INVESTIGATING FEEDBACK AS ELEMENT OF FORMATIVE ASSESSMENT IN THE TEACHING OF SENIOR PHASE MATHEMATICS

STANLEY ANTHONY ADENDORFF

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Promotor: *Dr JH Smit*
Co-promotor: *Prof. LLL le Grange*

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature: .... **Date**: ....

ABSTRACT

This action research study was aimed at establishing the importance and role of communication, and determining to what extent it impacts on formative assessment in the mathematics classroom with particular reference to feedback. During the first cycle of research it was evident that conditions within the mathematics classroom were preventing this from being realised. If we as researchers were to assess the nature of communication patterns within the classroom situation, then those communication patterns should have existed. Our findings reflect that teachers were generally in control of all aspects of communication of their learners, and that communication was usually a type of monologue, with very limited response from learners to closed questions, (characterised by "yes" and "no" responses), which were frequently posed. The feedback from learners (perhaps inadvertently ignored), was not optimally utilised to enhance learning. Through observation it was determined that teachers' ability to engage learners meaningfully for longer periods, or to consciously reflect upon their actions, needed to be developed.

Praxis as research paradigm, which is based on reflection and appropriate response or action geared towards improving the circumstances or conditions of the people concerned (in this case teachers), underlies this study. This research is furthermore based on the following learning theories: enactivism, constructivism, facilitation theory, action learning, andragogy, reification, and situated learning.

As a research team we intentionally intervened to address and counter those 'intervening' factors, and made a constructive effort to create conditions where dialogue and communication among peers could flourish. These actions of intervention involved creating an atmosphere conducive to constructivist teaching methodologies, training teachers in managing and facilitating small group work, making teachers aware of and training them in aspects related to feedback, listening, and questioning, and introducing modular learner material (during the course of Cycle II) to optimise teaching and communication time.

We gradually realised that limited subject knowledge was one of the main reasons why teachers lacked the ability to engage at a much higher level with learners. This was what was preventing them from operating on Davis's (1994, 1997) hermeneutic level of listening. Learners' reading problems were directly addressed by the modular learning material by confronting them with text. Simultaneously teachers and learners were exposed to relevant contexts and a wide range of question types as suggested by Bloom's Revised Taxonomy.

Form the outset we realised the importance of whole teacher development. If classroom communication was to be developed and enhanced, we needed to have enthusiastic teachers willing to develop themselves holistically, and expose themselves to our critique and intervention strategies. We succeeded in forming a support group through regular classroom visits and fortnightly focus group sessions, together with occasional social gatherings. All of these had a definite therapeutic effect on teachers' growth and commitment to improve.

In this study we have managed to increase teachers' awareness and knowledge with respect to issues addressed in the research questions. More importantly, however, is the fact that these four teachers have grown significantly holistically, and have become much more skilful at managing learning through improved questioning, communication (feedback) and facilitation skills. Our teachers' development and growth in confidence are reflected by their involvement as presenters at in-service training sessions arranged by the WCED for mathematics teachers.

OPSOMMING

Hierdie studie, aan die hand van aksie-navorsing, is daarop gemik om vas te stel wat die rol en belangrikheid van kommunikasie, en veral terugvoer, is ten opsigte van die effektiwiteit van formatiewe assessering in die wiskunde klaskamer. Gedurende die eerste van drie aksie-navorsing siklusse is deur waarneming bevind dat daar omstandighede binne die wiskunde klaskamer voorkom wat kommunikasie en gesprekvoering nie net benadeel nie, maar selfs verhoed. Anders gestel – as ons as navorsers daarop ingestel is om kommunikasiepatrone in wiskunde-onderrig te bestudeer, dan moet sulke kommunikasie-patrone ten minste aanwesig wees. Daar is bevind dat opvoeders meestal in beheer was van alle fasette van gesprekvoering met of van hul leerders in die klaskamer. Kommunikasie was dus meer 'n tipe monoloog, met oor die algemeen beperkte respons vanaf leerders. Vraagstelling is dikwels gekenmerk deur geslote vrae met oorwegend 'ja' en 'nee' antwoorde. Terugvoer, indien nie onopsetlik geïgnoreer nie, is nie optimaal benut om leer te fasiliteer nie. Opvoeders betrokke, halwe twee, het weinig vermoë getoon om effektief, betekenisvol of onderhoudend met leerders in gesprek te tree oor wiskunde-aangeleenthede. Hul vaardighede om bewustelik deur gesprekvoering te reflekteer oor hul onderrigpraktyk moes ook ontwikkel word.

Hierdie studie word onderlê deur praksis as navorsings-paradigma, wat geskoei is op reflektering en die neem van gepaste aksies om die omstandighede van mense (in dié geval opvoeders) te verbeter. Verder word dit ook onderlê deur die volgende leerteorieë: enaktiwisme, konstruktiwisme, fasiliteringsteorie, aksieleer, andragogie, reïfikasie en gesitueerde leer.

As 'n navorsingspan het ons ons doelbewus toegespits op intervensies om hindernisse by begripsvorming en leer, aan te spreek en teë te werk. Die doel was dus om 'n konstruktiewe en daadwerklike poging aan te wend om omstandighede te skep wat dialoog en kommunikasie tussen porture sou laat posvat en bevorder. Hierdie intervensies moes help met die totstandbrenging van 'n atmosfeer bevorderlik vir die gebruik en toepassing van konstruktiwistiese onderrigmetodologieë. Dit moes opvoeders ook toerus met bestuurs- en fasiliteringsvaardighede wat koöperatiewe leer en groepwerk betref. Verder was dit gemik op die bewusmaking van en onderrig van aspekte wat nou verwant is aan terugvoer, luister en vraagstelling. Gedurende siklus II is wiskunde-materiaal in modulêre formaat geïmplementeer om die beskikbare tyd vir onderrig en kommunikasie te optimaliseer.

As navorsingspan het ons tot die besef gekom dat beperkte inhoudelike kennis van die leerarea, in hierdie geval wiskunde, grootliks daartoe bydra dat opvoeders nie op 'n hoër

gespreksvoeringsvlak met leerders kan kommunikeer nie. Gevolglik verhoed dit dat opvoeders tot op die hermeneutiese vlak van luister – volgens Davis (1994, 1997) – ontwikkel. Hulle is nie net met teks gekonfronteer nie, maar sowel opvoeders as leerders is ook blootgestel aan relevante kontekste, asook 'n wye verskeidenheid tipes vraagstelling soos uiteengesit in die Hersiene Taksonomie van Bloom. . Leerders se leesprobleme is direk aangespreek deur die material in module-formaat.

Die oorsprong, betekenis en toepassings van terugvoer, soos dit aan kommunikasie, formatiewe assessering en die leer van wiskunde verwant is, is nagevors. Daar is ook gefokus op maniere om kommunikasie-patrone in die klaskamer aan die hand van aksie-navorsing te ondersoek. Behalwe om aspekte wat nou verwant is aan terugvoer en kommunikasie aan te spreek, het ons ook 'n doelbewuste poging aangewend om opvoeders toe te rus met vaardighede om produktief met verandering om te gaan.

Met hierdie studie het ons daarin geslaag om by opvoeders 'n bewustheid te kweek en hul kennis te verbreed ten opsigte van die aspekte wat aangespreek word in die navorsingsvrae. Selfs meer belangrik is die feit dat die vier opvoeders, wat aktief aan die navorsingsprojek deelgeneem het, holisties betekenisvol gegroei het, en baie meer bedrewe en vaardig is om leer te hanteer en te bestuur aan die hand van verbeterde vraagstellings-, kommmunikasie- (terugvoer) en fasiliteringsvaardighede. Hierdie opvoeders se ontwikkeling en groei word gereflekteer deur hul betrokkenheid as mede-aanbieders by die opleiding van wiskunde-opvoeders deur die Onderwysdepartement.

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I DEDICATE THIS DISSERTATION TO:

The children of Laurie Hugo PS, Moorreesburg, Stawelklip PS, Piket-Bo-berg, and Willemsvallei PS, Porterville in Circuit 6 of the West Coast Winelands EMDC.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
BOLA	Business Open Learning Archive
CASAA	Canadian Association of Student Activity Advisors
CTA	Common Task for Assessment
CDE	Centre for Development & Enterprise
CNE	Christian National Education
EMDC	Education Management & Development Centre
FET	Further Education and Training
HS	High School
IMSTUS	Institute for Mathematics and Science Teaching of the University of Stellenbosch
IRE Model	Initiation, Response and Evaluation Model
OBE	Outcomes-Based Education
PS	Primary School
QCA	Quality and Curriculum Authority (UK)
QUILT	Questioning and Understanding to Improve Learning and Thinking
RME	Realistic Mathematics Education
RNCS	Revised National Curriculum Statement
WCED	Western Cape Education Department

CHAPTER 1: SETTING THE SCENE: WHAT, WHY, WHERE, WHEN AND WITH WHOM?

> *"If we believe the learning of mathematics is a process of mastering pre-established and universal truths, then the purpose of listening to learners would be to diagnose and to remediate difficulties – the teacher would "have a somewhat damping manner of listening only to correct." Indeed, altogether too often it seems that if the teacher listens at all in a mathematics classroom, it is in this manner."* (Davis, 1994:279)

1.1 INTRODUCTION

"One of the most important observations here today was the fact that learners do not listen effectively when the teacher speaks, nor does the teacher actually listen to what she says herself – if she did she might have corrected herself. Or the message the teacher wants to convey to the learner in some way becomes blurred or distorted because the wrong word or phrase is used. One could also pose the question as to the extent to which the teacher actually listens to herself while she does the explaining. It is however possible that the way in which the following statement was uttered lent itself to confusion or misinterpretation:

The learner asked the question: "What does the 2 mean in *5^2?"*. The teacher in an effort to explain the meaning of *5^2*, says the following: "Five multiplied by itself twice", instead of just saying 5 multiplied by 5. Most of the learners interpreted this to mean 5 x 2. What she means is that 5 is multiplied by itself – thus there are two fives involved in terms of multiplying the one 5 with the other one. Important is the fact that no learner asks whether the way in which they understand it is correct. I intervened and in a subtle way focus her attention on the fact that her explanation creates confusion for the learners where I was sitting, and we tried to remedy the situation." (Journal Entry: Adendorff, 2005).

A glimpse at the region where the research was done …

A street close to Laurie Hugo

Willemsvallei PS

… an RDP House in Moorreesburg

Open air assembly at Willemsvallei

The above is an extract from my field notes made during a grade 8 lesson on “developing quadratic patterns”. There are many instances where learners receive feedback from teachers that not only causes confusion, but also results in misconceptions. If the problem is not detected in good time, it could interfere with learning. Instances or learning moments such as the one described above form the prime focus of this study.

This learning moment entails formative assessment during which the teacher responds verbally by means of feedback to the learner’s uncertainty as to the meaning of the ‘2’ in 5^2. The teacher should clear up any confusion, and not only explain the meaning of the concept, but also make sure the explanation has been grasped. In this case, feedback serves as a means to ensure that the equilibrium in the learning system is maintained. A system according to Littlejohn (1992:40) consists of a “set of objects or entities that interrelate with one another to form a whole”. In this particular instance the system consists of the learner who is trying to make sense, the learning content consisting of concepts to be taught or facilitated, the teacher as facilitator of the learning process, and the peer learners.

Misinterpretation, confusion or lack of understanding by learners implies that this learning system is no longer in equilibrium (Nickols, 2000:1-3). If the teacher fails to clear up the confusion, this could hamper learning and interfere with comprehending more difficult concepts later. Appropriate feedback, on the other hand, should help “learners pay attention to what they are learning”, and restore equilibrium by enhancing conceptualization (Gunderman and Williamson, 2002:449). This connection between formative assessment, and questioning (and listening) to receive or give feedback, is researched in this thesis.

In the remainder of this chapter I explain the rationale for embarking on this particular research, describe the research problem in more detail, and elaborate on the purpose of this research study. Further on in the chapter, I provide situational information to sketch the wider context within which the study occurs. The reflective summary at the end of the chapter highlights the essence of each of the chapters to follow.

1.2 RATIONALE FOR THIS STUDY

It is evident from the above discussion that feedback is an inherent component of formative assessment, and involves those assessment tasks that focus on diagnosis and ultimately remediation and improved learning. Formative assessment is thus undertaken or applied purely to provide feedback with regard to the learners’ performance in different aspects of mathematics. The following essential elements of feedback as identified by Morgan (1997:6-11) will be used to guide this study:

1. Effective two-way communication (dialogue) between learner and teacher

2. Effective listening strategies on the part of the teacher
3. Effective skills of analyzing learners' written work and / or verbal comments
4. Appropriate responses (verbal or written) by the teacher to ensure optimal learning.

Somewhere in the formative assessment process, the learner is often lost as a result of 'blockages' in feedback (Monga, 2002:4). Shortcomings in two-way communication can often be attributed to ineffective listening by both teacher and learner. Erven (2002:5) considers "providing feedback [to be] the most important active listening skill". Listening is also viewed as a mental process involving amongst other facets, making sense of the information coming from the learner (Carty, 2001:1), and also listening to what is not said.

Inadequate response to a learner's needs, might result in anxiety which could eventually develop into self-doubt and a decline in mathematics self-concept, resulting in a general belief of 'I can't do mathematics?' or 'I hate mathematics!'. Based on my experience, the majority of learners generally seem to be inhibited or cautious as to when to respond (Hickman, 2002:4) or to not say the 'wrong' thing since much emphasis is put on 'right' and 'wrong' (Dillon, 1998). Consequently, they do not always have the assertiveness required to show the teacher that they still do not understand and that they need further clarification. As a result, some confusion or misconceptions are never adequately addressed.

