teacher repeated the process, doing a few sums on the board while the class recalled the steps involved. The teacher praised the learners when they

answered correctly, for example, "*Good*" and "*Good job*". One learner was then asked to go to the front and do one example on the board while the teacher repeated the steps. The teacher made a point of encouraging learners to count on their fingers and reprimanded learners who provided incorrect answers and who were not counting on their fingers. After the teacher's demonstration the learners were required to do another similar exercise in their books.

Teacher B rewarded learners by making positive comments when they displayed desirable behaviour, for example, "*Very good. At least you tried now*". The teacher's feedback to learners not only involved praise but often also disapproval, for example, "*If you were paying attention yesterday you would have known*" and "*Very bad*". As with Teacher A, the teacher affirmed the learners' correct responses by repeating it.

In many instances, Teacher B did not probe learners to communicate their understanding, but rather continued to direct the questions to the next learner or to the whole class until someone provided the correct answer, as the following example involving rounding off of numbers demonstrates:

Teacher: Thursday, 79 405. Yes? [to learner]
Learner: 80 000
Teacher: No. Yes? [to another learner]
Learner: 18
Teacher: 18? No.
Learner: 81000 Sir
Teacher: No. Don't just guess! Yes? [to another learner]
Learner: 77 000
Teacher: We're on Thursday now. You are not remembering the word 500. You're not remembering 500.

5.4 EVIDENCE OF WRITTEN FEEDBACK

Data collection also involved document analysis in order to examine the evidence of teacher feedback in the learners' books and the assessment tasks. Teacher A marked the learners' work correctly with a tick and incorrectly with a cross. Where learners achieved the maximum mark for a test the teacher wrote the word "*Excellent*" next to the mark awarded. As a reward for tests and written work, the teacher pasted stars or other stickers in the learners' books.

There was no evidence of written feedback or comments in the books of learners in Teacher B's class. The teacher also marked work correctly with a tick or incorrectly with a cross as a means of providing feedback to learners on whether they had achieved the desired outcome.

5.5 TEACHER RESPONSES TO INTERVIEWS

The interviews with the two teachers were conducted in the school library, at a convenient time for the teachers. The library is quite spacious. There are shelves right around the room, packed with books. The books were however basically scattered on the shelves with no catalogue system in place. There are five big tables arranged in a rectangle in the centre of the room with seventeen green leather padded chairs arranged around the table in a boardroom style. There is an old TV in the library, which looks like it does not work. The bottom shelves on the right contain about twenty computers that are packed away, some are stacked on one another and some are closed with a cloth. There is a door leading to a small room with a copy machine where teachers are allowed to make copies.

In order to put the participants at ease I made small talk by discussing neutral issues such as the weather. I then thanked them again for volunteering to participate in the study and I again explained the purpose of the research. The interviewees were given

the assurance that the discussion would be treated as confidential. At this point I asked the participants for permission to record the interview for further reference.

5.5.1 The teachers' epistomological paradigm

As discussed in 2.1, teachers' belief systems about the nature of mathematical understanding will impact on their pedagogical practices. In order to understand the reasons for the extent to which teachers use feedback strategies to enhance the learning of mathematics, it was thus necessary to ask questions pertaining to their epistemological paradigm.

In response to a question on how they think learners learn best and the best way to teach learners both Teacher A and Teacher B believe that the best way to teach mathematics is to first demonstrate a procedure or concept to the learners and then give learners the opportunity to practice what they have observed. As Teacher A put it: "*I think in our school that's what most of us do. It's because of the background of our learners. We demonstrate and then we ask them to do it*". Teacher B agreed in the following statement: "*I would say keep on doing the same exercise a few times to see if they can grasp what we actually want from them and what the textbook wants*". When asked about allowing learners to learn through exploration and discovery, Teacher A and Teacher B felt that only a few learners are capable of learning mathematics in this way because of "*the type of learners that we have*". Both teachers indicated that they prefer teaching through demonstrating fixed procedures and consolidating through drill and practice.

To further determine the teachers' beliefs pertaining to instructional approaches and the way learners learn, they were asked questions about the extent to which they allow for the application of mathematics in context, relating the mathematics to the learners' real life-world. Both teachers contended that for the most part they teach mathematics in context. Teacher A claimed that she teaches in context approximately 70% of the time. Teacher A cited the example of teaching learners about money: "…*like say if we were*

doing something on money, if you going to the shop and you have R20 and you gonna buy something for R17, let them do everyday things". Teacher B was also of the opinion that he often teaches mathematics in context because he simplifies content to accommodate the level of the learners: "*If the question in the textbook is too hard for the learners then I'll try to bring it to their level and see if they can get that answer and then relate it to what the textbook says*". However, when asked how often problem-solving forms part of their lessons, both teachers pointed out that they do problem-solving "*about once a week*".

When asked whether they had received any pre- or in-service training on different teaching methodologies, both teachers indicated that they had not received any such training. Teacher B said that he had not received any training on how to implement the new curriculum.

5.5.2 Opportunities created for effective communication and classroom discourse

Given the assertions by several authors (see 3.3.5), regarding the importance of communication and classroom dialogue to facilitate feedback to learners, a key question was asked regarding the opportunity provided for learners to have classroom discussions about mathematics. Both teachers responded that they do not give learners much opportunity to have discussions about mathematics because learners "*don't want to*" talk about mathematics. The teachers also felt that if they do initiate class discussions it is mainly teacher-centred. As Teacher A puts it: "…*we find that we do most of the talking*". Teacher B concurred: "… *I think it's because I feel that maybe learners … they not good at it, so they try to get the information from us so that they can get what we're trying to explain to them*". The teachers both contended that it is this lack of participation on the part of learners which results in them not often making use of group work. They did, however, feel that some activities lend themselves to group work.

5.5.3 Evidence of feedback strategies used by the teachers

One of the objectives of this study is to explore evidence of feedback strategies used in a mathematics classroom context. The questions posed to the teachers were: "How do you inform learners about their progress? Teacher A indicated that assessment is the best way to "*gauge whether your lesson is a success or not*". Teacher B regards homework as a good way to determine learners' understanding. When probed further about how the learners receive feedback other than their test marks, Teacher A pointed out that "*most of the time the marks will show you …. then the child knows that if there were twelve examples and maybe the child got three out of twelve, then definitely they haven't fared well*". Teacher B indicated that he never uses comments to provide feedback to learners: "*You mark the work and you give them a mark as their feedback*". According to Teacher A she preferred to use marks or to stick a star or a symbol in the learners' books. Teacher A stated: " … *these children don't even understand those words. Whereas if we write three out of twelve they know that three tells them I didn't do as well as expected. The words are not so meaningful to them*".

In addition the teachers were asked how they determine the misconceptions that learners have. Teacher A indicated that she determines the misconceptions learners may have when she notices mistakes that they make when they complete the worksheets they are given. Teacher B pointed out that the work learners complete in their homework books is a good indication of that which they do not understand. When asked whether the teachers specifically study the learners' work to analyse the misconceptions that they hold, Teacher B replied: "*I think nine out of ten times, we have a feeling, we know the learners and who can do it and who can't do it, and most of the time the learners who know their work can do it. So I always try and check on the learners that don't know it and try and get them to understand it by teaching it again in the hope that they can get it*". When asked what they do once they determine that the learners do not understand a particular aspect of the work, both teachers indicated that they teach the work again, using the same or a similar method, and then give the learners additional exercises to determine whether they understand it.

5.5.4 Assessment strategies employed by the teachers

Considering the important role that assessment plays in providing both learners and teachers with effective feedback information as posited by Hattie and Timperley (2007:101) discussed in 3.4.2, questions related to the assessment practices of the teachers were crucial. In response to a question asking which methods of assessment they prefer and use mostly, Teacher A pointed out that she most often used the worksheets (in the form of a test) which form part of the work schedules provided to them as part of a project which the school participates in. According to Teacher A it is "*the most effective way for us to judge the performance of the learners*". Teacher B pointed out that he prefers the use of formal tests as a means of assessing learners: "*I would think for maths formal tests is good because you can gauge whether the learner is understanding or not. Doing a project is not gonna help for me to know whether they know what they supposed to be doing. So for me projects in maths are not favourable for the way I'm thinking it should be*".

The teachers were also asked to what extent they use informal activities, such as questioning and observation as a means of assessing learners. According to Teacher A observation is very important. The teacher maintained that she often uses observations during the course of a lesson in order to determine the learners' understanding. Teacher B agreed that questioning learners in class gave him an idea of what learners do not understand and what he needs to re-teach. When asked whether they ever use the information from this informal assessment of learners to report and provide feedback on the learners' progress, Teacher A replied that she does not use this information but mainly focuses on the learners' test marks. She did, however, say that she uses this information when she reports informally to the learners' parents during discussions. Teacher B pointed out that he does not use this information because "*at our school you required to do the two tests and to have something in writing*".

In addition the teachers were asked at what juncture they formally assess the learners work. According to Teacher A as a rule the learners are assessed at the end of each

theme or chapter as well as summatively at the end of each term. The teacher also mentioned that she assesses learners after teaching a particular concept to determine whether they understand and whether she needs to re-teach. Teacher B stated that the school requires them to test learners at the end of each month and at the end of each term by means of a formal test.

The teachers were asked whether they analyse the learners' results to determine their level of understanding. Both teachers indicated that they check the learners' tests to determine who requires "remedial work". When asked whether the learners are ever given the opportunity to redo an assessment task, Teacher A stated that this is only done when the entire class or approximately 80% of the class had fared poorly. Teacher B also said that the learners are given a second chance if they "*do badly*". They further pointed out that, if given a second chance, the second assessment task is similar to the first task.

A question was posed asking the teachers whether they give learners the opportunity to do self- and peer-assessment. Teacher A indicated that she does not allow learners to do self- or peer-assessment. The teacher does, however, believe that there is value in learners doing self-assessment and stated that learners will know what is expected of them and it will be a learning experience for them. Teacher B is of the opinion that there is no value in learners doing self-assessment because they are unable to assess themselves accurately even if they are given the criteria and even if the teacher explains the criteria to them. When asked about the fact that learners mark their own homework every morning he said that if he doesn't write the answer on the board and if he doesn't check it "*they'll mark even the wrong answer right*". He did however cite an example of an activity in the textbook given to learners which provided them with criteria to design a cube and said that "*they did ok*" with this activity. When asked whether they ever design their own criteria and provide it to learners before they attempt a task, Teacher A said that it would be problematic and again attributed this to "*the language barrier*" which the learners' experience, and felt that the learners would not understand

the assessment criteria given to them. Teacher B stated that he sometimes designs his own criteria but that he would only share this with learners verbally.

5.5.5 Alignment between learning standards, the contents of assessments and ongoing instruction

The teachers' ability to provide constructive feedback to learners is also determined by the extent to which there is alignment between all the components in the curriculum as explained by Biggs (1999:64; 2003:2) and Race, Brown and Smith (2005:12) referred to in 3.4.3. Therefore questions were asked to determine whether the teachers create such an aligned system.

When asked what informs the teaching methods that they will use to teach learners what they want them to learn, the teachers indicated that they use the teaching guides and lesson plans provided to them (the school is a project school for a South African publisher; so they use all their resource materials). The teachers were then asked whether they analyse the learning outcomes and assessment standards stipulated in the lesson plans in order to decide on appropriate teaching activities and to determine the knowledge and skills that learners need to demonstrate. Teacher A replied that they do "*look at*" the outcomes. Teacher B indicated that they simplified the learning outcomes in order to "*try to make the work simpler and bring it down to the level of the learners*".

When asked whether the teaching guides and lesson plans which they use also indicate the assessment to be done, both teachers said that it does, but according to Teacher A *"most of the time we do our own assessments*". Teacher B agreed and said that it is "*because that level is too high for our learners*".

The teachers were also asked whether they plan for assessment beforehand or after they have completed the lessons. Both teachers indicated that they plan for assessment once they have completed the lessons. Teacher B said: "*Once we've*

gone through the lesson we'll see that certain questions they are doing ... I'll use it. From the activities that we give them we'll take that same questions and give it back to them to see whether they understood it or not".

When asked whether they analyse the assessment tasks to determine whether it addresses the intended learning outcomes and assessment standard, the teachers said that they have not done this previously but will begin to ensure that their tasks address the different levels in Bloom's taxonomy since they had recently attended a workshop on how to do this.

The teachers were asked whether they also plan for the provision of feedback when planning their lessons and assessment. Both teachers indicated that they do not plan for the provision of feedback to learners. Both Teacher A and Teacher B simply replied "No."

5.5.6 Teacher training

The knowledge and skills that teachers require in order to effectively manage sound instructional and assessment practices, analyse and interpret evidence of learning and give feedback to learners can only be achieved through initial and continuing professional development (ARG 2002:13). The research therefore tried to determine the frequency and quality of teacher training which the teachers receive. Questions were asked regarding the pre- and in-service teacher training received, which would prepare them for managing the classroom environment needed for the effective provision of feedback to learners.

Both teachers indicated that they had not received any pre- or in-service training on different teaching methodologies. Furthermore Teacher A pointed out that the training she received on the National Curriculum Statement was based on the Foundation Phase and that it did not include any training on instructional approaches. Teacher B stated that to date he did not receive any training on the National Curriculum Statement.

When asked about his pre-service training as a student teacher he replied: "*We were basically given books and we had to learn the books*".

The teachers were also asked whether they had received any training on how to provide feedback to learners to improve their learning. The teachers stated that the topic of feedback strategies has never been part of any curriculum training which they had received. They also pointed out that they had not had any mathematics workshops for the year and that the subject adviser has not visited their classrooms to provide support for the entire year.

5.6 CONCLUSION

In this chapter the findings of the investigation are presented. Findings related to the classroom observations provide a preliminary impression of the classroom environment created by the teachers and how this may impact on the provision of feedback to learners. The teachers' responses to interview questions give an indication of their belief systems about the nature of mathematical understanding. The interviews also offer details about the extent to which they provide opportunities for their learners to have classroom discussions about mathematics, the ways in which they diagnose the misconceptions that their learners may hold and about how they provide feedback to learners. In addition they give an indication of the assessment practices they employ. The following chapter provides an interpretation of the research results.

6

ANALYSIS AND INTERPRETATION OF RESEARCH RESULTS

6.1 INTRODUCTION

In chapter 6, the aims and objectives of exploring the use of feedback to improve learners' performance in mathematics are underscored for empirical investigation. The classroom observations and interviews are discussed and the findings are analysed and interpreted. The researcher attempted to ground the study in particular classroom circumstances. The researcher then inferred general ideas and conceptualisations through the interpretation of these practice-grounded data. Furthermore, the observations, interview questions and their responses are linked to literature related to various learning theories, particular trends in the teaching and learning of mathematics and the use of constructive feedback for enhancing learner performance in mathematics.

Through the empirical investigation the researcher aimed to:

- examine and evaluate which feedback strategies are currently used in mathematics classrooms

- reflect on the factors that impact on the ability of teachers to provide constructive feedback to learners to enhance learner performance in Mathematics

- determine the contextual realities at classroom level that impede the use of constructive feedback to enhance learning

6.2 ANALYSIS AND INTERPRETATION OF DATA COLLECTED FROM THE OBSERVATIONS AND INTERVIEWS

The deductions presented in this section are based on the researcher's observations of the interactions between the teacher and the learners and amongst the learners themselves as well as the teacher's responses to the interview questions. The researcher strives to infer the "implicit rules or social norms" that the participants appeared to be following in an attempt to explain their mutual construction of the observed patterns (Cobb 1990:207). Cobb (1990:207), as discussed in 2.3.1, refers to the "socio-anthropological context", wherein the purpose is to "identify and account for aspects of a culture…by analysing regularities and patterns that arise". These patterns are however entirely the observer's own interpretation derived from the researcher's observations "rather than from the inferred experiences of the participants as they interact with each other".

Terre Blanche and Durrheim (2002:153) argue that in a constructionist approach, whatever meanings are created in an interview are treated as "co-constructed between the interviewer and interviewee". Neumann (2000:370) agrees that it is a "joint production" of a researcher and the participants. Throughout the data analysis, the conventions "Teacher A" and "Teacher B" are used to refer to the two teachers involved in the study.

The analysis of the data was guided by three of the key research objectives listed in 6.1. In order to address the research objectives the following themes were identified in the analysis of the data:

- **Feedback strategies used by the teacher**
  A key aspect of the study was to determine whether the teachers are currently giving feedback to learners; therefore an analysis of the data sought to determine this. The observations and interviews also probed the type of learning environment which the teacher creates for the learners and the extent to which

social interaction and meaningful discourse amongst learners and between learners and teacher is incorporated in teaching and learning since the classroom environment sets the scene for the provision of feedback to learners.

- **The ability of teachers to provide constructive feedback to learners**

  The observations and interviews sought to reflect on the teacher's epistemological and ontological paradigm and how this may impact on pedagogical practices, which includes the provision of feedback. It was also necessary to determine whether the content of assessments match learning standards and is connected to ongoing instruction; or whether there is disconnect between the contexts of learning versus that of assessment. The study also asked questions regarding the pre- and in-service teacher training received, which would prepare them for managing the classroom environment needed for the effective provision of feedback to learners.

- **The contextual realities at classroom and school level**

  It was also imperative to obtain information regarding the contextual realities of the teacher's classroom situation, the school, the physical environment and economic and social factors that may have bearing on the phenomenon.

6.2.1 Feedback strategies used by the teachers

The study aimed to explore the feedback strategies which teachers are currently using, so as to determine best practice and also highlight shortcomings in order to make suggestions for improvement. It was, however, necessary to first explore whether the learning environment created for the learners facilitates the provision of feedback.

6.2.1.1 The type of learning environment created and the extent to which social interaction and meaningful discourse is incorporated in teaching and learning

The critical role that social interaction plays in learning and in the learner's mathematical knowledge development is underscored in 2.2.3.1.1. Furthermore, as discussed in 3.3.4, it is through meaningful classroom discourse that the teacher is able to determine the learners' level of understanding and hence provide constructive feedback to improve their learning. An important aspect of this study was therefore to determine the extent to which opportunities for social interaction and meaningful discourse are created for learners.

In both Teacher A and Teacher B's classes, there was very limited social interaction and classroom discussion. In both classes the teachers created an individualistic culture of learning. Although the learners in Teacher A's class appeared to feel free to chat to the person sitting next to them, there is very little interaction between learners which involves mathematics. As already mentioned in 5.3, Teacher A generally addressed comments and questions to the entire class and the learners responded to questions in chorus. During all the lessons observed the learners in Teacher B's class were not allowed to interact with one another. The teacher expected them to focus their attention on him and answer the questions which he posed to them. The classroom discourse was mainly focused on the correct completion of corrections from the board, and whole class discussion of the exercise for the day. Whole class discussion was mainly teacher-centred, with learners providing answers from time to time.

Both teachers agreed that they do not provide the learners with opportunities to have discussions about mathematics and acknowledged that they find their role as facilitators of such sessions quite difficult. They ascribed this to the learners' unwillingness or inability to participate in classroom discussions. Teacher B argued that "…*they're not good at it, so they try to get the information from us so that they can get what we're trying to explain to them*". Teacher A agreed that the teachers do most of the talking

and believes that it is due to their "*unique situation*", referring to the fact that the majority of learners are not taught in their home language and that they come from a poor socio-economic background.

- ***Level of questions and wait-time***

In both classes, the learners were not encouraged to ask questions and classroom questioning was indicative of the "one-way-traffic" alluded to by Clarke (1992:34) as mentioned in 3.3.4. Both teachers mainly posed "low level" questions that required learners to recall facts and procedures and the learners were therefore not expected to think, reason and communicate critically. The assertions of Black and Wiliam (2008:8); Clarke (1992:32); Hodgen (2007:2) and Wood, Cobb and Yackel (1991:606) as discussed in 3.3.4 regarding inadequate wait time and asking questions that can elicit an immediate response from learners, is evident in the following transcribed classroom discussion:

Teacher A: Do you know what is a bar graph children? [waits 5 seconds]. Right, we did this before, you know what's a bar graph right. Here's a picture of a bar graph [puts picture on board]. We've done this before, but I drew the bar graph for you. Today, you are going to draw a bar graph. Right, let's look at that picture. What is the picture about?

The research evidence (for example, Black & Wiliam 2008:8; Clarke 1992:32; Hodgen 2007:2; Wood, Cobb & Yackel 1991:606), as highlighted in 3.3.4, suggests that wait-time used in this way is likely to diminish the quality of classroom discourse. In this example, the learners were not prompted for a response and the teacher herself eventually provided an answer.

Teacher B, on the other hand, on a few occasions provided adequate wait time given that the questions he asked were mainly "lower level factual questions" as asserted by Reynolds and Muijs (2001:44) and discussed in 3.3.5. Unfortunately, after the

appropriate wait time the teacher redirected the question to another learner without prompting the first learner for a response. The following transcribed classroom discussion on the algorithm of multiplication provides an example:

Teacher: Next step. Lungilo what's the next step? (waits 10 seconds) What must you do first?
Lungilo: Two times...
Teacher: No! What are you supposed to do in the next line first? First thing you must do in the next line? (waits 19 seconds)
Lungilo: Silent
Teacher: First thing you must do as your step 2. First thing. Yes Thobeka? [to another learner]
Learner: Put a zero.
Teacher: Zero. What must you do Lingilo? What must you do Lingilo?
Lungilo: Zero.
Teacher: Zero. Don't forget OK. Right, next step. Yes boy.

- ***Opportunities for exploration and construction of mathematics meaning***

In the lessons observed, the teachers did not create instructional and learning environments which provide opportunity for the construction of mathematics meaning and for learners to explore mathematical concepts as advocated by Verschaffel *et al.* (2006:54) and discussed in 2.3.1. Teacher B mainly fostered passive rather than active learning. Teacher B provided no opportunity for learners to explore the mathematics as all the lessons observed comprised of the teacher eliciting answers to questions from learners or demonstrating a fixed procedure. Teacher A did consolidate that which she had demonstrated by giving learners activities to do which required them to be actively involved. However, the teacher first attempted to transmit the knowledge rather than encouraging independent exploration. For example, in the lesson on Tessellations, which is discussed in 5.3, the teacher could have allowed learners to predict certain outcomes regarding whether or not a shape will tessellate. This could have led to

meaningful discussions regarding the properties of polygons and why certain shapes in and of themselves will not tessellate. The lesson also provided valuable opportunities for learners to engage in problem solving as they discovered the different ways one can tessellate polygons. The groups could have been asked to come up with a definition of tessellating rather than the teacher stating the definition upfront.

Teacher A did attempt to provide some opportunity for exploration in a lesson on measuring the capacity of liquids. It would however be more effective if the teacher had not demonstrated the measuring herself while standing in the front of the class, but had allowed the learners to investigate in co-operative groups and shared their findings with the class.

- ***Group work***

Although both teachers were in agreement that "*certain activities lend themselves to group work*", Teacher B admitted that he seldom does group work activities in his class and said that when learners are required to have group discussion "*they will talk about everything else*". During one of the lessons observed in Teacher A's class, the learners were seated in groups as opposed to the other observed lessons where the desks were arranged in straight rows. The format of the lesson was however similar to when the learners were seated in rows. The teacher demonstrated and explained the topic of the day and then the learners were required to practice what they had learned by completing an activity on their own. This is evidence of Reynolds and Muijs' (2001:54) conclusions that in most classes group work is merely sitting in groups with little group collaborative work, and Noddings' (1990:18) assertions that teachers should ensure that the groups are engaging in mathematical activity (see 3.4.1.1).

- ***Teaching through problem-solving in real-life contexts***

In both classes there was little evidence that problem-solving is used as a "vehicle for learning" as espoused by Murray *et al*. (1998:171) as summarised in 2.3.2.1. A lesson

on “problem-solving” observed in Teacher B’s class was introduced as follows: “*Today we're doing problem-solving that's on page 79*” and “…*in your textbook there's a problem question that we need to do the answers for*”. The lesson unfolded with the teacher and learners reading through the questions and the teacher guiding learners to the “correct” calculations. It is clear from the observations and interviews that both Teacher A and Teacher B’s understanding of problem-solving is indicative of Hiebert *et al*. (1996:14) and Murray *et al’*s. (1998:171) assertions (as discussed in 2.3.2.1) that many teachers’ understanding of problem-solving involves a distinction between acquiring knowledge and applying it. This is exemplified by Teacher B’s definition of problem-solving: “*I would say getting the learners to use the skills of what we already taught them to try and get the answer*”. These two case studies provide a case in point for Smit’s (1997:23) concerns regarding the “problematising of mathematics” wherein he refers to the learner’s limited mathematical experience, their ability to express their ideas and the teachers’ limited ability to respond to learners (see 2.3.2.3).