1.3 DESCRIPTION OF THE PROBLEM

In this section I give a description of the problem as I encountered it as a facilitator during my classroom visits and deliberations with both teachers and learners. Therefore, a brief description of my role as facilitator is given at this point. Closely linked to this is an effort to formulate the rationale for this study. I also share perspectives on the nature of the problem by referring to perspectives from other educational researchers.

1.3.1 Perspectives on the nature of the problem

A question that confronts me as an action researcher is the following: Why is a study like this one needed, or overdue, or even crucial? In a sense - as I view it - there is no one answer to this question. I will attempt to answer it in the following way.

Improvement in the quality of mathematics teaching is essential (for obvious reasons such as addressing and countering learner under-achievement, learner attrition, the fact that very few learners do mathematics on the higher grade, and the alarmingly low matriculation pass rates). We need to develop positive mathematics concepts in learners to enhance learning, and consequently learner achievement.

The above reasons must also be viewed within the current South African context. Our country is experiencing a national crisis with regard to education in Mathematics and the Natural Sciences:

- South Africa’s performance was the worst of all 38 participating countries in the Third International Mathematics and Science Study (TIMMS-R), conducted in 1998–1999.
- In 2003, only 23% of all learners with Higher Grade Mathematics in their final school year were black African. One fifth of secondary schools do not even offer Senior Certificate Mathematics. These trends are similar for Senior Certificate Physical Science. (CDE research report no 13, November 2004).
- Many teachers lack the necessary subject expertise and pedagogic skills and are ill-equipped to implement the country’s National Curriculum Statement.

When she opened the Association for Mathematics Education of South Africa (AMESA) conference on 1 July 2004, the national Minister of Education, Naledi Pandor expressed these matters thus:

> *Our National Strategy identified three key thrusts, namely, to raise participation and performance by historically disadvantaged learners in Senior Certificate Mathematics and Physical Science; to improve on the number and quality of teachers of Mathematics, Science and Technology; and to provide high quality Mathematics, Science and Technology education from Grade 1 to Grade 12 …*

In an effort to address this complex issue, this study focused on the communication patterns that currently exist in the mathematics classroom and how these impact on formative assessment. In order for improved teaching and learning to occur, it may be important to find ways of improving the communication patterns in the mathematics classrooms.

My research is to a large extent also informed by Davis’s (1997) enactivist framework that offers an alternative way of approaching mathematics teaching, which focuses on the manner in which the teacher listens as integral to communication. This is presented as “a metamorphic lens through which to reinterpret practice”, and as a “practical basis for teaching action”. One of the main objectives would be to ascertain whether teachers listen ‘evaluatively’, ‘interpretively’ or ‘hermeneutically’. Hermeneutical (analytical) listening is considered to be the highest level of listening. This is elaborated upon in chapter 4 under (4.4).

According to Davis (1994) there is an intimate relationship between communication (conversation) and listening. The way somebody listens actually reflects the degree of interaction that occurs between the teacher and learner. In his words: "The conversation is a fertile place to search for an understanding of the nature of listening" (Davis, 1994:271). This intimate relationship between feedback (built into conversation) and listening is highlighted by the following quotation from Davis (1994:279): "The listener must always be oriented toward gaining a fuller understanding, always vigilant to the fallibility of interpretation. This is why listening cannot be silent; it is in itself a kind of speaking, a means of probing and checking emerging understandings".

Studies by Bishop (1985), Brown and Campione (1986) showed that an increase in learners' interactions in general and their mathematical communications in particular, facilitate learning. Meaningful and constructive interaction facilitates the process of making sense in the course of learning mathematics" (Leiken & Zaslavsky, 1997:352).

Stephen Brookefield (1987) used a variety of nouns to describe the nature of the work teachers do, or duties they perform with respect to teaching. He describes teachers as painters, artists, craftsmen, builders, etc. In order to be a good builder, for instance, implies that you are required to be aware of the tools you need to perform your work effectively. It is even more important to know the potential and extent to which your tools would allow you to excel in whatever it is you do.

One of the most important tools in terms of teaching mathematics is language and communication, with specific emphasis on feedback given or received. The manner in which the teacher responds to make teaching more meaningful and effective, thereby increases the extent to which learning is facilitated (Beatty and Bremley, 1999:1; Morgan, 1997:9). This implies that the teacher must be a good listener. It also implies that the teacher must be aware of the different types of questions, and how to use questions (Wolf, 1987:2) to get learners to reveal their thoughts and share their views, their understanding, their misconceptions, etc. Wolf (1987:2) argues that the "way in which teachers ask questions can undermine, rather than build, a shared spirit of investigation". This further implies that an atmosphere needs to be created within which learners feel free to express opinions, make statements and pose questions. In this regard Davis (1994:280) emphasises the fact that the "ability to listen also depends upon a certain trust that the speaker has something to say".

Papert (1993:89) focuses on the lack of language and dialogue in traditional mathematics teaching and maintains that an essential component in the art of learning mathematics is open and free discussion of learning experiences in the mathematics classroom.

Furthermore, Papert (1993) found that “good discussion promotes learning” and is an integral part of all intellectual discovery. This cannot be disregarded when teaching mathematics.

Ball (1987) stresses the crucial role of “intellectual honesty” between teacher and learner in the mathematics classroom. This means, allowing learners space and freedom to make sense of mathematics, pose questions, link new experiences with their own knowledge, and take note of others’ reasoning. She stresses the need for teachers to learn to hear, and painstakingly listen to aspects learners deem important and think about in the mathematics classroom. Thereby “establishing a community through conversation”, attention and response as crucial components of both learning and teaching. Davis (1996) also takes mathematics teaching and learning “into the realm of the auditory, where language and speech are the focus”, in an effort to “decenter the learning of mathematics away from its primary focus on the visual to what has been a secondary means of learning, the auditory”. He admits that learning and using mathematics require both the visual and the auditory, but he maintains that the auditory has been neglected. How do mathematics teachers listen? The way teachers listen ultimately affects the value or worth they attach to the learners’ answers and the quality or degree of response.

1.3.2 Aim of the research

Against the background pictured above, and mostly using qualitative research methods (to be elaborated upon in Chapter 2) this research is aimed at:

(1) investigating the nature of feedback as an integral part of formative assessment in mathematics teaching,

(2) investigating in what way the quality of feedback hampers or enhances understanding and learning,

(3) finding through observation, focus groups, interviews, etc., ways to improve feedback and ultimately, learners’ understanding in order to facilitate learning and enhance performance in mathematics.

1.4 PURPOSE OF THE RESEARCH

The purpose of the research is primarily to explain and gain insight and understanding of the interaction-feedback-listening cycle in the mathematics classroom through intensive production of narrative data. The approach could be described as inductive, holistic and process oriented. A better understanding of the feedback process is intended to help develop strategies to remedy problems that might exist with respect to teaching and learning.

Operationalization of the problem statement will occur by focusing on research questions such as the following:

1. What effect does feedback have on learning mathematics and how can the quality of feedback be improved?
2. To what extent are teachers able to listen effectively to what learners say?
3. How do listening strategies affect the quality or the appropriateness of teachers' responses?
4. What assessment instruments do teachers use to gather information about the learners' diverse problems?
5. How do mathematics teachers view formative assessment and how is it applied in their classrooms?

1.5 CONTEXT OF THE STUDY

This research was done while I was working as a Mathematics facilitator at the Institute for Mathematics and Science Teaching of the University of Stellenbosch (IMSTUS) in an intervention project that involved in-service training of teachers. At this stage I want to discuss my role as facilitator and how my observations of lessons and encounters with teachers brought me closer to the idea of researching the impact of feedback as integral to communication, during formative assessment in the mathematics classroom.

1.5.1 Brief insights into my role as facilitator

School visits and facilitation are closely connected to the process of observation. My role as facilitator amongst others, involved school visits in an effort to monitor, and observe the extent to which modelled teaching strategies and skills demonstrated at workshops are applied in the mathematics classroom.

My role as facilitator of teachers as adults, however, was a complex and multi-facetted one. The competencies and characteristics as described by Schuman (2003:1) involve the following: the ability to use core methods by distinguishing between process and content, effective management of the facilitator-teacher relationship and thorough preparation, skilfully evoking participation, at all times maintaining a high degree of 'objectivity', reading, interpreting and analysing underlying dynamics of a group, an adroitness in adapting to a changing situation, producing powerful documentation, maintaining personal integrity, and continually demonstrating professionalism, self-confidence and authenticity.

This study can be described as a case study that is essentially an action research project. The nature of my work as facilitator is situated inside this action research study that spans over three years. A more theoretical discussion of the role of the facilitator appears in Chapter 2 under 2.3.10. My work as facilitator entails critically analysing the needs of mathematics teachers in the project, and the situations that prevail inside their classrooms. Furthermore, as facilitator I have to assist teachers in implementing appropriate teaching methodologies, applying effective formative assessment instruments and tools. I thus have to provide in-service training for teachers by means of workshops, reflect on lessons taught, co-teach lessons, advise them as to appropriate learning materials, effective teaching methods to enhance interaction with peers and mathematics content, possibilities for integration of learning outcomes within mathematics and integration with other learning areas, appropriate questioning strategies, etc.

Post lesson reflection …

class visit …

My experience as facilitator in working on assessment programmes that involve Mathematics teachers, raises the question whether the low numbers of learners who successfully graduate in higher grade mathematics, amongst others, can be linked to the inability of teachers to apply formative assessment optimally. The seminal question is how to equip teachers with the required skills to address the diverse needs of individual learners through formative assessment, within class context. Findings of research done in Britain also point to lack of skills in this (Black and Wiliam, 1998) regard.

There seems to be a general inability on the part of many teachers to recognise or interpret the information contained in learners' responses (for example written calculations, verbal answers, etc). Consequently these teachers do not use this kind of information to facilitate learning adequately, or to adjust their teaching strategies or methodologies accordingly (Black and Wiliam, 1998). Nakabugo & Siebörger (1999) also point out that inadequate feedback from teachers hampers meaningful learning, and limits teachers' chances "to assess how learners were thinking or understanding…" or "to assess what strategies the learners already had in place…", or "to assess and to enhance the learners' ability to develop independent thinking skills".

1.5.2 The other research participants

There are at least two research partners who played important roles in the execution of the planned outcomes as far as the project was concerned. Firstly, Marina van Heyingen (ex-teacher and materials developer) played a significant and crucial role throughout. Technically speaking, we were jointly responsible for the coordinating and managing of the project. She is a dynamic and innovative person, who was essentially responsible for the translation of the modular mathematics material from Dutch to Afrikaans and English, and formatting of the said materials. We were also jointly responsible for the editing of the material and to ensure that the contexts used were appropriate and relevant to our learners. Furthermore, as co-facilitator, she frequently observed lessons and took charge of several of the focus group and workshop sessions. In order to ensure that we had a common focus, we observed certain lessons as a team.

The collaborators

Bertus in class

Secondly, Bertus van Etten was responsible for developing mathematics learner material that was used in the project. Thus far he has developed 36 mathematics modules for the senior phase learners. Bertus is a teacher trainer at the University of Fontys in the Netherlands. His relationship with IMSTUS spans over many years. For the first three months of the first terms during 2004 and 2005 he visited schools on a daily basis to monitor and observe teacher and learner interaction with the modular materials. Bertus also conducted most of focus group sessions during his visits to South Africa.

The three of us collaborated throughout the past three years, continually corroborating our findings and planning follow-up intervention strategies. As a team we generally worked well together, but at the same time we consciously maintained an openness and frankness to ensure that the project outcomes were meticulously pursued. Marina is also the person with whom I discussed and tested the validity of my ideas. She cleared up confusion on an array of issues, varying from teacher evaluation, to how to build relationships with teachers, to mathematics content related aspects – acting as the proverbial sounding board. Her advice was not only invaluable, but her critique and support made a strong contribution to keeping my studies on track and ensuring the success of the project.

1.5.3 A brief description of the project teachers

My four-year involvement centres on at least four teachers who were in the project (and the three action research cycles) for its entire duration. These are really exceptional teachers in the sense that they showed an openness and willingness to expose themselves to outside intervention. Occasionally there was a degree of doubt and uncertainty, to be detected, especially with Attie who was very hesitant to become a participant in the project. Of all the teachers, however, he made the most significant shift in his approach to teaching. His hesitance to intervention, and possibly change, should be viewed against Fullan's (1993:3) statement that the education is essentially conservative and "the way that teachers are trained, the way that schools are organized, the way that the educational hierarchy operates, and the way that education is treated by political decision-makers results in a system that is more likely to retain the status quo than to change".

What was especially evident was their ability to recognise and realise their own short-comings, and their continuous willingness to improve themselves. We experienced constant progress and improvement, but we also experienced moments of self-doubt and uncertainty. For instance, the shift from conventional teaching to facilitating small groups of learners did not suit at least one teacher, who offered all kinds of reasons why it would not work. This fear and frustration gradually disappeared as this teacher became more skilful and adept at using facilitation techniques. What was evident in all four teachers was the fact they had some teaching skills, but that there was room to improve these skills as well as their content knowledge. Another important fact is that they generally required guidance to make the shift to OBE (in 2003-2004) and that their knowledge and use of formative assessment were very limited at that time.

In this study I thus basically reflect on the progress of four teachers, namely Attie, Catherine, Bryan and Pedro. After an elimination process these were the teachers who remained in the study for the whole duration of the study. Occasionally I also report on comments and interactions with other teachers, who either came in late or dropped out of the study.

Marina & Bryan

Attie, Bryan & Catherine

Marina, Stanley & Attie

1.5.3.1 Arthur (Attie) Adonis

Attie is in his late forties and has 24 years of teaching experience. He teaches at Laurie Hugo Primary School in Moorreesburg. This is also his alma mater. He completed his high school training at Schoonspruit Secondary School in Malmesbury with three years of teacher training. Attie has a very mature and relaxed demeanour. He teaches mathematics to most of the grade 7 classes as well as Life Orientation. The class sizes here range from 35 to 40 learners per class. My first experience of Attie in 2002 is that of the teacher who is in control. He explains first and then the learners get their chance to apply the rules or algorithms and to follow the examples that he as teacher has explained.