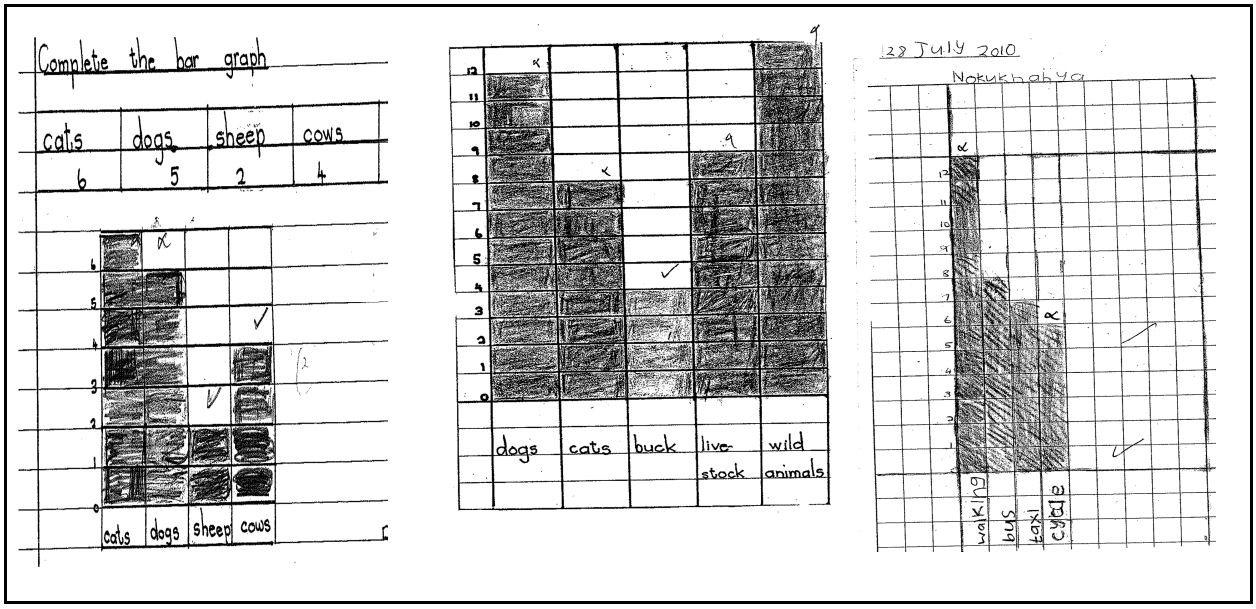
Teacher A and Teacher B’s statements that they often teach mathematical concepts in contexts related to the real-life world of their learners but, on the other hand, that they do problem-solving “*once per week*” is in conflict with the conceptualisation of problem-solving as “doing mathematics in context” advocated by proponents of Realistic Mathematics Education as discussed in 2.3.1 and 2.3.2. Observations of the teachers’ lessons and a study of the learners’ workbooks provided little evidence that conceptual processes are connected to or learned within the context of authentic everyday experiences. For example, in the lesson on Tessellations, Teacher A could have used numerous contexts such as the patterns on Zulu artefacts, interior design, art or architecture to help learners build understanding and, as posited by Zlatan (2005:13) and quoted in 3.2.1, to “relate mathematical knowledge properly to their beliefs, their values, to their cultural background and foreground as well as to their professional activity”.

6.2.1.2 Evidence of verbal and written feedback provided to learners

The teachers' tendency to repeat the learners' correct answers could be regarded as a form of verbal feedback, since it conveyed to learners that they had achieved the outcome, which in both classes was mainly to provide correct responses.

Most of the feedback, both verbal and written, was primarily directed to the self level. Comments to the learners during lessons and in the learners' books consisted entirely of praise, punishment or extrinsic rewards such as stars or stickers in their books. The teachers in the study, particularly Teacher A who made a point of using stars and symbols as reward, felt strongly that "*it is more meaningful to them* [the learners]". However, Black and Wiliam (2008:6) (see 3.3.6), Hattie and Timperley (2007:96) (see 3.3.1.2) and Thalheilmer (2008:44) (see 3.3.6) are of the opinion that this type of feedback is least effective for enhancing achievement and has no learning benefits.

There was also no evidence in the learners' books of corrective feedback that offers information about the task, or any feedback directed at the process level or self-regulation level, as described by Hattie and Timperley (2007:93), referred to in 3.3.1.2. In Teacher A's lesson on the drawing of bar graphs, also discussed in 5.3, a common mistake which many learners had made in two previous tasks involving bar graphs was not highlighted for discussion and feedback: Learners had difficulty interpreting the "0" bar on the graph. Many did not count the bar and did not consider how to apply the particular scale to the height of the bar. In the lesson the teacher did refer to this by saying: "We start off at zero right", but did not point out the common error that learners made or facilitated a discussion to determine their understanding. The following examples from one learner's book show how the learner made the same mistake in three different tasks over a period of five months:



In the following excerpt from a transcription of a lesson in Teacher B's class the teacher did attempt to provide corrective feedback by stressing the "rule" which he had taught the learners. But the fact that the learners continued to guess the wrong answer is an indication that further clarification was needed. The teacher could have slowed down at this point in the lesson and, for example, probed the learners to determine what they were thinking and simultaneously encouraged them to verbalise their understanding; asked other learners to explain why the answers provided were incorrect or could have used a number line to demonstrate and consolidate the concept of rounding off.

Teacher: Tuesday, 75 413. 75 413, round it off to the nearest 1000. Yes Thando.
Thando: [inaudible]
Teacher: Tuesday now. Remember 500 then you'll get your answer. Yes [to another learner]
Learner: 76 000
Teacher: No. If it is more than 500 it will change, if it is not more it will remain the same. Yes? [to another learner]
Learner: 80 000

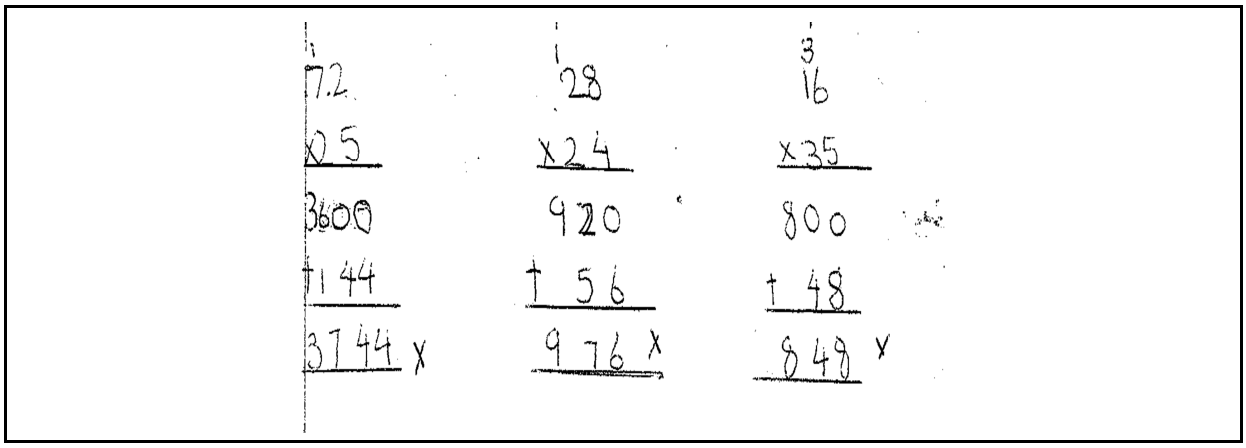
Teacher: Not 80. Yes [to another learner]. Come on class, what's wrong? Yes? [to another learner].
Learner: 1000
Teacher: No. Why you say 1000? You're not reading on Tuesday. Put your finger on Tuesday 75 413! Round it off to the nearest 1000! So what is the answer? Yes? [to another learner]
Learner: 74 000
Teacher: 74 000.

- ***Identifying and correcting misconceptions***

Teacher A and Teacher B's commentaries regarding diagnosing the misconceptions which learners may have suggests that the teachers merely scrutinise the learners' work and test results to determine how many learners understand what they have been taught and how many do not understand, rather than analysing the learners' work with the aim of determining the misconceptions they may hold in order to give constructive feedback to enhance their learning.

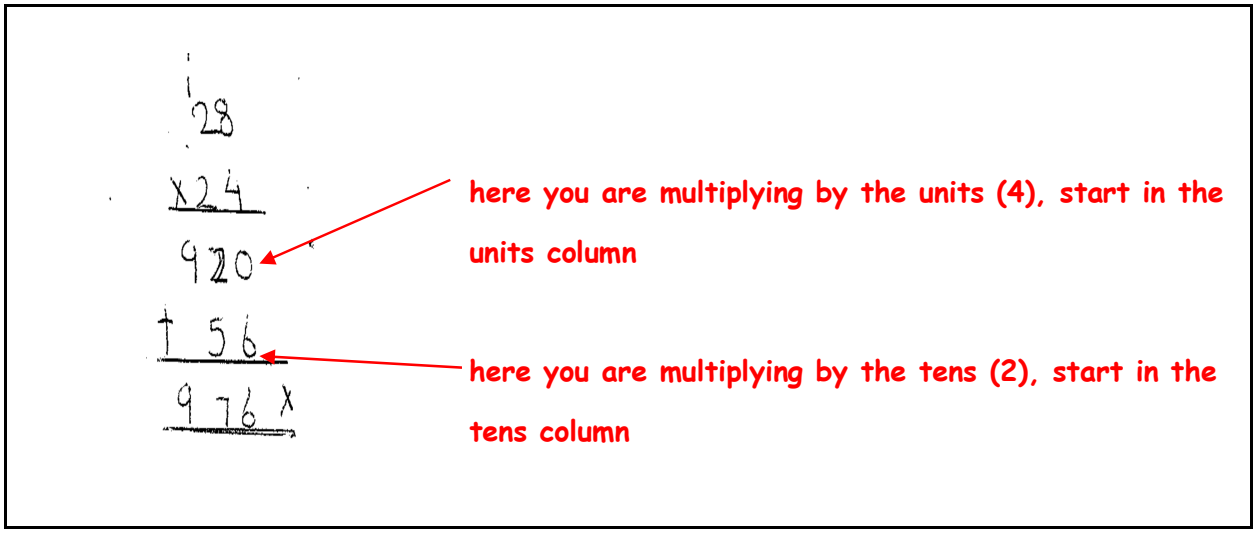
The following examples of learners' work on the multiplication algorithm in Teacher A's class are used to indicate how the teacher could have analysed the learners' work to determine their misconceptions and provided constructive feedback:

Learner 1



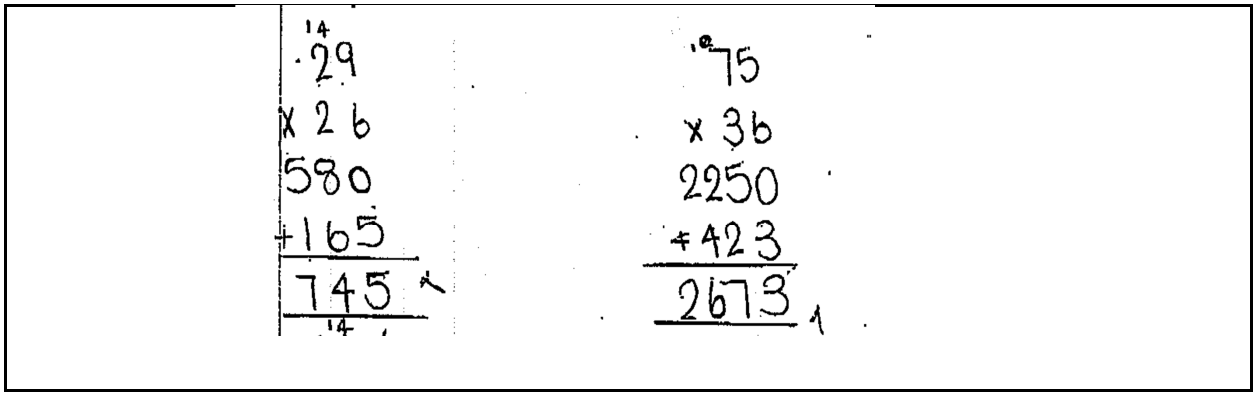
In carrying out the multiplication algorithm, the learner put down zero in the first step rather than in the second step to indicate that she is multiplying by the tens digit. She also failed to adhere to the practice of placing the units directly under units, tens under tens and so on. The learner multiplied the units and tens digit in the multiplier as if they are both units. For example, in 72 x 25 (see page 135), the 20 x 2 is treated as 2 x 2