I thus found him to be the typical ‘conventional’ teacher – the authority who does the explaining, who tells learners when to respond and when not. Attie is very methodical in his approach and his writing board skills are excellent. Although he was initially hesitant to join the project, he became a model teacher. I have never seen someone so eager to learn and apply what he has learned. This does not imply that he just meekly and uncritically accepted everything doled out to him. He was prepared to learn and change to meet the demands made by Outcomes-Based Education. Attie increasingly allowed learners an opportunity to struggle and to make sense for themselves. He is a kind of father figure to his learners, who trust him.

Towards the end of 2004 Attie was already a radically changed teacher. He displayed a level of openness and willingness to improve and change that I did not experience with any of the others, except maybe for Bryan. I thus also consider him to be the teacher who made the most progress in my endeavours with him. He now provides ample opportunity for learners to grapple with issues, allowing them time to discover and construct their own concepts. The learners display a high degree of trust in him as teacher. Learners either have to work individually, in pairs or in groups. He facilitates by visiting all the learner groups, giving guidance and posing appropriate questions. His comments, when busy with one group, are audible to the whole class. This gives learners in other groups a chance to pick up on what was being said (Van Etten, 2004).

1.5.3.2 Catherine Coetzee

Catherine is assertive and is not scared to share her honest opinion on matters that bother her. At the outset her teaching style showed similarities with that of Attie’s. She experienced problems getting used to teaching by means of small groups. At some stage she went back to the conventional seating arrangement of learners facing the writing board. This was mainly because her teaching style did not effectively accommodate learners working in small groups. Eventually, after some structural changes and her coming to grips with facilitation, the introduction of our module system (to be explained at a later stage), and means of intervention, she eventually started to adapt to a cooperative learning style of teaching. Catherine has become an excellent planner, and is very methodical in her approach. She thus continually models excellence and accuracy to learners.

Catherine was herself a learner at Laurie Hugo PS. After having completed her high school training at Schoonspruit HS, she studied at Bellville Teacher Training College for four years. She has 15 years of teaching experience and is in her mid thirties. She taught mathematics to both grades 7 and 9 in 2002 and 2003, but currently teaches mathematics to grade 9.

She admitted that there are many things regarding the new education system that she still had to learn. She was enthusiastic, dynamic and innovative. The teaching style that she developed of using examples and non-examples to develop concepts, corresponds to the model reflected in our modular material (Van Etten, 2004:31). Like the other teachers she found the project materials quite helpful. In common with other teachers at the beginning of 2004, her teaching was still geared towards the whole class approach. She has made significant changes and increasingly allows learners opportunity for self-exploration.

1.5.3.3 Bryan Pieterse

When I observed Bryan the first time in 2002 it was obvious that he had been exposed to OBE and that he was in the process of transition to OBE – ahead of the majority of teachers in the country. I then learned that he worked on a project named Kathloga during which they received training in Montana in the USA.

He is in his late thirties and teaches at Stawelklip PS, situated on top of the mountain close to Piketberg. Stawelklip PS is the smallest of the three schools and has only one grade 7, one grade 8 and one grade 9 class. Bryan teaches mathematics to all of these classes. Bryan mostly lets his learners work in small groups. He facilitates effectively by allowing peer discussions and only intervening when required. Like most teachers, at the start of the project, his questioning techniques needed to be developed. In his case, he still needed to learn to use appropriate contexts to develop learners' conceptual understanding.

He completed his schooling at Steynville Primary and Secondary Schools. He did his four years of teacher training at Bellville Teaching College. At the school where he teaches, there is only one class of grade 7, 8 and 9, respectively. He also teaches Life Orientation, and Economic and Management Sciences. The class sizes are all approximately 30 learners per class.

I initially experienced Bryan as being different from all of the other teachers I worked with. While others were still battling to come to grips with cooperative learning through small group work, or were trying to make sense of why they should implement group work in their classrooms, in 2002 he was already effectively facilitating learning in small groups. To him it already made sense to address issues as they came up in the different learner groups. It was evident that he had successfully applied some of the pedagogic skills he had learned during the Kathloga project.

1.5.3.4 Pedro Fortuin

Pedro is in his early thirties and has been teaching for 9 years. He obtained a four-year education diploma from Bellville College of Education. He went to Willemsvallei Primary School in Porterville and continued his high school training at Roodezandt Secondary School in Saron. He teaches at Willemsvallei at present. Pedro takes all the grade 7 and grade 9 classes at Willemsvallei PS for mathematics. Although he has 10 years' teaching experience, he received his permanent appointment only two years ago.

Of all the teachers I found Pedro to be the one who most easily talked about his experiences, his short-comings, his intentions, about what went wrong in a lesson, what and how he thought he needed to improve, etc. He thus had the ability to communicate his frustrations, progress and teaching experiences very effectively and in detail. Consequently we often engaged in lengthy discussions about what transpired during his lessons. Our discussions and post-lesson reflections were honest and frank, and he always appreciated my views and suggestions on how to do things differently. Learners in Pedro's classes tended to pose questions more often than the learners in any of the other classes whose teachers I observed. At the start of our educational relationship his teaching style was still very conventional – learners facing the writing board, and he 'in authority' transmitting knowledge before allowing learners to follow the steps and rules previously supplied by him.

He has the ability to prompt many learners to become engaged in classroom conversation. Learners are frequently allowed to engage with peers on content issues. Furthermore he has the ability to improvise. Although he can be quite jovial in class, he also tends to be a bit abrupt with learners. In the same way as Attie, Pedro readily applied our suggestions and skills learned at workshops in his classroom, with great success. His ability to reflect on his own practice is greater than any other teacher I know. This is in line with Turner's (2005:4) view that "Individuals vary in their reflectiveness, and their ability to change thinking and behaviour".

1.5.4 Situational information

As a mathematics facilitator for IMSTUS I have become increasingly aware of the numerous problems that hamper effective or optimal learning in mathematics in the Senior Phase. The cumulative factors such as (ineffective) teacher preparation, (inadequate) teaching methods, learners' diverse backgrounds, pedagogical gaps in learners' subject knowledge, learners' levels of cognitive and social development and classroom communication (weakly developed reading skills, lack of insight, learners' inability to express themselves) have a detrimental effect on learner progress, performance and achievement.

What particularly interested me as researcher was the quality of communication that occurs between learners and teachers. Very often educators talk about concepts or phenomena that fall outside of the learners' frame of reference. What is alarming here is that educators frequently do not seem to realise that they communicate in a vacuum or that the idea or concept formed by learners radically differs from what was communicated or intended. This implies that in order to improve communication, teachers should be conscious of the learners' frame of reference so that they can facilitate the accommodation and internalization of new concepts or concept formation. The terms "accommodation" and "assimilation" are terms used by Piaget (Copeland, 1974:39) to describe the cognitive process involved with conceptualizing new ideas or concepts by linking them to existing ones in a meaningful way. Assimilation is described (Curzon, 1985) by Piaget as the process by which new experiences and information are placed into the cognitive structure of the learner, and accommodation is viewed as the product of any restructuring of the cognitive schema.

Teachers appear to take comfort in the notion that they have done a particular section of the work. Whether or not most learners understand it is a secondary consideration. The emphasis then falls on the fact that "I have done that." or "We covered that", instead of concentrating on what the learners learned, what the learners achieved, or what skills they acquired. This attitude can be viewed as a direct consequence of pressures put on teachers to "complete" the syllabus. The pressure exerted on them compels teachers to move on to the next item. Consequently whether all learners understand or whether 'slower' learners keep up are not thoroughly addressed or remedied.

In order to ascertain how educators handle or deal with feedback in their mathematics classrooms I collected data through classroom observation of lessons dealing with various topics from the current syllabus (that is the Revised National Curriculum Statement) in the Senior Phase of General Education and Training. My research was embedded in a greater research project referred to as the 'Brave Maths Mouse' project managed by the Institute for Mathematics and Science Teaching of the University of Stellenbosch (IMSTUS). This project currently runs in two circuits of the West Coast Winelands Education Management and Development Centre and is discussed below.

1.5.5 IMSTUS

At one stage during 2004, IMSTUS successfully managed 10 projects. These projects mainly involved teachers and learners from previously disadvantaged communities (which involve Coloured and Xhosa people), by focusing on Mathematics, Physical Sciences and Life Sciences. Our activities can be divided into four categories:

- University accredited training programmes aimed at improving the subject knowledge and didactic skills of teachers.
- Projects in schools for teachers aimed at addressing the dire need for subject knowledge and didactic skills.
- Projects for learners aimed at improving performance and stimulating an interest in Mathematics and the Natural Sciences.
- Research and development aimed at monitoring the successes of various initiatives.


The neighbourhood…

the school…


sandwiches for break…

All IMSTUS' interventions are project-based. Each project has specific objectives, time-frames and a budget. The planned outcomes of all projects are carefully monitored and evaluated. Sponsors and donors receive regular feedback on outcomes and expenditure.

The Advanced Certificate in Education (ACE) and the BScEd Programme are fully accredited by the Council on Higher Education and the Department of Education.

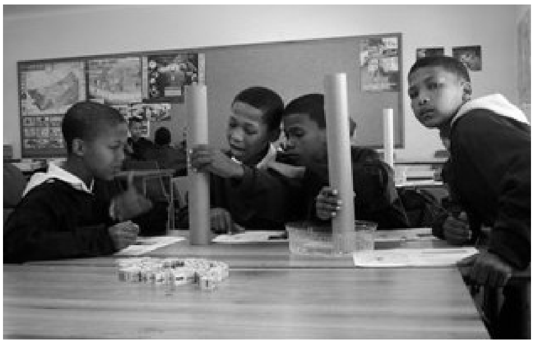
The Institute currently has 27 employees with expertise in teacher training and all with many years of experience in the fields of adult and learner education. The majority of the staff members are appointed annually on a contractual basis. IMSTUS also makes frequent use of experts from other faculties and departments of Stellenbosch University to conduct specialist demonstrations, workshops and talks at parent evenings, or to evaluate project work. This ensures variety and depth by specialists benefiting all involved.

Projects are generally funded by South Africa's private or corporate sector with limited financial support from the University Stellenbosch. All other funds must be secured by the Institute through donations and sponsorships. Before projects are finalised and parameters are determined, IMSTUS liaises with all relevant role players, such as the Western Cape Education Department (WCED). In order to ensure that the most urgent needs in mathematics teaching and learning are addressed, appropriate project objectives are developed and mutually agreed upon.

The duration of most of the projects is at least three years. Built into each initiative, there are several ways of assessing whether we have met the outcomes of the specific action within the broader objectives of the overall project. Joint ownership of the projects by all participants is encouraged and the involvement of all beneficiaries is considered to be essential. A deliberate effort is not only made to create opportunities to empower teachers and engage learners in a structured, and active way, but also to involve parents and the broader community to become more involved in the education and progress of their children.

1.5.6 Brief overview of Brave Maths Mouse Project

At this stage I deem it essential to paint the wider context within which this research has occurred. In this project rural schools in Vredendal, Moorreesburg, and Porterville on the West Coast, Western Cape, South Africa were targeted. These schools are situated in Coloured areas in the places mentioned. The schools involved are the following: Uitsig PS (Lutzville), Vredendal PS (Vredendal), Stawelklip PS (Piketberg), Laurie Hugo PS (Moorreesburg), Willemsvallei PS (Portverville).

Mathematics week Uitkyk PS, Lutzville

The project, within which my research was situated, focuses on Mathematics for Grade 7 to 9 learners (the Senior Phase) from historically disadvantaged communities located in a particular rural area. IMSTUS identified five schools where Mathematics learners in the grades mentioned do not have their own textbooks. Because they have to spend their time copying information from the writing board, the learners and their teachers do not have sufficient time for real education. The map below indicates where these towns are situated:

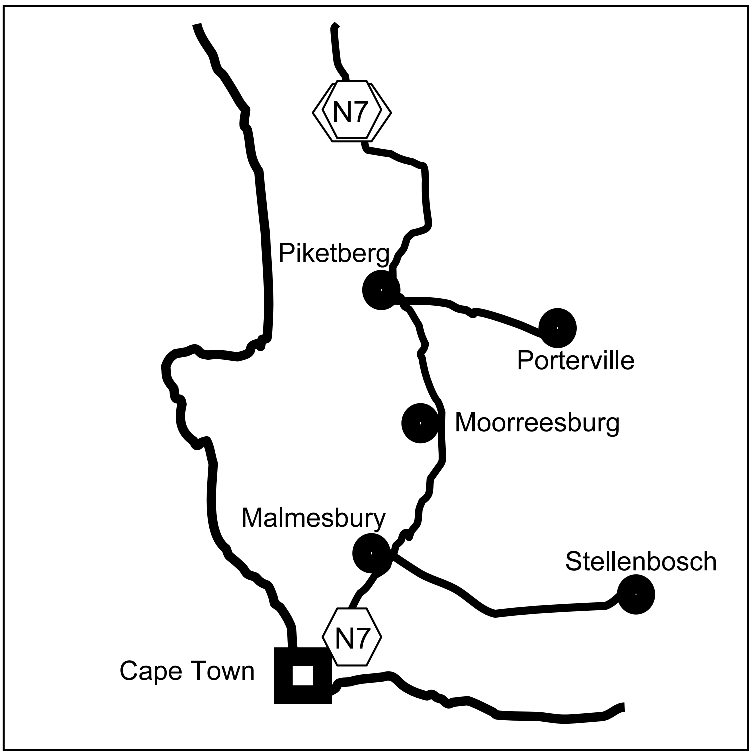


Figure 1.1 West Coast Winelands Circuit 6

A pilot project was launched in these schools in 2004, whereby structured, modular learning material was supplied at no cost to these learners. In addition, IMSTUS facilitators provided guidance on teaching skills within the framework of Outcomes-Based Education. My research on feedback occurred at the latter three project schools that were assigned to me as facilitator in the Piketberg region.