The teacher could have pointed out the learners' mistake by providing some kind of feedback, for example:

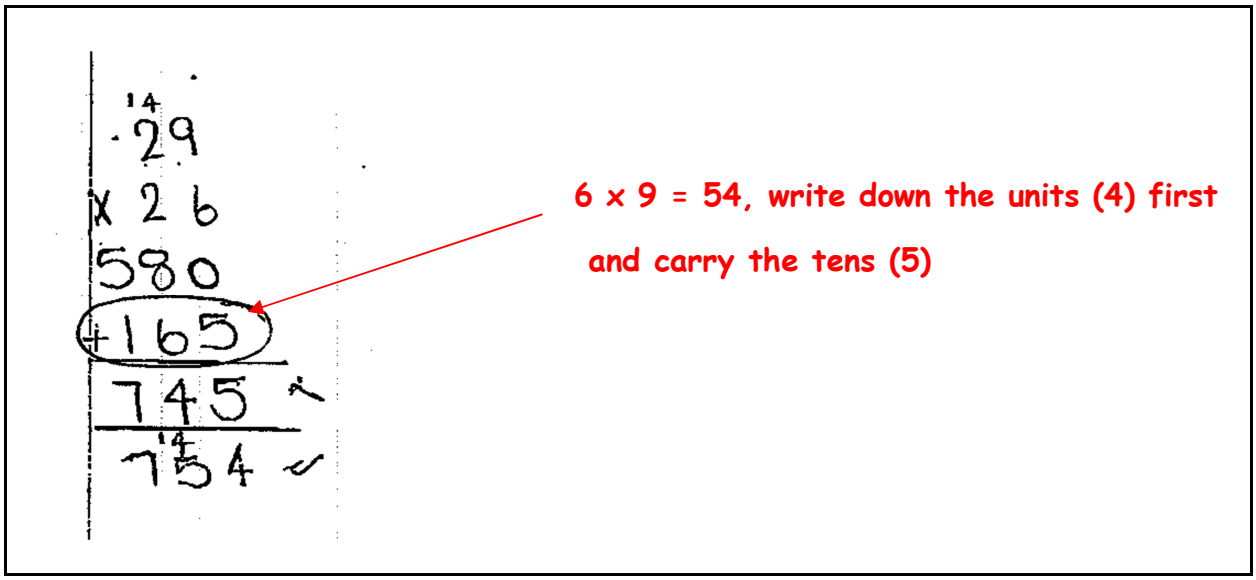


The teacher would then need to follow up on this feedback by having a discussion with the learner or the whole class if the misconception is a common one.

Learner 2



This learner also put down the zero in the first step but he went on to multiply the tens digit in the multiplier first, which could have resulted in correct answers. But when he multiplied with the units digit in the multiplier, he wrote down the tens digit from the answer he got rather than the units, for example 6 x 9 = 54, so he wrote down the 5 and carried the 4 instead of the other way around. The teacher could have highlighted his error in the following way and subsequently had a discussion with the learner to point out the error and why it did not make sense.

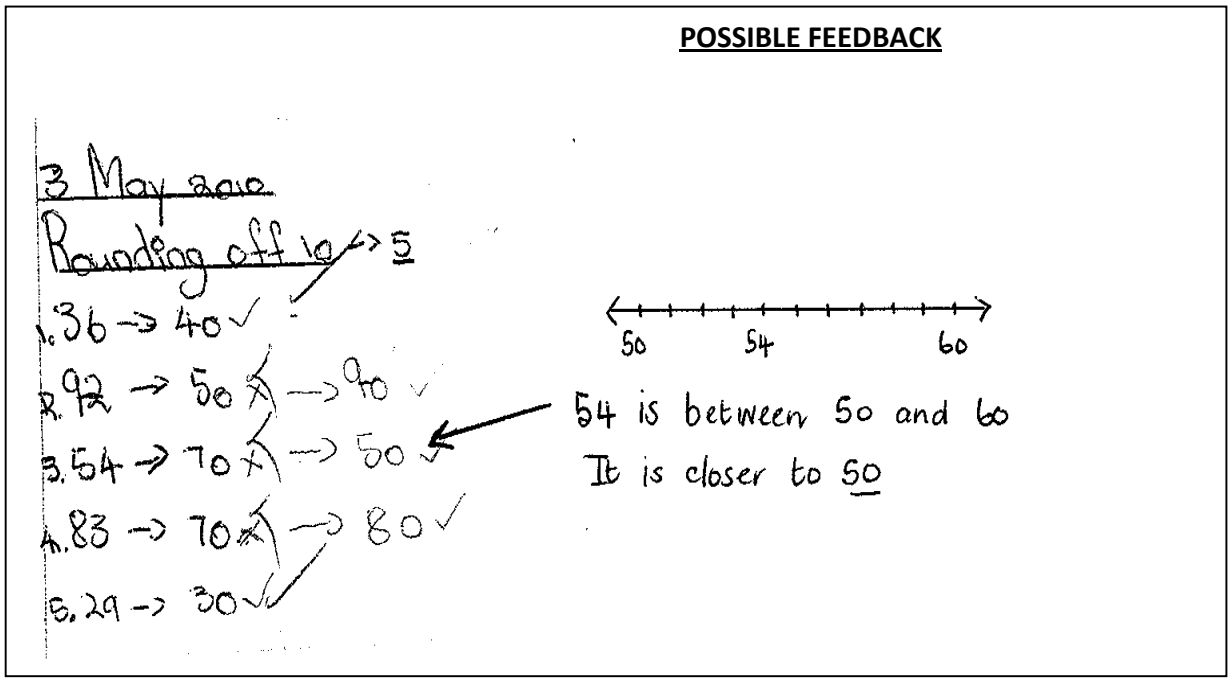


In the examples, it appeared as though the children had tried to remember the algorithm, but had become confused as to where to put down the zero. Other examples of confusion with the algorithm method were also found, which often occurs when learners are required to remember a set of rules which they do not understand.

If the teacher had diagnosed these misconceptions upon which the errors were based they could have been corrected. Many of the learners' errors indicated a lack of understanding of place-value, and this would have been a good place for the teacher to start. The focus thus was on the processes (the algorithm) rather than on conceptualisation. The teacher may have to rethink her entire teaching strategy as it would appear that the learners were not ready to grasp the multiplication algorithm as

she had taught it. It is unlikely that merely re-teaching the same procedure (as both teachers admit to doing during the interviews) would produce a different outcome.

The following example from the work of a learner in Teacher B's class showed how the teacher could have provided simple feedback to learners in order to provide a scaffold which could improve their understanding of the concept of rounding off. In the sample of the learner' work, the teacher merely marked the work correctly with a tick or incorrectly with a cross. The possible feedback that the teacher could have provided is illustrated alongside.



The use of marks as feedback to learners

The teachers' conviction regarding the use of marks as a form of feedback is conflicting with many literature studies (such as Black & Wiliam, 2008:8; Stiggins, 2008b:3; Swan 1993:26 as was highlighted in 3.3.6) who contend that marks and grades do not provide beneficial feedback as it does not give learners specific guidance on their strengths and weaknesses.

- ***Communicating standards to learners***

If the intended outcomes are not communicated effectively to learners, feedback cannot result in improved learning, as posited by Hattie and Timperley (2007:89) referred to in 3.3.2.4. In both classes, the teachers did not explicitly communicate the intended lesson outcomes to learners. Comments such as the following from Teacher B were uttered matter-of-factly at the start of the lesson: "*Today, we're doing problem-solving that's on page 79*". It is unlikely that the learners had a clear understanding of the lesson outcomes and this would affect whether learning takes place effectively, as various authors suggest (see 3.3.2.4).

The next section explores the factors that impact on the ability of teachers to provide constructive feedback to learners.

6.2.2 Factors that impact on the ability of teachers to provide constructive feedback to learners

In order to reflect on the teachers' ability to provide constructive feedback to learners, three aspects were explored, namely, the teachers' epistemological and ontological paradigms; the alignment between learning standards, assessment and instruction; and teacher training

6.2.2.1 The teachers' epistemological and ontological paradigms and how this may impact on pedagogical practices

Hattie and Timperley (2007:82) and Thalheilmer (2008:6), as discussed in 3.3.2.2 and 3.4, contend that feedback takes place after learners respond to initial instruction. It is therefore important to look at the instructional approaches to which the learners have to respond.

Both teachers admit to having a proclivity towards behaviorist approaches that involve transmission of knowledge, drill and practice and rote memorisation as posited by various authors (see 2.2.1). This is supported by data collected from classroom observations and an analysis of written documents.

An analysis of the data suggests that the teachers' methods are certainly not constructivist in nature. There is no evidence of learner collaboration and dialogue, active knowledge creation and the promotion of independent thinking, autonomy and initiative of learners that is central to the constructivist approach as discussed in 2.2.3. The lesson on tessellations in Teacher A's class as described in 5.3, is an indication of how the teacher taught a concept through transmission of knowledge. If a constructivist approach was followed learners would have been given the opportunity to engage in exploration and problem solving.

There is no evidence that the learners were encouraged to use any method that made the task easier for them. For example, Teacher B went to great lengths to drill the multiplication algorithm. An analysis of the learners' work in their books showed that Teacher A also experienced many problems in getting learners to understand multiplication by a two-digit number but did not consider changing this approach. This is indicative of the "conformity to established one-way methods" which Handal (2003:1) talks of, which is referred to in 2.2.1.

Despite Teacher A's attempts to incorporate visual aids into her lessons in order to simplify the content for the learners, her instructional approach was primarily behaviorist in nature. The teacher generally demonstrated a procedure in a step by step format and made use of a lot of "repetition and constant reinforcement" (Skinner 1954:94) (see 2.2.1). Teacher B made no use of any teaching aids or manipulatives other than the textbook.

The impact which the teachers' epistemological beliefs about the nature of mathematics learning had on their assessment practices (see various authors in 2.1), and the extent

to which they used feedback to improve learning is proven by the statement of both teachers when they were asked what limits them from providing learners with feedback. Teacher B said: "If a learner doesn't know we have to go back to it. If we are going to take that time to write in their books, they don't care, to them it's nothing … that time could be used to concentrate on whatever they couldn't understand". Teacher A said: "So if we're going to write remarks in their books they don't even read it … most of them got the multiplication wrong, so let us see how we gonna put it right. So we do remedial work (reteaching the work that the learners did not undertand)".

6.2.2.2 Alignment between learning standards, the contents of assessments and ongoing instruction

Biggs (2001:2; 2003:1) and Race, Brown and Smith (2005:12), as referred to in 3.4.3, state that the process of providing useful feedback to learners has to be supported by an alignment between the intended learning outcomes, the teaching and learning activities and the assessment tasks. If the feedback is not linked to the learners' demonstration of the intended outcomes they cannot learn from the feedback and use it to improve their learning. This study therefore examined the data to determine the extent to which these various components were aligned as this would impact on the teachers' ability to provide useful and constructive feedback to learners.

- ***Defining the Intended Learning Outcomes***

The research revealed that the teachers used the lesson plans and teaching guides provided by a publisher since they are a project school involved in piloting all the resources which are published. The intended learning outcomes were stated clearly in these documents and were based on the National Curriculum Statement. It did stipulate exactly what learners should be able to do to demonstrate their understanding, as suggested by Biggs (2003:2), discussed in 3.4.3. Although the lesson plans stipulated the Learning Outcomes and Assessment Standards targeted, the teachers did not analyse these to determine the teaching and learning activities that would result in the

achievement of these standards. Rather, the teachers had resorted to simplifying the intended learning outcomes and the subject content because they believed that the level was too high for their learners. This had obvious implications for the provision of feedback, as posited by Hattie and Timperley (2007:89), referred to in 3.3.2.4. If the feedback is not related to the intended outcomes it cannot serve to reduce the gap which learners' experience.

- ***The teaching and learning activities***

As discussed in 6.2.1.1, the teaching and learning activities in the classes of both Teacher A and Teacher B were characterised by traditional methods focused on the transmission of knowledge to learners and the decontextualised acquisition of knowledge, with very limited opportunity for social interaction and construction of mathematics.

- ***The extent to which assessment tasks reflect the intended learning outcomes***

The assessment tasks were all related to subject matter information. All of the assessment tasks in both classes were mainly focused on testing memorisation and rote skills as opposed to problem-solving strategies in real-life contexts that could have exposed their particular strengths and weaknesses, and which supports the assertions by Black and Wiliam (2008:4), Clarke (1992:2), Niss (1993:19) and Swan (1993:26) as referred to in 3.4.2.1. The assessment tasks also did not represent a broad range of assessment instruments which Biggs (2001:2) (see 3.4.3), asserts is needed in order to be aligned to the learning goals and to ongoing instruction.

None of the assessment tasks had pre-determined criteria against which learners responses were measured. Both teachers were adamant that the learners are not capable of understanding pre-determined criteria for achievement. Teacher A again attributed this to the "*language barrier*". The learners were therefore not provided with

the ongoing feedback about their progress and the opportunity to self-assess and revise their own work as suggested by Andrade and Du (2005), referred to in 3.3.2.4.

The teachers also revealed that they only plan the assessment once they have completed the lessons. The fact that the tasks were as a rule administered at the end of a particular session or at the end of the term (as stated by Teacher B) diminishes its usefulness for formative assessment as posited by Black and Wiliam (2008:8), referred to in 3.3.6.

- ***Arriving at a final grade***

The assessment practices of both teachers were typical of norm-referenced assessment as described by Lapp *et al*. (2007:75) referred to in 3.3.2.4. The learners' progress was measured quantitatively by calculating a total test mark. Furthermore, the test results were used to determine global achievement rather than to diagnose the learners' strengths and areas needing support. When asked what the test analysis conducted by the teachers at the end of each term entailed, Teacher B said: "*It tells us how many wrote, how many passed and how many failed*".

It would seem that the teachers' assessment practices were motivated by the need to generate marks for the end-of-term report card, as the following statement by Teacher B suggests: "…*so we do one monthly test and we do the term test. So that will be 25% of the marks and the other 75% comes from what the department requires for CASS*". The teachers' preference for using marks to communicate the learners' achievement as discussed in 5.5.3 is another indication that there was no alignment between the intended learning outcomes and assessment as suggested by Biggs (2003:4) discussed in 3.4.3.

The assessment practices of Teacher A and Teacher B are typical of traditional assessment practices which are "still rooted in philosophies of scientific measurement" described by Shepherd (2000:5), as discussed in 3.4.2.1. Teacher B clearly endorsed

this in the following statement: "…*basically I'm doing what I did at school, where the teacher would explain it, we would do it and we would be tested on it*".

Samples of the planning documents, the teaching and learning activities and the assessment of Teacher A were subsequently used to explore the extent to which there was alignment between the various components, by referring to the four steps which Biggs (2003:2) describes as necessary in setting up an aligned system of teaching, learning and assessment (referred to in 3.4.3). The samples relate to the drawing of bar graphs.

(a) Defining the Intended Learning Outcomes

The lesson plan which the teacher used as reference stipulated the intended Learning Outcome which is "Learning Outcome 5: Data Handling". It also stipulated the following assessment standards related to the learning outcome, as set out in the National Curriculum Statement: "Organises and records data using tallies and tables; Draws a variety of graphs to display data including bar graphs".

What should be noted here is that these assessment standards are preceded by the following two assessment standards in the National Curriculum Statement (DOE 2007b:56). "Poses simple questions about own school and family environment and identifies appropriate data sources in order to address human rights, social, political, cultural and environmental and economic issues in that environment" and "Collects data (alone and/or as a member of a group or team) in the classroom and school environment to answer questions posed by the teacher and the class". These were not stipulated in the teacher's lesson plan.

(b) The teaching and learning activities

In order to ensure alignment between the intended learning outcomes and the teaching and learning activities the learners should execute the verbs described in the assessment standards (Biggs 1999:64; Biggs 2003:2).

In the lesson that was observed, the teacher told the learners that they would be drawing a bar graph. The learners were then referred to the textbook to read data about the different modes of transport that learners use to commute to school. The teacher then demonstrated to the learners how to draw the bar graph using the data from the textbook. The learners were then required to draw the same bar graph on a grid provided by the teacher.

Taking into account the assessment standards that are stipulated in the teacher's lesson plan, the verbs which describe the learners intended performance (Biggs 2003:2) are "*organise* and *record* data and *draw* graphs". The assessment standards that are not stipulated require the learners to "*pose questions*, *identify* data sources, *collect* data and *answer questions*".

The researcher refers to the assessment standards that were not stipulated in the teacher's lesson plan in order to highlight how the design of lesson activities can result in "fragmented outcomes" as discussed by Biggs (1999:60), referred to in 3.4.3. Learning Outcome 5 represents a sequence of stages in a data handling cycle and learners should address the assessment standards as they work through a cycle and not individually. For example, they should identify a problem or situation and pose questions related to the problem, such as how learners commute to school. The learners should then collect data related to the problem. The learners should have been given the opportunity to do a survey in their classroom or in the school in order to collect this data. The assessment standards require the learners to organise the data using tallies and tables. The teacher could help learners to interpret the data by posing relevant questions. However, the teaching and learning activities that were executed in Teacher A's class only provided the opportunity for the learners to draw the bar graph, also only after the same graph was demonstrated by the teacher. The teacher's design of teaching and learning activities therefore reflects the "surface approach" described by Biggs (1999:60), referred to in 3.4.3.

(c) The extent to which assessment tasks reflect the intended learning outcomes

The activity used to assess the learners' understanding was similar to the activity which the learners completed in class. The learners were given a set of data and were required to draw the bar graph on a grid provided by the teacher. The drawing of the bar graph formed one of the questions of a broader task. The assessment task therefore did not reflect the intended learning outcomes as suggested by Biggs (2003:5). The activity that formed part of the assessment task was the following:

Complete the bar graph:

cats	dogs	sheep	cows
6	5	2	4

6				
5				
4				
3				
2				
1				
0				
	cats	dogs	sheep	cows

A group project would be a more appropriate assessment task aligned to the intended learning outcomes. The project could require learners to find and discuss a question to investigate; collect information from the learners at the school or in the classroom by using a simple questionnaire; organise and record the group's results using either tallies or tables. As an individual activity the learners could represent the data on a bar graph. They could also refer to their graph and include a paragraph on the most important findings of their investigation and answer questions and recommend possible actions and solutions based on their findings. Pre-determined assessment criteria based on the intended assessment standards would be used to assess the learners' understanding.

(d) Arriving at a final grade

The teacher awarded a mark for every bar drawn correctly. The teacher therefore awarded a total of 4 marks for the bar graph activity. These marks were then added to the rest of the marks awarded for the other questions in the test in order to arrive at a final grade.

The intended assessment standards require the learners to demonstrate various skills. It also involves critical outcomes such as identifying and solving problems; using critical and creative thinking and organising and managing themselves effectively. It would therefore be more appropriate to make holistic judgements by using specified criteria as suggested by Biggs (2003:5), as referred to in 3.4.3.

A learner who correctly completed the bar graph on the grid provided would be awarded full marks for the activity. This would create the impression that the learner had achieved the intended learning outcome when in fact, taking into account the teaching, learning and assessment activities, the learner had only demonstrated achievement at the lowest level described by Biggs (1999:65), referred to in 3.4.3 and illustrated in figure 3.7.

The example indicated that there is no alignment between the intended learning outcomes, the teaching and learning activities and the assessment tasks. An analysis of Teacher B's documents revealed similar findings, as could be expected given the teacher's proclivity towards teaching and learning activities that mainly involve drill and practice of routine activities. The findings were consistent with the teachers' responses to interview questions pertaining to an aligned system (see 5.5.5). Therefore, feedback cannot be linked to learner evidence that demonstrates achievement of the intended learning outcomes as posited by Race, Brown and Smith (2005:13), referred to in 3.4.3.

6.2.2.3 The pre- and in-service teacher training received

The fact that the teachers have not had any pre- or in-service training in either teaching methodologies related to mathematics or how to use various feedback strategies to improve learners' performance in mathematics, or any learning area for that matter, has major implications for the teachers' ability to employ a range of appropriate teaching methodologies and assessment practices; and to create sound instructional and learning environments which facilitates the provision of feedback. The claim by Stiggins (2008a:7) that professional development is "nearly non-existent", as discussed in 3.4.2.1, is endorsed by these teachers who indicated that they had not attended any mathematics workshops or received any in-class support for the duration of the year. The call for pre- and in-service professional development is echoed by the ARG (2006:12), Stiggins (2008a:7) and the DOE (2009a:55) as referred to in 3.4.2.1. The ramifications of this lack of ongoing professional development and support is obvious from Teacher A's statement when she says that "*We're just basically feeling our way here*".

6.2.3 The contextual realities at classroom and school level

In its report the 2009 Task Team for the Review of the Implementation of the National Curriculum Statement concludes that "the conditions under which teachers work is central to their ability to enact the curriculum" (DOE 2009a:58). This section provides relevant information about the community at large, the school demographics, classroom characteristics as well as the social and economic factors pertaining to the study.

6.2.3.1 Teacher Profiles

The fact that both these teachers are not qualified to teach mathematics in the grades that they are currently teaching impacts not only on the way that they deliver the curriculum, but also on the self-confidence of the teachers to deal with the type of

classroom environment which facilitates the effective provision of feedback as discussed in 3.3.4 and 3.4.2.1.

This is the impression created by both teachers given their responses to a question asking whether they believe they have the necessary expertise as a mathematics teacher to manage problem-solving activities in their classes. Teacher A said: "*With me it's a first experience, right. As I said I am a foundation phase teacher, this is the first time that I am teaching maths, so I battle a bit, you know, I do what I feel will help the children. And the fact that I have grade 4, it's a step on from grade 3 so I use methods that I used to use in grade 3*" and Teacher B said: "*As ma'am says she's a first time, likewise I'm also a first time. So I'm still coming to terms with how to get these learners to do the work*".

Teacher A admitted that she is at a disadvantage because she had been trained in the Foundation Phase and now has to teach in the Intermediate Phase. Both teachers indicated that they felt that they lacked knowledge and skills related to teaching methodologies related to mathematics.

This is endorsed by numerous literature studies, for example Cai *et al*. (2005:218) and Fae Ho *et al.* (2005:239) as discussed in 2.3.2.3, and Black and Wiliam (1998:7) and Easley and Taylor (1990:225) as referred to in 3.3.4.

In the following section issues pertaining to the home language and the socio-economic background of the learners are identified as contextual factors that have bearing on the phenomenon. These factors were not discussed in the literature review given that the researcher had no knowledge about the contextual aspects relevant to the school and the school environment prior to the empirical investigation. The empirical investigation revealed that these factors have a significant impact on the phenomena being explored. It is therefore imperative to address these issues by referring to relevant literature studies in order to reflect on the impact they may have on the teachers' ability to provide constructive feedback to learners.

6.2.3.2 The home language of the learners versus the language of learning and teaching

Data from the interview with the school principal revealed that the majority of the learners speak isiZulu as a home language while the language of learning and teaching at the school is English. Of the sixteen teachers at the school, five teachers are able to speak the home language of the learners.

The teachers in the study attributed most of the problems they experience in teaching the learners to the "*language barrier*" of their learners. In their responses to questions the teachers repeatedly cited the language issue as a reason for the limited opportunities provided for learners to have classroom discussions about mathematics, the use of group work, the provision of corrective feedback to learners and the engagement of learners in peer- and self-assessment.