1.5.6.1 Background and Overview

This is an in-depth and closely monitored project with the aim of empowering teachers to help learners to accept ownership of their own learning processes. The fresh and innovative format and structure of the material - very different from a conventional textbook - enables learners to work independently and at their own pace. Through this holistic approach, learners and teachers are actively and intimately involved in the process of teaching and learning mathematics. Complementary, yet critical issues such as developing basic reading skills and the integration of learning areas are also addressed by training teachers to cope with and develop learners' reading skills.

The context-based (real life-based) material reveals new ways for teachers to integrate subject knowledge with everyday publications such as newspapers and magazines. Interactivity and co-operative learning in the classroom are enhanced by deliberately focusing on the nature and format of the learner material which should allow more time for elaborate questioning and timely feedback. The format and nature of the material should also allow learners to become less inhibited. It should furthermore, change the classroom culture to one in which two-way-communication is more prevalent, with teachers increasingly adopting and adapting to the role of facilitator, rather then merely acting as instructors during the learning process.

It was hoped that this project would not only have a positive impact on the learning of Mathematics in the selected schools, but that the material could ultimately be distributed more widely to reach increasing numbers of learners in different languages. Efforts were geared towards improving the attitudes and performance of learners and teachers who participated in the selected schools. The degree or extent to which some of the goals can be achieved depends largely on factors which can be viewed as intervening variables. Some of these factors included the following:

- Learners should work through all modules in the recommended order, as supplied per grade by IMSTUS, with the necessary guidance and support from project teachers.
- Teachers should actively co-operate with project facilitators in transforming the classroom culture from a teacher-centred to a more learner-centred approach.
- Schools and teachers should utilise opportunities created by IMSTUS to enhance their learners' reading skills through specific, expert techniques.
- Teachers should attend regular focus group meetings and workshops.
- Teachers should be committed to changing their methods of assessment in accordance with the Revised National Curriculum Statement and in accordance with IMSTUS guidelines.
- Teachers should allow facilitators in their classrooms to observe lessons on a regular basis.

Through this process of intervention, IMSTUS wanted to ascertain whether these strategies would bring about a significant improvement in the nature of the learning and teaching culture that existed prior to 2003.

1.5.6.2 Region and population

Subjects in this study included 6 Mathematics teachers, and approximately 400 grade 7, 300 grade 8 and 300 grade 9 (Senior Phase) learners at three West Coast Winelands schools in the Piketberg region (Circuit 6). Both male and female teachers were included in the study. A standing agreement existed between IMSTUS and the Western Cape Education Department (as well as the EMDC) that allowed IMSTUS facilitators to work in the schools. A contract of co-operation between IMSTUS and individual schools was signed by participating schools. A copy of this contract is included as appendix A.

During the 2003 phase of the study there were 16 teachers involved in the project. Most of them were reluctant to allow themselves to be scrutinised by ‘outsiders’. These teachers did not participate fully in the project, since they did not attend all the workshops and cluster meetings. These are quarterly meetings prescribed by the Western Cape Education Department (WCED). Some were unwilling to incorporate OBE strategies and methodologies in their teaching practice. IMSTUS facilitators did not have the authority to enforce project intervention strategies. Consequently, it was decided to concentrate efforts on teachers who were really willing to change and not be afraid to be scrutinised and willing to expose themselves to external interventions. This first phase (2003) thus was to a great extent used to establish trust relationships and to analyze what was happening inside the Senior Phase mathematics classrooms. Simultaneously those teachers who were willing to be co-opted into a more in-dept research endeavour for at least three years were identified. Due to the fluidity of the teaching situation, a number of teachers also left the project, either moving to other schools in different circuits, others opting not to be involved in the project any longer, while others had to teach learning areas other than mathematics.

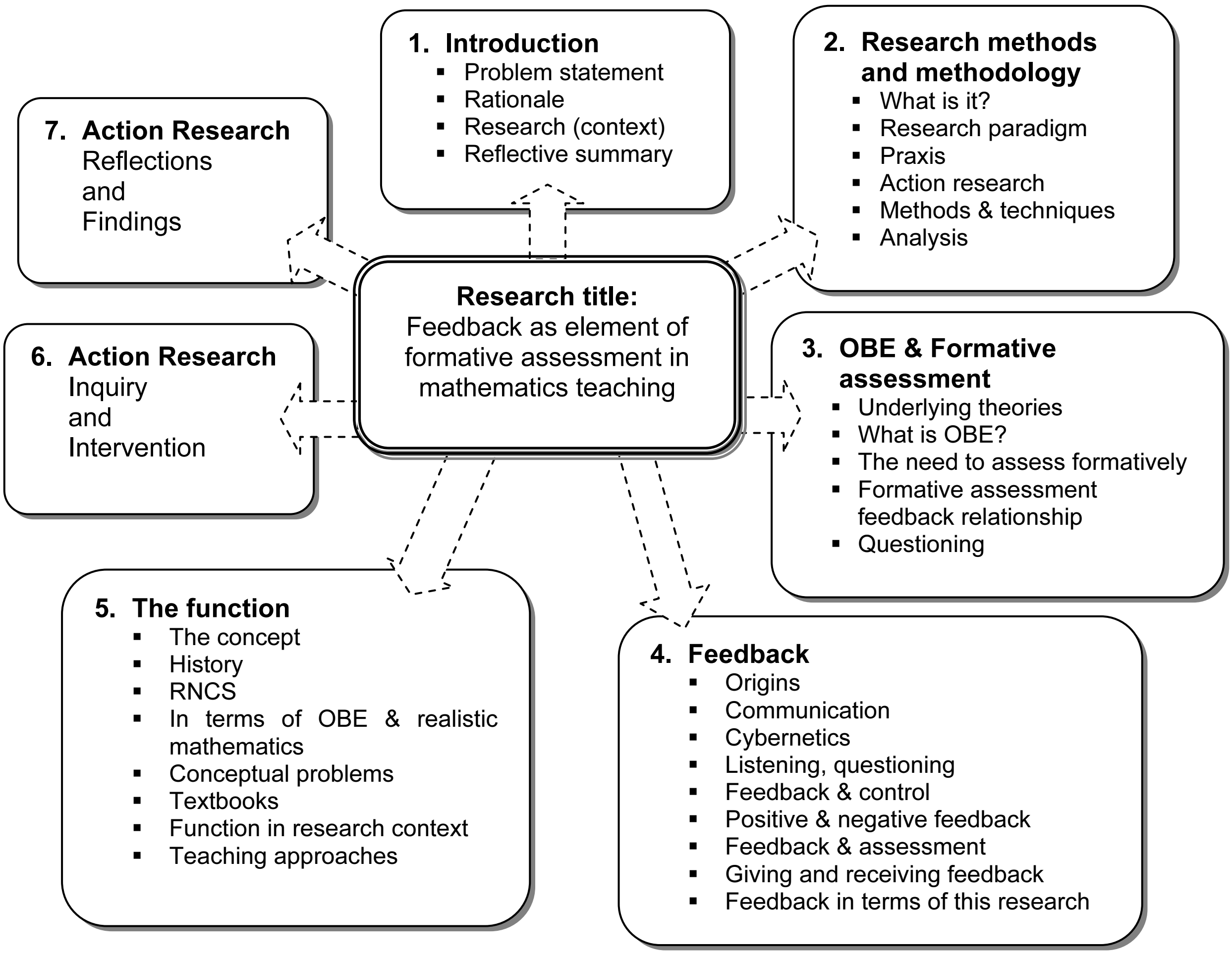
1.5.6.3 Needs that prompted this project

IMSTUS identified rural schools from historically disadvantaged communities in the Western Cape where learning and teaching time in the mathematics classroom could be increased. Productivity could be enhanced by changing certain aspects of the management of learning. Introducing learning material in the form of learner modules would not only have the potential to save time on copying notes from the writing board, but also allow more time for teacher facilitation and two-way communication, between learner and learner, and learner and teacher. Interaction with learning material could also be enhanced.

Initially learners were seen to play a rather passive role in the classroom, while the teacher was mostly the active party. This was not considered to be the ideal way in which to build essential mathematical constructs. Teachers and learners often associate learning with negative experiences because they had enjoyed so few success moments and because of the negative energy spent on disciplinary matters. Assessment was seen as something additional rather than integral to teaching (Neesom, 2000), and a means of comparing learners with one another rather than being criterion referenced. This is in strong contrast to the idea that assessment is actually a way of identifying the needs and learning problems of each learner on his/her road of progress and of addressing them for optimal learning.

1.6 A REFLECTIVE SUMMARY

This chapter was devoted mainly to the rationale for embarking on this research journey. I also described how the problem of feedback is linked to my experience in my dealings with teachers and observing lessons. The context within which the research occurred as part of one of the intervention projects run by an IMSTUS team was sketched. In the chapters to follow I will draw on and elaborate what has been shared here. This should "help me to be reflexive about what will unfold in the rest of the thesis" (Le Grange, 2001:18). The following diagram gives a bird's eye view of the structure and main aspects covered in this thesis. This is followed by a summary of what is contained in each of the chapters:



In essence **Chapter 2** provides my rationale for selecting and using a particular research methodology, as well as the methods I considered appropriate. Through a process of elimination I concluded that collaborative action research would best serve my collaboration with in-service teachers: it merges theory and practice and joins practicing teachers and researchers in a mutual search for improving teaching and learning.

I elaborately describe what action research entails as praxis, as opposed to more conventional positivist and interpretive research. All salient aspects related to action research are addressed – these include the meaning and use, variations and principles guiding this kind of research, positioning it in an appropriate paradigm, and with a short historical perspective. The different research methods and techniques are explained and a rationale for choosing particular methods is given. Lastly, I deal with contentious issues such as rigour and validity that have bearing on the credibility of my research.

In **Chapter 3** I zoom in on three important aspects. Firstly, I explore the learning theories that inform this research. Secondly, I focus on the purpose, principles and premises of Outcomes-based Education, the teaching philosophy on which our current education system. Finally, I discuss assessment, with the emphasis on formative assessment in mathematics education.

In this chapter the complex nature of the learning process and how formative assessment can be utilised to enhance learning and teaching are reflected upon. The salient features of particular theories that underly the learning process with respect to both children and adults as learners are discussed in an effort to position this research theoretically. At the same time I endeavour to come to grips with what different theories on the learning of mathematics entail.

Once again there is a deliberate effort made to show the inter-connectedness of communication (questioning and feedback), assessment, learning, teaching inside the OBE 'paradigm' with respect to mathematics teaching. OBE as philosophy that underlies our current education system is analysed with respect to purposes, premises and principles.

Chapter 4 forms the crux of this whole research. Feedback as concept and fundamental prerequisite for meaningful dialogue, conversation or other forms of communication is researched and analyzed. The way teachers use feedback in their classrooms prompted me to research what exactly is meant by feedback, how it impacts on the process of communication, what strategies and skills are required to improve feedback from teacher to learner, and what methods should be employed to facilitate feedback from learner to teacher.

The link between feedback and formative assessment is explored by focusing on listening and questioning strategies. These strategies not only determine the effectiveness of feedback, but ultimately determine the degree to which successful formative assessment influences optimal learning.

In **Chapter 5** the “function concept” as part of the senior phase curriculum is explored in an attempt to link it to the outcomes (in OBE) and assessment standards already discussed in Chapter 4. Questions such as the following are addressed: What is meant by the concept ‘function’? Where does the function concept fit into the current senior phase curriculum? How is the function concept viewed in terms of realistic mathematics education and outcomes-based education? What are the major conceptual problems encountered by learners? What is the prior mathematical knowledge required by senior phase learners? How do textbooks deal with the function concept? How is the function concept viewed within the context of this research? In short, I explore communication in terms of mathematics concepts, questioning and feedback.

At the outset of Chapter 5 I share reasons and provide a rationale for choosing functions as mathematics curriculum content to use in this research. This section of the curriculum is thus used to analyse how subject language or jargon, within the constraints of the extent to which listening, questioning and feedback are optimised, could facilitate or hamper understanding, concept formation and ultimately learning. These reasons include the significance of this aspect in mathematics, the difficulties learners encounter with respect to conceptualisation, and the way teachers deal with it inside the classroom. The concept of function is elaborated by exploring the viewpoint of various mathematics educationists. For instance, I expand on O’Callaghan’s function model, as well as DeMarois and Tall’s (1996a, 1996b and 1999) analysis in terms of facets and layers.

A short history of the function concept is given to put its development over many years into perspective. The position and importance of the function within the South African mathematics curriculum from Foundation Phase to Senior Phase is highlighted in terms of realistic mathematics education and outcomes-based education and the revised national curriculum statement (RNCS).

I draw on research literature in order to explore the most common difficulties that learners experience in trying to understand the function concept. I also highlight approaches relating to methodologies put forward by different mathematics educationists. It was important to familiarise myself with these issues in order to better understand and re-orientate myself in this regard. This is closely linked to the material development strategies that we employ in an effort to facilitate understanding and learning of mathematics in the senior phase.

The research chapters, **Chapter 6** and **Chapter 7**, provide a detailed discussion of some of the most important issues with respect to the action research cycles from 2003 to 2005 - also referred to in chapter 2. Each of the action research cycles is characterised by an initial period of assessing and analyzing the situation. This is followed by **Chapter 7** which deals with the implementation stage (and which essentially entails the intervention taken). In the final analysis observation and reflection were used to gauge and analyse success moments, the changes that occurred, and what needs to be addressed and explored further.