The teachers' concerns are relevant considering the assertions by Fleisch (2008:100) that research studies are unanimous in its conclusion that there is a distinct correlation between under-achievement and being taught and assessed in a second or additional language. Taylor, Muller and Vinjevold (2003:54) concur stating that "[i]t is highly probable that the difficulties associated with studying in a language other than one's home language are more pronounced in subjects like maths and science, which are strongly dependent on technical languages". This is endorsed by a study conducted by Howie (2005:128), analysing the performance of the South African students in mathematics in the Third International Mathematics and Science Study-1999. The study concluded that learners from schools in urban communities and learners from schools where the learners speak the medium of instruction at home are more likely to fare better in mathematics. The Task Team for the Review of the Implementation of the *National Curriculum Statement* in its report (DOE 2009a:14) also highlight the fact that learners changing from their home language in grade 3 to the language of learning and teaching in grade 4, are ill-prepared for the change.

6.2.3.3 Socio-economic background of the learners

According to the school principal the majority of the learners at the school come from a poor socio-economic background. Because of the socio-economic status of the community, parental involvement at the school is low. The principal indicated that attendance at school meetings is very poor and says: "*We don't have their co-operation with regards to that* [school meetings]". Only approximately 25% of the parents assist learners with their schoolwork at home. The principal explained it as follows: "*The majority of our learners are from historically disadvantaged backgrounds and quite a large percentage of them are taken care of by grannies and because of these backgrounds they themselves are not equipped to assist learners at home*".

Fleisch (2008:60) identifies a definite correlation between poverty and under-achievement of learners. He attributes this to the "socialisation and enculturation that takes place inside the home". This includes the way that language is used in the home and the form that conversation takes, how reading is modeled and access to other educational resources such as computers.

In a summary of the results of the OECD's Programme for International Student Assessment (PISA) (OECD 2004:165) they conclude that although poor performance in school does not automatically follow from a disadvantaged home background, home background remains one of the most powerful factors influencing performance. They also point out that there is a significant relationship between parental occupational status and parental involvement and children's academic success.

These contextual factors certainly impact on the provision of feedback to learners. A language barrier and the constraints of a disadvantaged home background has a negative effect on the learners' ability to effectively engage in classroom discourse, the linguistic skill to proficiently express higher order levels of thinking and the ability to understand feedback from the teacher. It also makes it difficult for teachers to effectively use language to convey mathematical ideas to learners.

6.3 CONCLUSION

In this chapter, data drawn from field notes and transcriptions of interviews and audio recordings of lessons were analysed to construct a descriptive model of the classroom context in terms of the feedback strategies employed by teachers, the ability of teachers to provide effective feedback and the contextual factors which have an effect on the teachers' ability to provide feedback. As already alluded to in 1.6, an exploratory and descriptive approach was followed in the investigation.

As the analysis of observations and interviews progressed, it became apparent that the teachers involved in the study were employing very little feedback strategies in their classrooms. In the instances where the teachers provided feedback to the learners, it was done without much forethought or planning and was mainly related to feedback at the self level as described by Hattie and Timperley (2007:90), as referred to in 3.3.1.2. Consequently, the study used samples of the learners' work to illustrate possible ways in which verbal and written feedback can be provided to focus learners' attention on the misconceptions they hold and help them to close the gap.

The research highlighted key factors that either facilitate or impact negatively on the provision of feedback to learners. It also reflected on the contextual realities that teachers have to contend with, which impede the effective provision of feedback. Hence, the following chapter will provide recommendations pertaining to the effective provision of feedback to learners. These recommendations can be linked to the fifth general aim and research objective: provide recommendations aimed at developing teachers' competence in providing constructive feedback to learners.

7

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

The main focus of Chapter 7 is to draw conclusions based on the literature study and the research findings and to make recommendations aimed at developing teachers' competence in providing constructive feedback to learners.

The general aim of the research was to explore, from a theoretical and practical perspective, the use of constructive feedback to enhance learner performance in a mathematics classroom context (see 1.3). The general aim of the study was partly achieved through a review of literature on learning theories, trends in mathematics teaching and learning and the use of constructive feedback for enhancing learner performance (see chapters 2 & 3). It provided the background around which the data collection strategy was designed (see 5.4).

The empirical study that was undertaken offered a practical perspective on the use of constructive feedback to enhance learner performance in mathematics in a classroom context. Qualitative research methods within a constructivist paradigm were used in conducting the research (see 1.6). The data collection methods used in this study are observations, interviews and an analysis of documents. Details about the data collection strategy are outlined in 4.6. Data from these sources were presented and analysed in Chapter 5 and Chapter 6.

The literature review in conjunction with the empirical investigation was conducted with the purpose of achieving the following objectives:

- Review existing research into learning theories, trends in mathematics education and the use of constructive feedback as a way of improving learning and raising standards.

- Examine and evaluate evidence of feedback strategies used in a mathematics classroom context.

- Reflect on the factors that impact on the ability of teachers to provide constructive feedback to learners to enhance learner performance in Mathematics.

- Determine the contextual realities at classroom level that may impede the use of constructive feedback to enhance learning.

- Provide recommendations aimed at developing teachers' competence in providing constructive feedback to learners.

7.2 CONCLUSIONS FROM THE LITERATURE STUDY

7.2.1 Learning Theories

Literature studies are in concurrence that the teaching and learning of mathematics has evolved from the behaviorist practice of knowledge transmission and the attainment of concepts and procedures through drill and practice to that of active knowledge construction. Furthermore, the social and cultural aspect of learning is emphasised as being integral to conceptual development. Language as a cultural tool during social interaction is also recognised as a major contributor to the level of conceptual understanding that learners are able to attain (see 2.1 & 2.2).

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The active interaction and meaningful discourse associated with a social constructivist

approach leads to the conclusion that a social constructivist learning environment facilitates the provision of feedback to learners.

7.2.2 Trends in Mathematics Teaching and Learning

Conclusions from literature is that there is a radical change in traditional mathematics teaching and learning practices. The study highlighted particular trends in mathematics teaching and learning which various studies regard as integral to creating effective teaching and learning environments. These include active knowledge construction; a focus on mathematical reasoning and problem-solving skills and attitudes ; the use of heuristic procedures; the application of mathematics in real-life contexts; and the acquisition of metacognitive attributes and skills (see 2.3).

7.2.3 Characteristics of Constructive Feedback to Learners

Formative assessment serves to gather information to support the learner's development (see 3.2). This information is used by teachers to provide learners with constructive guidance in order to enhance their learning. Thus the research concludes that providing feedback to learners is central to the process of formative assessment.

The research highlights various aspects which have an effect on the quality of the feedback provided to learners. The research concludes that some feedback is more effective than others at reducing the gap between the learners' current understanding and the intended goal. Therefore the level at which feedback is directed determines its efficacy (see 3.3.1.1 & 3.3.1.2). Furthermore, for feedback to be effective it should aim to correct misconceptions and provide learners with specific corrective information (see 3.3.2.1).

In all feedback processes the learner should be given the opportunity to demonstrate understanding of the feedback by using the feedback to improve on prior performance (see 3.3.2.2).

Literature evidence (see 3.3.2.3) led to the conclusion that there is no consensus regarding the timing of feedback. Valuable arguments can be made for providing feedback immediately as well as for delaying feedback, depending on the context in which the feedback is provided.

Section 3.3.2.4 is conclusive in that feedback cannot be effective if learners do not have an understanding of the goal. Teachers should provide learners with clear pre-determined criteria for achievement.

Evidence from literature in section 3.3.3 suggests that self-regulated behaviour is associated with academic achievement and improved learning.

Creating opportunities for meaningful classroom discourse supports formative assessment, facilitates feedback to learners and allows learners to conceptualise their own understanding. Conclusions from the literature review suggests that, at the time of writing, the majority of teachers struggle to effectively facilitate classroom dialogue (see 3.3.4).

Section 3.3.5 recommends a variety of strategies that teachers can use to provide feedback to learners. The study identifies class work and homework exercises, journal writing, classroom discussion, observation of classroom activities, the marking of written work and report cards as some of the avenues that teachers can utilise to provide feedback to learners.

The study is conclusive that only providing learners with grades and external rewards has no learning benefits provided it is accompanied by feedback about the task that identifies incorrect mental models and corrects misconceptions (see 3.3.6).

Literature evidence from sections 3.4.1 and 3.4.2 proposes that for feedback to be effective it should be supported by sound classroom instruction and assessment

practices. The study identifies co-operative group work and whole class teaching as examples of teaching strategies that promotes the provision of feedback to learners.

It also concludes that the assessment strategies that teachers employ are still reminiscent of traditional methods based on scientific measurement, focused on memorisation and regurgitation of facts with the aim of grading learners summatively.

The study points to the importance of constructive alignment between all components in the curriculum - the intended outcomes, the teaching methods used and the assessment tasks - wherein all the components have the same objective. It is therefore concluded that an aligned system is needed for learners to receive constructive feedback pertaining to their achievement of the intended outcomes (see 3.4.3).

The conclusions presented here address the first objective of the study, which is to review existing research into learning theories, trends in mathematics education and the use of constructive feedback as a way of improving learning and raising standards. The next section provides conclusions deduced from the empirical research.

7.3 CONCLUSIONS FROM THE EMPIRICAL RESEARCH

7.3.1 Conclusions related to the evidence of feedback strategies used in a mathematics classroom context

This section draws conclusions on how the learning environment created for learners influenced the feedback provided by the teachers and reflects on the evidence of verbal and written feedback provided to learners.

Empirical evidence supports the literature conclusions that the classroom environment created by teachers has major implications for the provision of feedback to learners. The study concludes that the lack of dialogue and meaningful classroom discussion in both these classes hampers the adequate and effective provision of feedback to

learners, as discussed in sections 5.3, 5.5.2 and 6.2.1.1). There is no doubt that the teachers' contentions regarding the difficulty they experience in trying to facilitate meaningful classroom dialogue is true. However, it is also evident from these two case studies that avoiding classroom dialogue in order to ensure that the lesson proceeds smoothly has no benefits for learners or teachers. Numerous literature studies (see 3.5.3) are all in agreement that it remains the responsibility of the teacher to establish a classroom climate which encourages collaborative dialogue and meaningful negotiation of mathematics knowledge and skills. It is concluded that the teaching methodologies, approaches and strategies used by the teachers need to be improved upon to create a learning environment that supports the provision of feedback to learners.

The tendency to use mainly "low level questions" is certainly not limited to these two teachers considering the claims of Cooney, Badger and Wilson (1993:240) referred to in 3.3.5. Based on the teachers responses in interviews it could be argued that the assertions by Black and Wiliam (1998:7), as highlighted in 3.3.5, that many teachers use closed-ended questions that will result in specific answers because they lack the "flexibility or the confidence" to deal with unconventional responses from learners, rings true for these two teachers (see 6.2.1.1). The observations confirmed assertions in literature (see 3.3.4) that the teachers' focus on low level questions that only required recall of facts and procedures, and their ineffective application of wait time, resulted in limited opportunities for meaningful classroom discourse. The teachers subsequently had very little opportunity to guide learners in the right direction through ongoing feedback.

The study found that, in respect of using group work as a teaching strategy, the teachers have moved away from this practice altogether, as discussed in 6.2.1.1. Given the importance of social interaction and classroom talk for the provision of feedback as espoused in the literature (see 2.2.3., 3.3.5, 3.4.1.1), this does not bode well for the use of feedback as a teaching and learning strategy.

The teachers' responses to questions pertaining to teaching through problem-solving, as well as the fact that evidence from classroom observations point to a classroom culture that does not support the development of efficient and effective problem-solving strategies, leads to the conclusion that the teaching of mathemtics through problem-solving is challenging for these two teachers, as discussed in 6.2.1.1. Literature studies (see 2.3.2) advocate that efficient problem-solving skills involve metacognitive and self-regulatory activities that are essential for learners to process external feedback. This leads to the conclusion that the limited opportunities created for these learners to develop sound problem-solving skills inhibit their ability to process any feedback they receive.

The document analysis and classroom observations revealed very little evidence of verbal and written feedback to learners. Both teachers appeared to have little knowledge and understanding of the value of feedback to learners given the scant evidence of verbal and written feedback. The teachers' comments indicate that they had resolved that the learners would not understand the feedback.