Chapter 6 focuses on information gathered throughout the three cycles. In essence, it is a discussion of what I observed during my interactions with teachers and learners, whether through classroom visits, focus group sessions or informal discussions. This information mainly refers to teaching or pedagogic aspects such as classroom culture and classroom organization and management. I also address other salient issues such as teachers' needs, teachers' perceptions regarding feedback and assessment, communication patterns in the classroom, teachers' listening and questioning skills.

In **Chapter 7**, I deal with my reflections and findings as they happened throughout the three action research cycles and build on those observations that appear in Chapter 6. Consequently, the discussions in this chapter deal with the outcomes achieved, and reflections on what worked, what needs to be changed and advancing suggestions or the strategies needed to transform learning.

CHAPTER 2: RESEARCH METHODOLOGY AND METHODS

Action research can lead to the improvement of techniques and efficiency, without actually challenging oppressive structures. It is only when a closer link between classroom practices and the socio-political context is made, that the possibility of emancipation can emerge. The question here is: Do we need an outside facilitator to bring about enlightenment (Julie, Manie, Nkosie and Sonn; 1993:125).

2.1 INTRODUCTION

This chapter traces my conscious effort to position my research in ontological, epistemological and axiological terms. This positioning process was ultimately framed by the choice of an appropriate research paradigm. Given the nature of reality in which this research occurs, it should be evident right through the chapter why action research as praxis was ultimately found to be the most appropriate methodological approach. The salient features of action research are discussed in detail and incorporate aspects such as: issues to consider when deciding on a particular methodology, the meaning of action research, variations of action research, principles guiding action research, positioning action research in a particular research paradigm, a short historical perspective of action research, the task of the action researcher, what ethical issues to consider, research methods and techniques used, dealing with rigour and validity, and ultimately the analysis of data and reporting of data.

Images from focus group sessions

Making sense …

Suggesting alternatives …

Sharing…

Conferring…

In searching for a rationale for selecting a particular research methodology, it is crucial to explore and critically analyse reasons why various education researchers such as Borgia (1996:1), Lousberg and Soler (1998:1), Masters (1995:1-9), and O'Brien (1998:2) selected action research as the appropriate research methodology for the kind of research situation I am in.

At the outset of this research the concept “action research” was not part of my active vocabulary nor of my latent vocabulary. Professor Le Grange suggested, in view of the way schools are structured, that I explore research other than experimental research to find the most suitable way to go about this study. Consequently, I decided to explore action research as a research methodology.

The following extracts from a discussion in Ferres and Gough (1999:4) strongly influenced my decision to undertake action research:

- Research purists want scientific rigour in their research, and the control of variables. But almost always scientific rigour has no place in a school, or is too technically restrictive. How can we attempt to control for such variables as the time of day when a lesson occurs … the school timetable is not able to be altered by the researchers? What about the variables involved in different teachers taking different classes? Even if we limit our study so that only one teacher teaches all the experimental groups, we are unable to control for the different prior influences of previous teachers, … Of course if we restrict our research to one-teacher schools, to increase our control over teacher-related experimental variables, we would then be unable to generalise any results, …

- Moreover the do-nothing requirements of a control group may not be ethically justified … Is it fair, for example, to allow one class … to have eight-hour-a-day access to one computer for each student, when the class next-door has no computer at all, ….

Certain research methods, whether qualitative or quantitative, are normally decided upon by researchers in response to particular research question(s) and conditions. Similarly, action research is found to be suitable in complex social circumstances where empirical research and random sampling are difficult to employ (Carr & Kemmis, 1986:162; MacIsaac, 1996:1; O’Brien, 1998:21; Winter, 1989:43-67). The methods used in action research are usually overwhelmingly qualitative by nature, as opposed to statistical ones (Kim, 2001:6; Lienert, 2002:4; Lousberg, 1998:1). However, a combination of qualitative and quantitative research methods are often used (Lienert, 2002:4).

2.2 IN SEARCH OF A SUITABLE METHODOLOGY

Firstly, the meaning of the term ‘methodology’ is explored. Then in Section 2.3 I deal with the meaning of ‘method’. The distinction between ‘methodology’ and ‘method’ is often blurred. Le Grange (2001:70), for instance, argues that these concepts are frequently used interchangeably, without clearly distinguishing the differences. In view of this difficulty and to clarify the matter in my own mind, it seems useful to briefly outline the meaning each of these terms has.

The term methodology according to Harding (1987:2 cited in Le Grange, 2001:70) generally refers to the "theory of knowledge and the imperative framework guiding a particular research project". Similarly, Hills & Mullett (2000:6) speak of "methodology as a conceptual framework for doing research that is grounded in theory". Somekh (1995:340) describes action research methodology as that which "bridges the divide between research and practice"; this corresponds to the methodology that "engages people in a transformative process by cycling through several iterations of action and reflection" (Hills & Mullett (2000:6).

Hills and Mullett (2000:6) describe 'methods' as techniques and procedures employed to generate data. Like Hills & Mullett's (2000:7), I believe that the methods employed to "collect information about people and the human condition derive from and are contained by the principles of <u>action</u> research, the preferred methodology …, and the research question."

2.2.1 Deciding on a Methodology

It is imperative to deal with one's underlying ontological, epistemological, methodological and axiological assumptions when attempting to select an appropriate research paradigm and methodology. Hills & Mullett (2000:6) mention ontology, epistemology, methodology (suggested by Guba and Lincoln, 1994), and axiology (Heron and Reason, 1997) as the "defining characteristics of a research paradigm. This process of selection not only impacts on the research design, but also on the outcomes of the research, according to Burrell and Morgan (cited in Roberts, 2002:2).

A seminal factor in any research is the underlying 'assumptions" the researcher might have about reality. Before looking at ontological and other assumptions in more depth, I first want to focus on the meaning and significance of the term 'assumption' briefly. Gay (1996:618) describes an assumption as "Any important 'fact' presumed to be true but not actually verified". Gittens (2002:3) maintains "Valid research … [to be] based upon some basic assumptions which relate to underlying epistemology … which guide the research".

'Ontology' refers to the nature of, or a particular view the researcher holds of reality. Hills and Mullett (2000:4) call ontology "the form and nature of reality and what can be known about it". According to the view underlying more conventional research there is only one reality observable to the researcher on which limited or no influence can be exerted. The opposite view is that reality is intimately connected to the researcher's mental perception(s) of the issues being researched. Not only the researcher, but also the situation being researched are affected. The notion of 'subjective-objective ontology" (Hills and Mullett, 2000:4) relates directly to this. According to Abram (1996:124) subjective-objective ontology implies that “underneath our literate abstraction, a deeply participatory relation of things and to the earth, a felt reciprocity” exists. According to Hills and Mullett (2000:4) this encounter is “transactional and interactive”:

> *To touch, see, or hear something or someone does not tell us either about our self all on its own or about a being out there all on its own. It tells us of being in a state of interrelation and co-presence with us. Our subjectivity feels the participation of what is there and is illuminated by it.*

‘Epistemology’, on the other hand, “… relates to how such assumptions can be known”, and also points towards “… the relationship assumed to be present between the knower and what is known or being sought to be known” (Roberts, 2002:2). Likewise, Hills and Mullett (2000:4) view epistemology as being concerned with the “the relationship between the knower and that what can be known”.

Of direct relevance to my research is Hills and Mullett’s (2000:4) notion of “extended epistemology that endorses the primacy of practical knowing”, and that the “knower participates in the known and that evidence is generated in at least four independent ways – experiential, presentational, propositional, and practical”. Experiential knowing relates to direct experiences and interactions with people, places or objects. Heron and Reason (1997:281) views it as “knowing through participatory, empathic resonance with a being, so that as the knower, I feel both attuned with it and distinct from it”. Similarly, Heron (1996:164) speaks of it as “lived experience of the mutual co-determination of person and world”. According to Hills and Mullett (2000:5) presentational knowing is “grounded in experiential knowing” and relates to the manner in which “we represent our experiences through spatio-temporal images such as drawing, writing, dance, art or stories”. Empirical knowing is described as “factual knowledge”, that is “knowing about something conceptually”, and expressed as statements, facts or theories. Hills and Mullett’s (2000:4), like Heron (1996:34), maintain that practical knowing has “primacy” in research such as action research, and that it is actually “knowing how to do something – knowledge in action”.

The term ‘axiology’, comes from the Greek, ‘axia’, meaning value or worth, and normally refers to the study of value or quality. In this research context it deals with “the nature of value and captures the value question of what is intrinsically worthwhile” (Hills and Mullett, 2000:6). As such axiology focuses on the “values of being, about what human states are to be valued simply because of what they are” (Heron & Reason, 1997:287). Hills and Mullett (2000:6) maintain that a research paradigm such as the participatory paradigm deals with the “axiological question in terms of human flourishing” which manifests as a “process of social participation in which there is mutually enabling balance, within and between people, of autonomy, co-operation and hierarchy".

These issues are elaborated in 2.2.5 where the aim is to position action research as methodology with respect to positivism, interpretivism and praxis. A few reasons spring to mind when it comes to making the appropriate choice of research methodology. It is imperative that it should be useful. The essential question that follows this statement is: To whom should it be useful? This question is addressed in the discussion that follows. Furthermore, it should also be 'user-friendly', meaning that it would allow collaborative research with teaching practitioners. In this sense Hollingsworth (1997:485) states that "Action Research done by and with practitioners is clearly more directly useful for practitioners". Apart from this, the research methodology should lend itself to being used in a dynamic classroom situation in which we need to consult or collaborate with different role players. As such it should be practice based, and process oriented to effect change to solve problems. Not only should the problem(s) encountered be viewed in context of mutually interdependent factors, but also allow all relevant individuals to participate. Furthermore it should be flexible regarding the use of qualitative and or quantitative data-gathering and analysis and interpretation methods (Kim, 2001:6; Lienert, 2002:4; Lousberg, 1998:1).

2.2.2 What is meant by Action Research?

When deciding on a particular methodology it is essential to establish what it entails as well as how it can facilitate the research being embarked on. The question that follows naturally is: What exactly is the research methodology and how can it be employed to address the research questions meaningfully?

Firstly, I want to examine various definitions and viewpoints put forward by different action researchers in an effort to encapsulate the meaning of action research as methodology. The following definitions that are listed describe the applications of action research to real-world problems. Hatten, Knapp and Salonga (1997:1) view action research as a "non-traditional form of research which is often community-based and carried out by a practitioner in the field". McKernan (1991:3) describes action research as an effort "to render the problematic social world understandable as well as to improve the quality of life in social settings". Elliott (cited in McKernan, 1991:3-4), views action research as "the study of a social situation with a view to improving the quality of action within it". Davison *et al.* (2002:3) consider that action research is ideal "for organizational research as it enables researchers to become deeply involved with the processes that take place in organizations". Rapoport's (1970:499) definition that "action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable framework" is according to McKernan (1991:4) closely related to action research being viewed as "a special type of applied research which involves participants experiencing problems directly in the search for a solution…"

Smith (2002:1) claims that the debate about action research can be classified into mainly two groupings, namely what he refers to as the "British tradition" on the one hand and that of the United States on the other. In the British tradition action research is closely related to research in education to improve practice directly. Carr and Kemmis (1986:162) as proponents of this viewpoint define action research as "… a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out." Hollingsworth (1997:485) emphasizes that the array of different outcomes that can be effectively addressed by action research as methodology depends on the people involved, the type of organization researched, contexts, and circumstances, but that "the common feature across those goals [*outcomes*] is [*was*] benevolent change to improve the human condition". Dadds (1995:135) cited in Hollingsworth, 1997) focuses on the particular value of action research as an instrument to facilitate transformation. He concludes that "[b]y its nature, definition and purpose, action research is oriented towards change, towards doing something useful with the knowledge gained …". With respect to the the United States tradition it is important to mention John Dewey's idea of "inquiry" which implies that "action research proceeds from a problematic situation to the resolution of the problem to the generation of a new problem" (Doer and Tinto, 2000:409), and where the "new problem comes in combination with changes in the context that result from interactions with the original problematic situation".

Some sources portray action research as the ideal research methodology when research in Education or the classroom has to be conducted (MacIsaac, 1996:1; Kim, 2001:6; Lienert, 2002:4; Lousberg & Soler, 1998: 1). Its suitability is captured by Lienert (2002:4) who claims that "An action research approach helps tailor projects to local situations. Put simply, it asks what works – how, when, where, for whom, and with what outcomes." Kim (2001:2) describes action research as easy-to-use, when arguing that "[a]rmed with a few basic research tools, and basic knowledge of the research paradigm, it is possible for teachers to conduct action research in their classrooms". To MacIsaac (1996:1) action research represents "a growing field of educational research whose chief identifying characteristic is [*was*] the recognition of the pragmatic requirements of educational practitioners for organized reflective inquiry into classroom instruction… to improve the practices conducted within the educational experience". Gray (2000:92) thinks of action research as a process of combining "thinking and doing". She goes as far as to claim that action research as methodology "… offer[s] a whole-system approach to integrating the researcher … with the researched … and embedding research in practice".