The teachers' responses to interview questions create the impression that they do not give much thought to analysing the learners' work to identify the misconceptions that they hold, as discussed in 6.2.1.2. Analysis of the leaners' books also gives no indication of feedback based on correcting learners' misconceptions. Given the teachers' responses to interview questions it coud be concluded that the fact that they have not been trained in this skill and they do not have the necessary expertise and experience in mathematics, offers some explanation of why they neglect this important aspect needed to provide corrective feedback to learners (see 3.3.2.1).

Responses to interview questions leads to the conclusion that both the teachers believe that allocating marks are the best means of providing feedback to learners because "*words are not so meaningful to them*" (see 6.2.1.2). Their views substantiate the fact that there is no evidence of written feedback or comment in the learners' books, other than occasional words of praise accompanied by stickers.

Literature studies (see 3.3.3) suggest that in order for learners to evaluate their own progress and respond to feedback they need to have a clear understanding of the desired goal or targets. The classroom observations revealed that the teachers in this study generally do not communicate the expected standards to the learners prior to lessons (see 5.3 and 6.2.1.2). It could be regarded as one of the reasons why their feedback was not related to the task, process or self-regulatory level.

7.3.2 Conclusions related to the factors that impact on the ability of teachers to provide constructive feedback to learners to enhance learner performance in Mathematics

This section deduces the effect of the teachers' beliefs about how mathematical knowledge is acquired, the extent to which there is alignment between the components of the curriculum, and the frequency and quality of teacher training on their ability to provide constructive feedback to learners.

In responses to interview questions, the teachers acknowledge that they are not very confident about their own expertise in mathematics and their ability to manage problem-solving activities in the class, as discussed in 5.5.1. This corroborates findings from literature studies (see 2.3.2.3), that the shortcomings in teachers' mathematical knowledge, whether actual or perceived, results in them embracing traditional teaching approaches which focus on rote memorisation, drill and practice. Given the assertions by Hargreaves, McCallum and Gipps (2000:30), referred to in 2.1, regarding the correlation between teachers' epistemological paradigms and their feedback strategies, it could be concluded that these two teachers' feedback strategies are a reflection of their teaching and assessment strategies.

Empirical research from section 6.2.2.2 confirms that in the teachers' classes the teaching and learning activities and the assessment are not aligned to the intended learning outcomes (which are described in the Mathematics Curriculum Statement). This supports literature studies (see 3.4.3) that assert that a system that is not aligned

impacts negatively on the teachers' ability to provide feedback to learners that is linked to their achievement of the intended learning outcomes.

One of the key findings reported in this study is that the training of teachers on the NCS did not include training in different instructional approaches or assessment and feedback practices, as discussed in 5.5.6). Furthermore pre-service training of student teachers leave novice teachers ill-prepared for handling classroom situations and in-service training is nearly non-existent. This is despite the literature (see 3.4.2.1 & 3.4.2.1) pointing to such training as being extremely important.

7.3.3 Conclusions related to the contextual realities at classroom and school level

Conclusions related to the extent to which contextual factors (such as the qualifications and teaching experience of the teachers involved in the study, the home language and the socio-economic background of the learners) hamper the effective provision of feedback to learners, are presented in this section.

The literature study did not specifically examine the effect of teachers' qualifications and experience in the teaching of mathematics on their ability to provide feedback to learners. However, both these teachers, in their responses to interview questions, allude to there lack of training and experience in mathematics teaching as reasons why they do not have the necessary expertise as a mathematics teacher to manage problem-solving activities in the class, to utilise different teaching methodologies, to employ various assessment strategies, as well as for their lack of knowledge about effective feedback strategies (see 5.5.6). Given that the conclusions from the literature review indicate that these aspects impact on the effective provision of feedback to learners, the research concludes that the profile of both teachers, in terms of their qualifications and experience in mathematics teaching, impacts on their ability to create and manage a classroom environment that facilitates the provision of feedback to learners.

7.3.3.1 The home language of the learners

The problems that many teachers experience in teaching second language learners are widely documented (see 6.3). The study concludes that the fact that the home language of the learners differs from the language of teaching and learning severely hampers the teachers' ability to effectively provide constructive feedback to learners, given that the effective provision of feedback is supported by a classroom environment that fosters active engagement and meaningful classroom discourse. Nonetheless teachers cannot simply succumb to despair. The teachers and the school as a whole have a responsibility to devise ingenious strategies to address this problem.

7.3.3.2 Socio-economic background of the learners

Based on the findings presented by literature studies (see 6.3), the study concludes that the low socio-economic status of the learners at this school could definitely be regarded as a factor that impedes the provision of feedback to learners and the learners' ability to use the feedback to monitor their own progress and alter the learning gap.

7.4 RECOMMENDATIONS FOR CONSTRUCTIVE TEACHER FEEDBACK TO ENHANCE LEARNER PERFORMANCE IN MATHEMATICS

Based on the findings from the empirical investigation, the research proposes that the teachers' limited use of feedback to learners as a way of improving their performance in mathematics can only be addressed through a comprehensive professional development programme that includes all the aspects which inevitably have bearing on the effective provision of feedback as discussed in Chapter two and Chapter three.

Important aspects related to feedback to be included in a professional development programme are the following:

- A shift in paradigm from defining mathematics learning as the passive and decontextualised acquisition of concepts and procedures to being defined as the active construction of meaning. If teachers do not make this paradigm shift, any subsequent training will be futile (see 2.1 & 2.2.3).

- Creating a classroom environment where social interaction and meaningful discourse and sharing of ideas are common place. Teachers need to be trained on how to manage classroom discourse, their role as facilitators of classroom discussion, and the dynamics of group work and whole class teaching, while still ensuring the learners' cognitive development. Emphasis should be placed on both constructive processes and the mathematical content (see 2.2.3.1, 3.3.4 & 3.4.1).

- Creating a learning environment that allows learners to construct knowledge and teaching through problem-solving in real-life contexts (see 2.3.1 & 2.3.2).

- Feedback Strategies – This should include the following:

    - The different levels at which feedback can be focused. Teachers should be made aware of the limited learning benefits which feedback at the self level contains, since this is the feedback which they use most often and sometimes exclusively (see 3.3.1.2, 6.2.1.2).

    - Providing corrective feedback to learners. A training programme should include samples of learners' work and teachers should be guided on how to diagnose learners' misconceptions and how to provide corrective feedback (3.3.2.1, 6.2.1.2).

    - Communicating the intended learning outcomes to learners. This should involve more than just writing the topic on the board or mentioning the topic matter-of-factly. Teachers should make it an everyday part of the

lesson to discuss with learners what they need to learn and be able to do. Complicated learning standards should not be repeated verbatim but should be simplified to the level of the learners. Teachers should also receive guidance on developing criterion-referenced rubrics related to the intended learning outcomes (see 3.3.2.4 & 6.2.1.2).

- Engaging learners in self-assessment, the design and use of self-assessment rubrics for learners and other strategies which promote self-regulatory processes in learners (see 3.3.3).

- Teachers should be capacitated in the use of various strategies to provide feedback to learners, for example, classroom discussion, analysing test results to serve formative purposes, class work and homework exercises, keeping of journals, report cards and so forth (see 3.3.5 & 6.2.1.2).

- The use of assessment strategies that is compatible with the use of socio-constructivist approaches to teaching. Teachers also need specific training on the design of a broader range of assessment instruments and the design of assessment items based on problem-solving strategies in real-life contexts (3.4.2 & 6.2.2.2).

- Teachers should be guided on how to plan for assessment as part of teaching and learning. The significance of ensuring that there is constructive alignment between the intended learning outcomes, the teaching and learning activities, the contents of assessment and feedback should be strongly emphasised (3.4.3, 6.2.2.2).

- The researcher recommends that professional development programmes should be rooted in support at the classroom level. Teachers should be guided and supported as they learn in the setting of their classrooms. Subject advisers, who are mathematics specialists, should spend time

with teachers in their classrooms, observing, coaching and mentoring them. Professional development should be an ongoing process rather than comprise of random workshops.

7.5 RECOMMENDATIONS FOR INITIATIVES TO BE IMPLEMENTED IN ORDER TO FACILITATE THE PROVISION OF CONSTRUCTIVE FEEDBACK TO LEARNERS TO ENHANCE THEIR PERFORMANCE IN MATHEMATICS

- The study recommends that the national department of education and provincial education departments begin to prioritise the promotion and development of formative assessment in schools. The study echoes the sentiments of Stiggins (2008:2) and calls for equal emphasis and allocation of resources to ensure a balance between formative and summative assessment and between large-scale and classroom assessments.

- The research again highlights the correlation between under-achievement and being taught and assessed in a second or additional language, particularly in subjects like mathematics and science. Hence, it is imperative that issues of language receive urgent attention. The study reiterates the call of the Task Team for the Review of the Implementation of the *National Curriculum Statement* (DOE 2009:42) and recommends that the official policy regarding the teaching of languages be clarified and communicated to teachers and that teachers are supported in implementing language policy in their classrooms.

- Student teacher training at teachers colleges and at universities must provide more opportunities for prospective teachers to gain experience in classroom practice. Student teachers should spend an extended period in the classroom under the guidance of an experienced teacher and subject specialists before being allowed to graduate. Attention must be given to acquiring professional knowledge and skills related to different teaching methodologies and assessment

methods and the use of assessment for formative purposes, which should include the provision of feedback to learners.

7.6 RECOMMENDATIONS FOR FURTHER RESEARCH

The literature study suggests that teachers' belief systems about the nature of mathematical understanding will impact on their pedagogical practices; and that their beliefs about learning determine whether the assessment strategies they employ serves formative purposes, as discussed in 2.1. The data collected from classroom observations and an analysis of written documents, reveals that the two participants in this study have a proclivity towards behaviorist approaches that involve transmission of knowledge, drill and practice and rote memorisation, as discussed in 5.5. This will impact on the extent to which they use effective feedback strategies. An important area that could be addressed in future research projects is whether this is indicative of the paradigms of most mathematics teachers, and if so, can these teachers still provide effective feedback to learners to enhance their learning of mathematics.

The empirical investigation revealed that certain contextual factors may impact negatively on the effective provision of feedback to learners as well as on the learners' ability to synthesise the feedback (see 6.2.3). Future research studies could focus on finding classroom-based evidence of teachers who are successfully implementing feedback strategies despite these contextual factors. These successful cases can serve as models of good practice for all teachers.

The effective provision of feedback to learners is supported by a classroom environment that fosters active engagement and meaningful discussion, as discussed in 2.2.3.1 and 5.5.2. The study alludes to the fact that the participants in this study have not had any pre- or in-service training in either teaching methodologies related to mathematics or the creation of sound instructional and learning environments which facilitates the provision of feedback (see 6.2.1.1). Hence, an important issue that should be followed up is

whether teacher training prepares novice teachers for managing an interactive teaching and learning environment that facilitates the effective provision of feedback to learners.

7.7 CONCLUSION

This study highlights the participants' limited and inadequate use of constructive feedback strategies to enhance learning in mathematics. It confirms that in order to enhance constructive feedback to learners, it is imperative that the teachers make a paradigm shift away from a teacher-centred educational approach towards a dynamic and active learner-centred approach. Significant changes in their classroom practice are needed if they are to improve the feedback between teacher and learners. They need to structure learning environments that support collaborative problem-solving and construction of mathematical knowledge and offers ample opportunity for classroom discourse.

The research does not propose that the practices of these two teachers are representative of the practices of all teachers in South Africa. However, it is believed that these two examples provide classroom-based evidence of feedback strategies implemented in classrooms. It offers empirical research that documents the changes to classroom practice which are needed for feedback to be successful. Furthermore, it reflects on the contextual realities that impede the use of constructive feedback to learners, which extends beyond these two classrooms and is undoubtedly applicable to many other classrooms in South Africa. While this study does not make any recommendations to this effect, it recognises the impact that certain contextual realities, particularly the language issue and the socio-economic background of learners in this case, may have on the delivery of the curriculum at large and specifically on the effective provision of feedback to learners.

In South Africa, the Department of Education and the national government has been vigorous in making changes and implementing reform campaigns in pursuit of raising learner performance in Mathematics. This study endorses the notion that the use of

effective and constructive feedback strategies that is properly planned and structured, and is supported by and aligned to a dynamic teaching and learning environment and sound assessment practices, would result in improved learner performance in mathematics.

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APPENDIX A

UNSTRUCTURED INTERVIEW FORMAT

PLANNING AND PREPARATION FOR QUALITATIVE INTERVIEWING

RESEARCH OBJECTIVES:

1. **Evidence of feedback strategies used in a mathematics classroom context**
2. **Factors that impact on the ability of teachers to provide constructive feedback to learners to enhance learner performance in Mathematics**
3. **Contextual realities at classroom level that may impede the use of constructive feedback to enhance learning**

1.1 (a) Effective communication and classroom discourse

(b) Assessment strategies employed by the teacher and the use of formative assessment

(c) Self- and Peer-Assessment

2.1 (a) The teachers' pedagogical practices

(b) Alignment between assessments, learning standards and instruction

(c) Teacher training

3.1 (a) Situation analysis – Predominant culture and home language of learners / socio-economic status / the profile of the school / training of teachers

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1.1 (a)

(i) Opportunity for meaningful discussion and debate in solving problems / Opportunity to explain the strategies used to solve problems/answer questions / Role of the teacher as facilitator [probe: is it easy or difficult for you to manage such situations in the class] / Do you allow time for learners to work in groups to discuss problems/questions / Do you encourage them to present their solutions to the class.

(i) Feedback to learners – how are learners informed about their progress toward understanding a particular standard/ learning outcome /topic / concept / Other than test scores, how do you provide feedback to your learners about their progress / The use of written comments to provide feedback about their work / Examples of comments to learners

(ii) Diagnosing misconceptions [probe: how do you diagnose why the learner has made a mistake / How are learners informed about their shortcomings and how they can improve? [follow up: Does this normally entail doing the same or a similar problem/calculation / what do you expect learners to do after they are informed about their mistakes/misconceptions

(iii) Reporting to parents / Opinion on report cards according to The Revised National Curriculum Statement Grades R-9 - description of the strengths, developmental needs, or areas of support required by the learner, linked to the Learning Outcomes and Assessment Standards. [follow up: Is this the way you report in learners report cards]

1.1 (b)

(i) How do you gather information about your learners' progress [follow up: what types of assessment methods or strategies do you use [probe: (through tests, assignments, observation, projects, investigations?) /are there any particular

methods of assessment that you prefer / Teachers opinion on most effective way to assess learners / use of informal activities such as questioning, observation and informal discussion as a means of assessing learners' progress? / If you do these activities, what do you do with the information you gather / do you ever use the information you gather from these activities to report on the learners' progress / If you do these activities, do you ever use the information you gather from these activities to provide feedback to learners on their strengths and the areas for improvement / teacher's assessment practices aligned to outcomes-based education?

(ii) At what stage of a lesson or series of lessons do you (formally) assess learners work [for example, at the beginning, during the course of the lessons or at the end when the chapter is completed] / frequency of assessment

(iii) What do you with the results of a learner's formal assessment [follow up: How do you use the information you glean from the learners results / [probe] analysis of learners' results / do you ever analyse results of an assessment task and then adapt your teaching based on your analysis / are learners ever given the opportunity to redo an assessment after a result is awarded or after you check the work and give feedback [follow up: if yes, how do you manage this process / if no, explain why is this not part of your assessment practice]

1.1 (c)

(i) Opportunities for self-assessment in mathematics [follow up: How do you prepare learners beforehand if they are to do self-assessment [probe: do learners know beforehand what they should be looking for when they assess themselves? How do you ensure this?] / Self-assessment: are learners provided with a set of criteria against which they can assess their own work / How do you ensure that they understand the criteria before assessing their own work / Do you find it difficult to formulate clear criteria to provide learners with so that they can assess themselves / Value of learners doing self-assessment (do you think it is important for learners to do or not? / Use of self-assessment results [probe: Do you ever discuss with learners the

results of their self-assessment [follow up: if not, are there any specific reasons why you do not]

(ii) Opportunities for peer assessment / managing peer assessment in class / how do learners respond to peer assessment [probe: do they enjoy it, do they feel intimidated, embarrassed? / preparing learners for peer assessment

2.1 (a)

(i) How do you think learners learn mathematics concepts best [probe: if you should teach learners a particular concept, explain how you would approach it for learners to be able to learn about that concept / Opinion on teaching learners through demonstrating fixed procedures/ algorithms, and practicing procedures / Opinion on learning through exploration, inquiry and discovery in social / group contexts

(ii) What is your idea of what problem-solving is in Mathematics / To what extent is problem-solving feature in your lessons [probe: are learners given ample opportunity to solve problems / How successful are your lessons when you focus on problem-solving / Multiple methods/strategies for solving problems / Do you teach learners certain strategies to solve problems or do you leave them to solve problems according to their own methods / Expertise as a mathematics teacher to manage problem solving activities in lessons

(iii) Use of real-life contexts in mathematics lessons / How do you teach concepts such as basic operations (addition, subtraction, multiplication, division) / Focus mainly on teaching math concepts out of context or connect math concepts to everyday experiences / [follow up: if not, what are the reasons for not relating math concepts to real-life experiences] / Have you ever received training on different teaching methodologies including the discovery and inquiry methods of teaching?

2.1 (b)

(i) What informs the teaching methods you will use to teach learners what you want them to learn [follow up: Do you have clear objectives about what you want learners to learn and be able to do [Los and ASs?] / When you plan your lessons do you write out exactly what it is the learners should be able to do to demonstrate their understanding / Analysis of LOs and ASs in order to decide on the teaching and learning activities / When do you plan for assessment [follow up: Do you plan for assessment when planning your lessons or do you develop assessment activities after you complete a lesson or series of lessons / How do you decide what your assessment will be based on [follow up – do you ensure that the LO's and AS's are reflected in the assessment tasks] / When planning your lessons and assessment, do you plan how learners will receive feedback on their progress (will they be given test scores, written comment, discussions, interviews etc)

2.1 (c)

(i) Pre- or in-service training on the provision of feedback to learners in order to improve their learning / Has the topic on feedback ever been a part of any curriculum training you have received in the past? / When was the last time you attended a mathematics workshop [what was the purpose of the workshop] / when was the last time the subject adviser visited your class to give you support?

3.1 (a)

(ii) In what year was the school established? / Status of the school prior to 1994 (DET / HOR / Model C)? / Which race or ethnic group did the school historically cater to? Is this still the case? / Language spoken by the majority of the teachers? / Home language of the majority of learners at the school? / How many teachers at the school are able to speak the home language of the learners? / Availability of resources / If not, what are the shortcomings? /

Availability of library and computer resources / Socio-economic background of the learners at the school? / Average learner-teacher ratio / Learners' achievement on external assessments? Do you have any evidence of learners' achievement on these tests? / Learners' achievements in Continuous (school-based) Assessment? / Parental involvement in terms of: (a) attendance of meetings or workshops (b) involvement with homework

SPECIFIC QUESTIONS NOT COVERED ELSEWHERE:

1. You are not formally qualified to teach Mathematics, do you think that this is a disadvantage to you seeing that you have to now teach mathematics?

2. What would you say are the main factors that impact on the frequency and the way that you provide feedback to learners?

APPENDIX B

FLOW CHART OF INTERVIEW

FLOW CHART OF INTERVIEW

Possible main structure	**Specific topics and issues – to be asked in relation to any of the main structure sections**
Introductory explanation ↓	
Assurance of confidentiality ↓	
Brief academic and professional profile ↓	
The teacher's epistemological and ontological paradigm ↓	Teaching methodology / learner-centred approach / problem- solving / heuristics for problem-solving / real-life contexts / training received
Creating learning environments for social interaction and effective ↓	Opportunity for discussion and debate / group work and presentation/ management of classroom discourse / Providing communication feedback to learners about their progress / determine the possible misconceptions / reporting to parents
Self-regulated behavior ↓	Self-Assessment / criteria / value / results of self-assessment/ management of peer assessment / learner response to peer assessment
The use of formative assessment ↓	Types of assessment methods and strategies / preference of teacher / informal assessment / use of informal assessment results / outcomes-based assessment Formal assessment – when, how often? / Formal assessment results – use, analysis, feedback to learners
Alignment between standards, ↓	clear objectives for teaching (LOs & Ass) / Analysis of LOs and instruction and assessment ASs \ planning for assessment / feedback planned as part of assessment
Specific questions (if not covered elsewhere)	

APPENDIX C

LETTER FROM SUPERVISOR

3 May 2010

To whom it may concern

Dear Sir/Madam

Mrs Charmon Naroth is a registered master's degree student in the Faculty of Education at the University of the Free State. She enrolled for a full dissertation in the Department of Curriculum Studies. The title of the research dissertation is:

Constructive teacher feedback for enhancing learner performance in Mathematics.

This research will contribute to the improvement of teaching and learning. Education practitioners in the field of mathematics education and assessment will benefit from the outcomes of this research.

I therefore request that Mrs. Naroth would be allowed to conduct this research in schools under your jurisdiction.

Yours truly

PROF G F DU TOIT
(HEAD OF DEPARTMENT)

APPENDIX D

LETTER TO PRINCIPAL REQUESTING PERMISSION TO DO RESEARCH IN THE SCHOOL

THE PRINCIPAL

Dear Sir

I am currently completing a Master's Degree in Curriculum Studies. My research question is: **"*Constructive teacher feedback for enhancing learner performance in Mathematics*".** To conclude my research findings I need your assistance. **I hereby request permission to conduct my research at your school.**

The purpose of my study is to explore, from a theoretical and practical perspective, the use of constructive feedback to enhance learner performance in Mathematics. Valuable lessons for professional development could be learned from this research. The study is intended to suggest ways in which teachers can adapt their own feedback practices and become reflective practitioners in their daily teaching and assessment of Mathematics. One of the objectives of the study is to provide recommendations which could form part of professional development programmes aimed at developing teachers' competence in the provision of feedback to enhance learning in mathematics, and possibly inform policy formulation related to assessment.

Consent will be obtained from the relevant teachers. I will observe the mathematics lessons of these teachers and conduct interviews with them. I will also examine their planning documents and the learners' mathematics books. All the data gathered will be used solely for research purposes and the anonymity of those involved is guaranteed.

I thank you for the opportunity that your permission offers and appreciate your contribution to the improvement of Mathematics education in our schools. If you have any questions you may contact me at any time.

Sincerely

_____

Charmon Naroth
Researcher
0716605087

I, _____ (print full name and surname) principal of _____ Primary School, give permission for Ms C. Naroth to conduct her research at my school.

SIGNATURE OF PRINCIPAL: _____ DATE: 14 JUNE 201

APPENDIX E

LETTER TO EDUCATORS REQUESTING PERMISSION TO DO RESEARCH IN THEIR CLASSROOMS

Dear Teacher

I am currently completing a Master's Degree in Curriculum Studies. My research question is: **"*Constructive teacher feedback for enhancing learner performance in Mathematics*"**. To conclude my research findings I need your assistance. **I hereby request permission to conduct my research in your classroom.**

The purpose of my study is to explore, from a theoretical and practical perspective, the use of constructive feedback to enhance learner performance in Mathematics. Valuable lessons for professional development could be learned from this research that can provoke debates and possibly policy formulation. The study is also intended to suggest ways in which teachers can adapt their own feedback practices and become reflective practitioners in their daily teaching and assessment of Mathematics. One of the objectives of the study is to provide recommendations which could form part of professional development programmes aimed at developing teachers' competence in the provision of feedback to enhance learning in mathematics, and possibly inform policy formulation related to assessment.

If you participate in this study, I will also ask you to allow me to visit your class to observe your mathematics lessons (at your convenience), and to avail yourself for interviews (also only at your convenience). I will also examine your planning documents and the learners' mathematics books. Be assured that all the data gathered from you the educator will be used solely for research purposes and that your anonymity is guaranteed.

I thank you for the opportunity that your permission offers and appreciate your contribution to the improvement of Mathematics education in our schools. If you have any questions you may contact me at any time.

Sincerely

_____

Charmon Naroth
Researcher
0716605087

I, _____ (print full name and surname) give consent to participate in this study. I understand that this consent is voluntary and can be withdrawn without penalty at any time.

SIGNATURE OF EDUCATOR: _____ DATE: 14 JUNE 2010