2.2.3 Variations of Action Research

It is important to examine the different types of action research that emerged through the years, that is from the 1940s onwards, and clearly position the action research in this study with respect to other types. The table below by Masters (1995:7), provides a useful outline of the essential differences:

	TECHNICAL ACTION RESEARCH	MUTUAL – COLLABORATION ACTION RESEARCH	PARTICIPATORY ACTION RESEARCH
Philosophical base	Natural Sciences	Historical	
Nature of reality	Single, measurable, fragmental	Multiple, constructed, holistic	Social, economic. Exists with problems of equity and hegemony
Problem	Defined in advance	Defined in situation	Defined in the situation based on values clarification
Relationship between the knower and the known	Separate	Interrelated, dialogic	Interrelated, embedded in society
Focus of collaboration theory	Technical validation, refinement, deduction	Mutual understanding, new theory, inductive	Mutual emancipation, validation, refinement, new theory, inductive deductive
Type of knowledge produced	Predictive	Descriptive	Predictive, descriptive
Change duration	Short lived	Longer lasting, dependent on individuals	Social change, emancipation
The nature of understanding	Events explained in terms of real causes and simultaneous effects	Events are understood through active mental work, interactions with external context, transactions between one's mental work and external context	Events are understood in terms of social and economic hindrances to true equity

	TECHNICAL ACTION RESEARCH	MUTUAL – COLLABORATION ACTION RESEARCH	PARTICIPATORY ACTION RESEARCH
The role of value in research	Value free	Value bounded	Related to values of equity
Purpose of laws underlying reality	Discovery of laws underlying reality	Understand what occurs and the meaning people make of phenomena	Uncover and understand what constrains equity and supports hegemony to free oneself of false consciousness and change practice toward more equity

Masters (1995:7)

Table 2.1 Types of action research

In terms of this table I would say that my research is overwhelmingly positioned in the third column, but elements of participatory action research in the fourth column are clearly present. Dick (1999: 2) mentioned the fact that "several varieties of action research" existed, similar in a particular sense, namely "that they are oriented towards achieving two sets of outcomes at the same time: action and research". Grundy (1982 cited in Masters, 1995:8) maintains the differences in the modes of action research does not relate to the methodologies, "but rather in the underlying assumptions and world views of the participants".

My research thus resembles what Sachs (1999:44) calls "collaborative inquiry". She describes this process of research as "what occurs when teacher educators and practising teachers engage in processes of collaboration which articulate academic research and practitioner research". This implies that the participating teachers ascertain the worth of the "cross-contextual kind of research" with respect to their own action research inputs, "and accordingly can situate their reflective practice in a wider context of information and school reform" (Sachs, 1999:44).

The reason for using collaborative inquiry is also based on Fullan and Hargreaves' (1991) stance, cited by Fullan (1993:5) that "There is a ceiling effect to how much we can learn if we keep to ourselves". Fullan also states on the same page that to collaborate "… is becoming one of the core requisites of postmodern society" and that "personal strength … goes hand-in-hand with effective collaboration". At the same time we as teacher researchers "become directly acquainted with what it means to be engaged in continuous improvement in teaching and learning in a specific context", but also "become aware of what teachers regard as important and relevant and why" (Sachs, 1999:44).

2.2.4 Principles guiding Action Research

Winter (1989:43-67) cited by O'Brien (1998:6-9), presents a broad outline of the principles he believes guide action research, namely (i) Reflective critique, (ii) Dialectical critique, (iii) Collaborative resource, (iv) Risk, (v) Plural Structure, (vi) Theory, practice, transformation.

"Reflective critique" (Winter, 1989:43), also referred to by MacIsaac (1996:4) as "reflection-in-action", not only involves documenting what is found and experienced in a manner that is honest and factual, it is also intimately linked to how the researcher(s) and other collaborators reflect on relevant aspects and processes (O'Brien; 1998:6). Elliot cited in MacIsaac, 1996:4), expresses the view that action research is "intended to be the reflective counterpart of practical diagnosis". This mechanism ensures that those involved in the research "reflect on issues and processes and make explicit the interpretations, biases, assumptions and concerns upon which judgments are made" (O'Brien; 1998:6).

"Dialectical critique" for Winter (1989:52) means to "subject observed phenomena to a 'critique'", and also refers to the ways in which language is used in communicating, and conceptualising the phenomena encountered (MacIsaac,1996:1). Kemmis and McTaggart (1990:122) emphasise the need for communication between research participants, saying that "[s]ince action research looks at a problem from the point of view of those involved it can only be validated in unconstrained dialogue with them…" and as such necessitates a "free information flow between them". O'Brien (1998:6), on the other hand, takes a more critical stance: "Phenomena are conceptualized in dialogue, therefore a dialectical critique is required to understand the set of relationships both between the phenomenon and its context and between the elements constituting the phenomenon".

The term "Collaborative resource" (Winter, 1989:55-59) relates to the roles of all those participating in a particular action research project as equal partners; the views and contributions of one should not be deemed more important than another merely because of a particular position held.

The principle of "risk" refers the omni-presence of change, and the fact that everything (such as ideas, ways of approaching or dealing with issues) is threatened by change and that nothing remains constant or unchanged. This creates uncertainty among participants. Consequently, this information should be shared with all involved in the research, and all should be "subject to the same process" (O'Brien, 1998:8).

Winter (1989:60) sees the following as at risk or subject to transformation:

1 Researchers' provisional interpretations of the situation, which become merely 'resources' along those of other members;

2 Researchers' decisions as to the questions at issue, and thus concerning what is and what is not relevant;

3 Researchers' anticipations of the sequence of events through which the investigation will pass."

The "plural structure" (Winter, 1989:62) of action research points to the fact it "embodies a multiplicity of views, commentaries and critiques, leading to multiple possible actions and interpretations" … and as such "… requires a plural text for reporting" (O'Brien; 1998: 8).

The sixth principle points to the cyclic nature of action research. This principle, "Theory, practice, transformation" (Winter, 1989:65) focuses on the nature of the "… relationship between theory and practice .." and … research and action…". From this it becomes evident that "[f]or action researchers, theory informs practice, [and] practice refines theory, in a continuous transformation". (O'Brien, 1998:9).

2.2.5 Positioning Action Research in a Research Paradigm

What is a research paradigm? Why is it essential to have to position action research within a particular paradigm? These questions will be addressed in the discussion that follows.

The concept 'paradigm' is quite often interpreted as "a worldview, which offers compelling explanations concerning the phenomenal world" (Fox & Gill, 2003:2). Guba and Lincoln (1994:105) refer to the concept 'paradigm' as a "set of basic beliefs … that deals with ultimates or first principles". According to them, it furthermore "represents a world view that defines, for its holder, the nature of the world, the individual's place in it, and the range of possible relationships to that world and its parts. In similar vein Lather (1986:259), drawing on Bernstein, Fay, Habermas and Hesse, refers to a paradigm as that which "inherently reflect[s] our beliefs about the world we live in and want to live in". The meaning of this concept, however, cannot only be understood from this perspective, since there are several other paradigms that researchers can choose from. These alternative paradigms, according Fox & Gill (2003:2) allow researchers to compare the findings of research studies on particular phenomena with findings on them in studies from alternate conceptual paradigms.

The different research paradigms are characterized by distinctive methodology and methods by means of which researchers develop their assertions with respect to what really happens in reality (Lather, 1986:258; Fox & Gill, 2003:2). According to Morris (cited in Fox & Gill, 2003:3), "[t]he etymology of the word itself imparts a helpful indication of its root meanings in Greek: *paradeigma* (model), from *paradeiknunai* (to compare, exhibit); *para* (alongside) + *deiknunai* (to show)".

2.2.5.1 Positivist Paradigm

Positivism is viewed as having been the dominant research paradigm for many years (O'Brien, 1998:10). Horton & Hanes (1993:2) describe positivism as an attempt to "… explain, predict, and control", and "… based upon the premise that there is an objective reality that can be fragmented, compartmentalized, and once understood, predicted and controlled". Since knowledge is viewed as value free and objective, the resultant dualism between the knower and the known means that implications related to political, economic and social aspects are ignored or excluded.

According to Hollingsworth (1997:485) researchers who advocate positivistic approaches "on knowledge assume that those with distanced and 'objective' views of practice can best understand and guide practitioners who are seen as 'too close' to practice to hold an accurate perception". I agree with her when she refers to this viewpoint as "… a hegemonic understanding of knowledge …" (Hollingsworth, 1997:485), which implies that practitioners are unable to understand their own practice, and are dependent on outsiders to clarify and interpret it to them. In this regard Winter (1989:27) is adamant that action researchers "… cannot simply use the research methods …" conventionally used by positivists. O'Brien (1998:10) states that "Positivism, used in scientific and applied research, has been considered by many to be the antithesis of the principles of action research."

2.2.5.2 Interpretive Paradigm

The interpretive paradigm developed in response to positivism. It is viewed by O'Brien (1998:11) as a reply by those in the social and human sciences "to break out of the constraints imposed by positivism". The interpretive approach is geared towards research that involves "… socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at understandings and interpretations of how people create and maintain their social worlds" (Neuman, 1991:68). It thus is concerned not only with how people experience and make sense of the world, but also examines the ways in which they interact and the circumstances or settings in which those interactions occur.

Methodological approaches such as phenomenology, ethnography and hermeneutics are closely aligned to this paradigm. (O'Brien, 1998:11). It reflects the belief that reality is socially constructed as well as subjectively based, since it is culturally and historically influenced. Hermeneutics, for instance, focuses on "… individual and group interpretations of reality within specific content to historical, societal, and cultural factors" (Horton & Hanes, 1993:3). Thus research methods are applied that "… try to describe and interpret people's feelings and experiences in human terms rather than through quantification and measurement" (Terre Blanche & Kelly, 1999:123).

The shortcomings with respect to the interpretive paradigm are perceived to be centred in the "… role of the researcher and practitioner in regard to subjectivity" and their attempt to separate themselves from "… their personal value theories in an attempt to be objective…" (Horton & Hanes, 1993:4). Likewise, O'Brien (1998:11) says of the interpretive paradigm: "… it still retains the ideals of researcher objectivity, and researcher as passive collector and expert interpreter of data".

2.2.5.3 Paradigm of Praxis

Many researchers (among others, Lather (1986), MacIsaac (1996), Morley (1991), Smith, (1999)) hold the view that the aforementioned positivist and interpretive research paradigms are not adequate epistemological structures to effectively deal with action research (O'Brien, 1998:11). Praxis is seen as the most suitable paradigm to accommodate action research(ers).

Gabel (1995:4) views the concept of praxis as the crucial element that characterises action research. Research as praxis is also described as the marriage between theory and practice, which implies integrating the processes of research and action, or as Hughes (2002:1) puts it: The "integration of theory and practice, the integration of research and action". "Praxis", also linked to "emancipatory research" (Oliver, 2002:2), is derived form the Greek. What is relevant here, is Aristotle's usage of the concept, namely that "… praxis is conscious rational action on a decision, it is quality of doing while in conscious awareness of what you are doing" (Hughes, 2002:1). Or as Smith (1999:2) puts it "… for Aristotle, *praxis* is guided by a moral disposition to act truly and rightly; a concern to further human well being and the good life". Aristotle felt that both theory and action were equally important and intimately interwoven. O'Brien (1998: 12) elaborates as follows: "That knowledge is derived from practice, and practice informed by knowledge, in an ongoing process, is a cornerstone of action research."

According to Smith (1999:2) praxis implies that the researcher cannot know beforehand what would be the correct process or way by which to realize how a particular situation might ultimately look. Bernstein (1983:147) pointed out that the final or ultimate situation is only specified in deliberating about the means suitable to a specific circumstance or situation. In this respect Smith (1999:3) wrote that this is so because "As we think about what we want to achieve, we alter the way we might achieve it".

It is thus clear that praxis entails much more than just reflecting on practice (Carr & Kemmis, 1986:190; Lather, 1986:269; Smith, 1999:3). It also involves action geared towards improving the circumstances or conditions of the people concerned, the search for truth or that which is real, while working within a framework of respect for other people.

2.2.6 A Historical Perspective of Action Research

It is clear from literature on action research that the concept action research has been around for quite a number of years (Feldman, 1994a:83-86; Hart, 2003:4; Masters, 1995:1; O'Brien, 1998:12; Smith, 2002:2). Kurt Lewin, a German social and experimental psychologist, is generally viewed as the person who first used the term 'action research' in the latter part of the 1940s and the 1950s (Masters, 1995:1; O'Brien, 1998:12).

Weiner (2003:7) and Feldman (1994a:2) also mention Stephen Corey's involvement with respect to the development of action research in the United States during more or less the same period. Corey was especially influential in promoting the wider use of action research methodology in educational institutions such as schools to hasten or effect curriculum change. According to Noffke (cited in Feldman, 1994a:2) "… Lewin's conception of action research was of practitioners in the field doing research to enact change, [while] Corey appeared to have been more concerned with generating knowledge through hypothesis testing, and in encouraging the acceptance of action research as a legitimate form of educational research".

From the 1970s onward the focus was on action research characterized by the teacher-as-researcher in response to the opposition to the secondary education system that prevailed in the UK then. This trend was developed by Stenhouse and Elliot from the UK. Kemmis, an Australian, and Carr, an Englishman, were responsible for developing the concept of critical action research. The tendency was toward developing teachers to become "… more critical and active in changing the conditions under which they work" (Weiner, 2003:8).

The term 'participatory action research' is associated with Australia during the 1970s and 1980s, concerned with political, social and economic conditions and emphasizing educators as "… producers of educational knowledge" (Weiner, 2003:8). The movement developed its own practices and epistemology with "emphasis on promotion of equity and social justice in schools and society through a number of projects advocating critique and emancipation" (Weiner, 2003:8).

Action research in the United States from the 1980's is viewed as the "teacher researcher movement" and is characterized by empirical and conceptual partnerships between teachers and university academics. Weiner (2003:8) writes that this was the result of among others, "… the growing acceptance of qualitative and small-scale research, the pioneering work of individual teachers, and the promotion of action research in university education departments".

2.2.7 The task of the Action Researcher

The role as action researcher is a multifaceted and intricate one (O'Brien, 1998:19; Wadsworth, 1998:6). O'Brien (1998:19-20) identifies the following roles evident at different stages of the action research process, namely that of "planner, leader, catalyser, facilitator, teacher, designer, listener, observer, synthesizer and reporter". These roles, not necessarily always easily discernable, should enable the action researcher to conduct research in a way that generates results that satisfy all role players, and empowers local participants to take charge of the process themselves. According to O'Brien (1998:20) the role of the researcher is essentially "… to facilitate dialogue and foster reflective analysis among participants, provide them with periodic reports, and write a final report when the researcher's involvement has ended".

Wadsworth (1998:6) summarises the role of action researchers as "really just researchers who have come to understand the practical and ethical implications of the inevitability of the value-driven and action-effects of their inquiry. These include

- the effects of raising some questions and not others;
- the effects of involving some people in the process … and not others;
- the effects of observing some phenomena and not others, the effects of making this particular sense of it and not an alternative one;
- the effects of deciding to take particular action (or 'no' action) as a result of the need that exists, rather than any other action and so on".

2.2.8 Action research and emancipation

Our (South African) history of oppression, and the political restrictions associated with the previous dispensation of apartheid that we had to endure and operate under, adversely affected our progress and development, socially and educationally. As such it is impossible to talk about action research without also considering its power in bringing about a certain degree of emancipation (Davidoff, Julie, Meerkotter and Robinson, 1993) especially for teachers who have to teach a curriculum, essentially decided upon and implemented by politicians of the day.

Action research is described by Kriel (1993:33) as "a form of educational research in which participants engage in a critical process of deconstructing the values, assumptions and interests underlying social practice to uncover different understandings of reality and power relations". To a large extent this description relates very closely to what this study aims to do, namely to change communication patterns inside the mathematics classroom. This has implications for existing teacher-learner power relations if the learners are to be afforded a greater 'say' in communicating their viewpoints, not only to the teacher, but also to peers. This would ultimately change the role of the teacher from that of transmitting facts, knowledge and algorithms or recipes to that of facilitating problem-solving and learning.

Skills provided and acquired by teachers during the course of this project, however, should also give them the confidence to 'stand up' to so-called curriculum advisors and curriculum managers to state their case and to motivate how they view things, or why they do things in a particular way. Emancipation could also come in the form of the ability to work more smartly and effectively to overcome some of the restrictions placed on them in terms of teaching the curriculum under mostly unfavourable conditions.

2.2.9 Ethical Issues to consider

Action research is described as being conducted in real world situations or circumstances Bogdan & Biklen, 1992:223; Carr & Kemmis, 1986:162; Dick, 2000: 7; Gabel, 1995:1; O'Brien, 1998:21). The action research process thus entails "open and close communication among the people involved" (O'Brien, 1998:21), and consequently the ethical domain needs to be focused on as a matter of great importance. As Dick (2002:21) puts it: "Ethical issues are inherent in any research study" and as such I also have to address these related issues in my research. Kelly (2001:101) emphasised the fact that "As researchers we were not neutral outsiders, observing and recording the participant's views; on the contrary we were actively engaged with the situation we were studying". As such action research is seen as value laden. Apart from this, says Kelly (1989:111), the ethical issue of "… gaining the informed consent of teachers" needs to be considered.

According to Winter (1996:16-17) certain important guidelines should be adhered to, namely that all relevant role-players, including individuals and groupings such as committees, authorities (local or provincial) need to be consulted, with prior approval of principles that guide the work program. Secondly, nobody's ideas or influences should be negated as meaningless or worthless, and wishes of those who refuse to participate or want to withdraw at a later stage should be honoured. Fourthly, the whole process should be transparent and open to ideas or suggestions. Winter, furthermore, suggested that permission "be obtained before making observations or examining documents produced for other purposes" (Winter, 1996:17). Fifthly, he stated that the use of other people's work and viewpoints needed to be negotiated prior to publication. Lastly, he claimed that the researcher was responsible for "maintaining confidentiality". Consequently, "… researchers need to regularly reflect on their work so as to develop their understanding of the ethical implications associated with social and educational investigation" (Burgess, 1989:8).

2.3 RESEARCH METHODS AND TECHNIQUES

The research methods chosen usually correspond to the particular research question(s) to be addressed (Borgia & Schuler, 1996:2). In addition, methods used in action research tend to be qualitative by nature, "with an emphasis on discovery and interpretation" (Borgia & Schuler, 1996:2).

At this point it might be appropriate to quote from an article by Lienert (2002:4) on the appropriateness of certain methods with respect to action research: "Rather than using surveys or statistics or comparing one group with another, the practitioners of action research are more likely to value and interpret people's experiences and stories (although action research may still include surveys and statistics or other scientific research methods if they suit the project). It is generally agreed that more traditional approaches cannot achieve the insights that come from people's experiences. Stories add colour, character and a new culture to the evaluation process." (Crane and Richardson)

Preference is normally given to methods such as interviews, participant observation, case study, and narration (Winter, 1989:20). Borgia and Schuler (1996:2) refer to "in-depth interviews, participant observation, case study, self-study, and telling of stories" as "preferred methods". Documenting occurs by means of "… carefully detailed description of people, events, and settings; field notes; interactive journals; memos; minutes of meetings; transcriptions; portfolios; photographs; films; and tape recordings" (Borgia & Schuler, 1996:2).

The following methods of data gathering are intended to gather information about the situation in the schools identified "… so that preliminary interpretations can be checked", for "making systematic records …", "… making permanent records …", and "… collecting detailed statements from …" (Winter, 1989:20) the relevant persons involved. The following discussion deals with the different methods used in this research to gather sufficient data to effectively address the research questions, as well as discussing reasons for using these methods.

2.3.1 Keeping a research journal

Researchers such as those referred to below emphasise the importance of keeping a journal. This can serve as an efficient way of preserving field observations. Keeping a journal regularly requires great amounts of discipline. Initially it was hard for me to get into the routine of recording all relevant data, happenings, and activities that had bearing on the progress of the study. I, however, realised that it was crucial to keep a regular journal. I had to train myself, once back in my office or at home, to elaborate on my brief notes made during actual field observation.

Researchers such as Le Grange (2001) and Rowley (2003) emphasise the importance of this practice to obtain valuable chronological facts of ongoing research. According to Fischer (2001) and Hubbard & Power (1999 cited in Dick, 2002:18) the benefit of keeping a journal is that "… it helps in finding patterns, themes and connections, analysing events, interpreting information, and making tentative conclusions".

Rowley (2003:131) describes a journal simply as "… a note of observations and experience". She also refers to it as "… essentially chronological records …". Hughes (1996:1) views it as "a record of the researcher's involvement in a project".

Meloy (1994) cited by Le Grange (2001) warns that journal accounts should not merely be factual, but should express or give a sense of how the researcher experienced his or her participation in a particular situation. The value of keeping a research journal is situated in the fact that it "… encourages reflection, and develops insights into both cognitive and behavioural elements of the situation", proclaims Rowley (2003:135). She continues by saying that the act of keeping a research journal regularly, "… imposes a discipline and a structure on the research process and ensures that events and responses to those events are captured when they happen", and it enhances "… the researcher's ability to identify key events and interpret responses". Not only does a research journal allow "retrospective comparison of journal entries", it also assists the researcher(s) "to identify patterns, and trends, and to anticipate responses, events and experiences".

Hughes (1996:1) provides four main reasons for keeping a research journal, namely to: "generate a history of the project, your thinking and the research process"; "provide material for reflection"; "provide data on the research process"; and "record the development of your research skills". In addition to these he maintains that it is helpful to use it in such a way as to explore you own practices, to use it as a "mirror in which you find yourself reflected", to "get practice and gain confidence in recording research and writing", "be empowered … through sharing experience with peers", and engage in supportive but critical interaction between peers and participants".

What should be recorded in a journal or diary? From the literature consulted the following appear to be the most important aspects to cover, namely: 1. Summaries of what transpires every day the project is being worked on; 2. Narratives of conversations, discussions, interviews, planning and focus group sessions, etc. with mentors, peers, co-researchers, participant teachers and learners; 3. Questions and relevant or related topics to pursue or to investigate; 4. Ideas, notions, hunches, thoughts, etc; 5. Diagrams, drawings, graphs; 6. Observations, perceptions and reflections; 7. Reflections of occurrences observed, experiences, discussions; 8. Reflections on the journal entries and plans for future action and [or] research (Hughes, 1996:1).

2.3.2 Questionnaires

In my research I have made frequent use of questionnaires as a way to gather information regarding certain relevant circumstances; to ascertain teachers' attitudes with respect to certain issues; to determine teachers' knowledge and insight into certain aspects relating to formative assessment; feedback, etc. McKernan (1991:126) describes the "questionnaire approach to gathering data [as] probably the most commonly used method of inquiry". He furthermore calls it "easy to administer", since it "provides direct responses of both factual and attitudinal information, and makes tabulation of responses quite effortless".

I found questionnaires to be effective data-gathering tools. As such I have taken great care with respect to design and question formulation. Questionnaires were also peer reviewed and scrutinised by experts in my department to increase validity, prior to distribution to respondents. Although a questionnaire is flexible in what can be measured one should bear in mind that the process of answering it should be considered "as multi-stage process beginning with definition of the aspects to be examined and ending with interpretation of results" (Gatech, 1997:1). Another reason for using questionnaires was to corroborate certain findings, such as for instance teachers' way of questioning learners in class as observed during class visits and lesson observation.

2.3.3 Classroom observation and field notes

I view the observation of lessons as an important and effective way to gather information and data about what transpire in classrooms. In my position as observer I engaged the teacher as collaborator, by sharing observations, and discussing reasons for certain behaviours or activities that I observed. I continually try to systematise my classroom observations by using checklists, and observation schedules to record and focus on particular aspects of communication and learner-teacher interaction.

My field notes include a mixture of all three types distinguished by (McKernan, 1991:94). Firstly, I use "observational field notes" that focus on "events experienced through direct listening and watching in the setting", and meant to be accurate descriptions, "rather than interpretation". Secondly, I also make use of what (McKernan, 1991:94) calls "conceptual field notes". He describes these as "self-conscious attempts to glean meaning from observations", by attempting "to look at the facts and then to construct a personal statement of their importance and significance". Thirdly, I use "procedural field notes" to "describe procedures, methods and operation", meant as a type of "observational note on the research process itself or on the researcher's work" (McKernan, 1991:95).

Although teachers' perceptions and explanations of what occurs in their classrooms are important, their "own accounts necessarily reflect their perceptions of what they do, but it is well known that such perceptions are dependent on personal interpretations both of what is intended and of what happens in practice" (McPake *et al*, 1999:2). They also point out that lesson observation should be done in conjunction with interviews with both learners and teachers "… so as to tap the thinking behind actions and the perception of each party of the others' actions" (McPake et al, 1999:3). Furthermore, I adopted, as suggested by Wilkerson (2002:1), a collaborative approach, by recognising the professional status of the teacher and to help "reduce the threat often perceived by the teacher in being observed, lessen the impact of observer bias, and enhance the skills of the teacher in accurately assessing and improving his or her own teaching".

I spent many hours in the classrooms of the participant mathematics teachers. My involvement was based on a relationship of mutual trust. My role inside the classroom developed over years, from being a non-participant observer to that of participant observer and occasional co-teacher, at the same time trying to assert myself as an observer. I consciously tried to adhere to the observer suggestions put forward by Chesterfield (1997:9) by recognising the teachers as experts of what goes on at the school, by being sensitive, considerate and helpful where possible, by interacting with teachers, learners and other staff members, by being less of an evaluator and more of a listener and confidant, and by recording as many events, impressions and personal feelings as possible in a research diary.

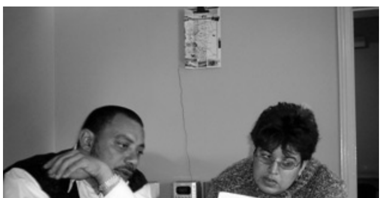
My observation strategies are similar to the ones described by Chesterfield (1997:11). During the earlier stages of my research I acted as non-participant observer, counting groups, drawing sketches of seating arrangements, and having minimal or no contact with the teacher and learners, and not being part of the "main action" inside the classroom. I would also sometimes sit in a learner desk, still not taking part in the classroom activities, but primarily focusing on teacher-learner interaction and communication. At other times I would walk around in class to listen to learner-learner verbal exchanges in small group discussions or teacher interactions with groups or individual learners around the classroom.

I have developed several observational instruments (included in the appendices to collect information in a more systematic way. These instruments also served to help me focus on specific aspects of a lesson to be addressed during post-lesson discussion and reflection. I aimed at gathering descriptive data used to analyse jointly (the teacher and myself) during post-lesson reflection. Like Wilkerson (2002:4) I used "a narrative system in which I attempt to record as much as possible of the verbal and nonverbal behaviours of the teacher and the students during the class period".

2.3.4 Focus group discussions

What is meant by focus group discussion? Why do I use this communication format in my research? Readings from researchers such as Dreachslin (1999), Kelly (2001), Krueger (1994), Nairne (2000), Nielsen (1997), Smith and Mander (2002) provided information to help me answer these questions.

Smith and Mander (2002:1) simply view a focus group session as “a group brainstorming session run by a moderator”. Kelly (2001:1) describes it as “a qualitative method of social science research” used in a variety of fields. Dreachslin (1999:226) aptly describes it as “a structured group interview technique that is … a qualitative, ethnographic data collection and analysis approach which is uniquely well suited to the assessment of adult learners’ satisfaction”. My reason for using focus group discussions also lies in the advantages set out by Kelly (2001:1) who maintains that it “can uncover and explain issues and reactions which may not be expected, anticipated or even surfaced during general qualitative surveys, questionnaires …”, it is a source of “rich and insightful information, data and feedback”, matters that are important to the “participants often emerge and decision makers can proceed with greater confidence than otherwise might be the case”, and crucial aspects related to the research “can be examined in-depth, as opposed to a general quantitative survey which is often confined by the survey structure and timing”. Krueger (1994:10) believes that the effectiveness of focus group discussion lies in its ability to “tap into human tendencies. Attitudes and perceptions relating to concepts, products, services, or programs are developed in part by interaction with other people … Often the questions asked in a focused interview are deceptively simple … When questions are asked in a group environment and nourished by skilful probing, the results are candid portraits of customer perceptions”.


Analysing …


Discussions on the stoep …


and in the backyard

It is clear from the above discussion that focus group discussions are invaluable with respect to feedback received from the teacher participants, not only to gather information regarding their needs, but also how they feel about crucial or salient aspects of their work and practices. As such, I, together with my peer researchers have used focus group discussions to listen and learn from the participant teachers. It is evident that teachers used this to compare and share ideas, experiences and problems (Nielsen, 1997:2). The interaction between teachers, and open and frank discussion were some of the advantages that flowed from this method of communication. I have tried to make the focus group sessions “free-flowing and relatively unstructured” as suggested by Nielsen (1997:2), yet at the same time, as facilitator, “follow a pre-planned script of specific issues and set goals for the type of information gathered”.

2.3.5 Using video-recordings for observing teacher-learner communication

In this study I made ample use of video recordings (as one of several means) to collect data of teaching moments. It should be emphasised that the limitations of this means of gathering data is realised, and attention is also given to this aspect. The reasons for resorting to this form of technology can be found in the following discussion. The similarities with respect to the advantages of capturing lessons on video are evident as portrayed by Curtis and Cheng (1998), DuFon (2002), Plowman (1999), Roschelle (2000), and Winter (1989). McKernan (1991:102) describes video recording as having “become the most indispensable tool for all those conducting observational studies in naturalistic settings”.

Using video-recording together with other observation instruments sounded to me like an excellent idea to assist researchers to gain a more comprehensive picture of what transpires in mathematics classrooms. Plowman (1999:1) rightly warns that the use of video-recordings should not be considered “… as a substitute for other forms of data collection …”. She admits, however, that “… it offers a number of advantages, such as the permanence of record, the retrievability of data to share with others, being able to check findings and easy reinterpretation”.

Video-recordings are used to study classroom activities and communication, as well as to monitor “… other observable dimensions …” (Winter, 1989:22). He continues by saying that video-recording “… enables repeated viewing …”, allowing the researcher “… to notice ‘surprising’ features of the situation which one initially glossed over under the influence of a general impression of familiarity.”

Roschelle (2000:709) provides similar positive reasons for using video-recordings to research classroom activities, saying that “Videotape can preserve more aspects of interaction including talking, gesture, eye gaze, manipulatives, and computer displays. … [Videotaping] allows repeated observation of the same event and supports microanalysis and multidisciplinary analysis. … enables researchers to leave controlled laboratory settings to enter naturalistic fieldwork. Finally, video provides analytical benefits: It can support grounded theory, whereby the emergence of new categories from source materials is rigorously controlled. Video can avoid the “what I say” versus “what I do” problem that can occur in self-reports. Video supports a critical incident methodology but also allows examination of the antecedents of the critical event."

Plowman (1999:1), like Curtis and Cheng (1998:4) speaks of the "…richness of information in video recordings…" which "…enables researchers to capture some of the complexities of learning experiences…". She assigns (1999: 1) the following advantages to the use of video recordings in research, namely "…permanence of record, the retrievability of data to share with others, being able to check findings and easy reinterpretation…". Edwards and Westgate (1987) cited by Bowman (1994:1) speak of the "retrospective analysis – at leisure, and in much greater depth than would have been possible even using techniques involving live coding".

DuFon (2002:43) describes data generated by means of video recording as having a higher degree of context(uality) than, for instance, audio recordings. She maintains, furthermore that it provides "…a more complete sense of who the people are, and acquaint us with the setting in which the people function and the type of activities they engage in from day-to-day as well as the nature of these activities themselves".

The following aspects concerning the use of video recordings in research are referred to since it relates very directly and intimately with the study of feedback in verbal classroom conversation or communication. Video recording not only allows the researcher

> *…to accurately identify who is speaking, but also … provides information about posture, gestures, clothing, and proxemics, which informs us regarding native speaker norms with respect to these features and the degree to which the learners conform to them… Gestures, facial expressions, and other visual interactional cues also provide important information on the negotiation of meaning and the negotiation of affect. … this kind of visual information can help us to disambiguate verbal messages by narrowing down the possible number of accurate interpretations … The visual information in videos also provides information on directionality and intensity of attention, which can be particularly useful in determining the levels of comfort and involvement of the interlocutors …". (DuFon, 2002:44)*

Finally it is claimed by Pfeiffer-Childs, Grant, Reston, McClain, Romagnand, Thompson and Wilsman (2001) that "By fostering the study of teaching, of learning teaching, and learning to teach, video-centred professional development can create collaborative reflective communities of professionals who engage in an extended conversation about their own practice and the practices of others".

2.3.6 Audio-recordings of mathematics lessons

I have found audio recordings to be a convenient way of gathering data. It allowed me to take part in discussions, interviews and post lesson reflections more readily and effectively and without worrying too much about writing down what is said. As a way of gathering accurate and reliable data audio recordings are frequently used (Lewis, 1995:5; Parent-Perez, 2002:245-254; Stockdale, 2003:14; Winter, 1989:22). Stockdale (2003:14) found portable cassette recorders to be the most widely used when it comes to recording interviews. I have mostly used the portable recorder, and tend to agree with Stockdale that the limited recording time was indeed a drawback (Stockdale, 2003:14).

Interviews, discussions and lesson presentations were tape-recorded. Learners' small group discussions were also recorded, concentrating on group dynamics and learner interaction. Lewis (1995:5) views audio recorders as "invaluable for group discussions", and according to Winter (1989:22) audio-recordings "… provide an objective record, which can be listened to repeatedly and/or transcribed, so that patterns or interaction or 'revealing' comments that go unnoticed at the time can be noted for detailed commentary." Similarly, Dick (2002:24) views audio tapes as additional tools to observational data, with the benefit of listening and observing "more intently and repeatedly".

McKernan (1991:106) also views audio-tape recording as a "popular technique for the classroom researcher since it allows for the creation of verbal interaction and its transcription". Not only is it "an ideal way of exploring the narrative aspects of segments of a lesson or lesson being investigated", but listening to the same recording several times may also "reveal qualities that may illuminate one's knowledge and understanding concerning teaching performance and professional practice". Furthermore, such audio recordings are "useful for identifying broad patterns of verbal behaviour and the selection of episodes for more extensive micro-analysis" (McKernan, 1991:106).

2.3.7 Photographs as source of data

Haviland (2004:10) views photography as "a useful and often overlooked tool for action research". Winter (1989:22) agrees that "As visual reminders of an experience, they [photos] can trigger detailed memories, and thus can form a very useful starting point for retrospective discussion among participants". In the same vein Kanstrup (2002:3) states that photography, similar to "… other visual data, leaves an opportunity for collaboration around the data material with research colleagues or participants in the study which is an opportunity for challenging imageries and biases". According to Kartoglu (2004:2) the use of cameras "may be the easiest way to add life to written notes on human behaviour". McKernan (1991:100-101) describes photographs "as windows into the world of the school", used by observers in research settings … to supplement other data collection techniques, …" . As such he sees photographs not only as "artefacts resources which represent the culture of the school", but also as "tools for inquiry" (1991:102).

Photography has a significant track record as qualitative research instrument, especially in research fields such as anthropology, sociology and history, but also in ethnographic and documentary studies in particular. This is evident from research by Collier and Collier (1986), Edwards (1992), cited in Haviland (2004:10), and by Hockings 1995, Banks and Morphy 1997 (cited in Kanstrup, 2002:3).

McKernan (1991:102) claims that photographs can form the "basis of thorough discussion among members of an action research project", especially when linked to other research data such as memos and observational field notes. McKernan (1991:102) maintains that with respect to the analytic or interpretive function of photographs researchers should grapple with the following two controversial aspects, namely "Do they convey objective meanings? Can they reveal the quality of life and action in school settings?" As I see it photographs can never be objective since the photographer is human. He or she decides on the event to be captured on picture, what the time or angle would be. However, I believe that pictures have the potential to give insight into the quality of life and the activities that take place within the school settings.

Working a a group …

Peer learning…

Teacher facilitating…

Remedying misconceptions…

Haviland (2004:12-13) is persuasive in listing the following advantages that relate to the use of photography in qualitative research: Photographic "… images can often speak for themselves." And can be "… very useful in establishing a non-verbal common point to begin or deepen communication across linguistic barriers." Furthermore, she claims that photographs "… can be an instant and effective way to provide context to a project or event". Lastly, she describes it as an excellent means to "… get people's attention and engagement in an idea or project", since "… it can communicate about our work and experiences in an instant, where it might otherwise take the proverbial thousand words to communicate similar information". Likewise, Dick (2002:24) states that photos "capture moments … that may otherwise go unremembered", and have the potential to "… complement written observations, jog memory of incidents, [and] help see things from a different perspective".

My inspiration for making use of photography as a means of data gathering, and to extend my methods of observation and analysis can be found in Kanstrup's (2002) work "Using Photography to explore use of technology within teachers' work practices". I agree that "photography is a very visible way of collecting data", however, unlike Kanstrup (2002:5) I have not experience of using the camera in classroom situations as unduly disruptive as teachers and learners quickly became used to my presence as photographer-observer.

2.3.8 Interviews

McKerman (1991:102) views the interview as "One of the most effective modes of gathering data in any inquiry …". Touliatos and Compton (1992:186) strongly agree that interviews open the "possibility of obtaining information that very likely could not or would not be obtained by any other method". The process of interviewing is similar to the questionnaire approach, but differs in the sense that the interviewer and interviewee are in a face-to-face situation or personal contact with each other. The interview method allows the interviewer "to probe areas of interest as they arise during the interview" (McKernan, 1991:129). Terre Blanche and Kelly (1999:128) maintain that interviewing has a personal element that makes it a more acceptable form of collecting data than for instance questionnaires, a test or having the respondents perform an experimental task.

It is important to decide on the type of interview to be conducted since the type of data to be collected is closely related to this. I have made use of semi-structured interviews, for instance to probe the teachers' knowledge regarding the role of feedback during the teaching and learning processes. This means that I prepared certain questions for the interviewees to answer. However, I also allowed the teachers "to raise issues and questions" (McKernan. 1991:130) as the interview progresses. Terre Blanche and Kelly (1999:128) agree that "if you want people to talk to you in some depth about their feelings or experiences, you will do better with …" an interview that is less structured or unstructured.

Interviewing is a complex process and if the interviewer is not careful it might be difficult to elicit sensitive or relevant information needed from the interviewees to make sense of the situation to be researched. As such Bergman (2003 cited in Henning, van Rensberg & Smit, 2004:78-79) lists a number of important issues to consider when interviewing people to gather information that would be more reliable. It is important to be accommodating and to use a tone of questioning that is non-threatening and that makes the interviewee feel at ease and willing to answer questions more readily. Easier questions at the beginning of the interview would help the interviewee to open up and be more willing to answer the more difficult questions. Rephrasing of questions is an important skill to apply when the interviewee has difficulty answering a question initially. According to Touliatos and Compton (1988:186) clarification of questions or ideas can be achieved by "repeating or rephrasing question[s], by following up leads in responses, or by probing more deeply to obtain a clear picture of the interviewee's ideas".

2.3.9 Workshops

Over a three year period workshops were used as a means to develop teachers' skills with respect to general OBE principles, communication aspects such as questioning, listening and feedback.

In a Google search I came across several definitions of the concept 'workshop' on the Web. The following two definitions I think aptly describe the function of a workshop in an educational sense: "A brief, intensive, educational program for a relatively small group of people that focuses on techniques and skills in a particular area" and "A gathering, usually three to five days in length, specifically for hands-on training or training where the participants really participate in the activity." Le Grange (2001:85) agrees that workshops are mainly used "… for participants to be actively involved and to interact with others …" to facilitate learning. McNaught and Raubenheimer (1991 cited in Le Grange, 2001:85) suggested that workshops "… should be contextual and not isolated from the actual teaching conditions.

As mentioned, we (that is the research team) used workshops to introduce new ideas, OBE related aspects needed to facilitate learning, and to hone particular teaching skills. They were thus used as a means to broaden teachers' understanding, and to model teaching strategies and methodologies. Consequent (post-workshop) classroom visits and lesson observation served as opportunities to observe the extent to which teachers apply these methods or display certain skills exposed to in the workshops.

2.3.10 School visits and facilitation

Not only is the question "What is a facilitator?" important in this context, but also the question, "Is the facilitator model suitable within the outcomes-based and constructivist paradigm?" needs to be addressed. These concepts (theories) are discussed in detail in Chapter 3. In order to address these questions meaningfully and adequately the role and meaning of a facilitator in a constructivist setting are critically analysed.

A facilitator can be described broadly as "… someone who makes it easier for another to do something" (Perrone, 2003:1). He continues by saying that educators who act as guides, who question and support their learners are typically called facilitators, since they facilitate learning. This implies that they attempt to make the learning process easier for their learners. By doing this, learning becomes much less educator focused and much more learner centred. Another important aspect related to effective facilitation is ongoing support by providing guidance, for instance through appropriate questioning (Perrone, 2003:1). Denning (1998: 2) writes that some educators view the "facilitator model" to be more preferable than transmission modes such as lecturing and that this view "… opens up the human side of learning …", since the educator "… must deal with the diversity of concerns, learning styles, backgrounds, and talents …" with respect to the learners.

Although I am using the term "facilitator" or "facilitating" it is identical or congruent to the term "mentor" or "mentoring" used by Holden (2002:9-21). Holden maintains that mentoring involves among others the role of "critical friendship" (2002:2). According to Costs & Kallick (1993:50), also cited in Holden (2002:15) "critical friend" is "a trusted person who asks provocative questions, provides data to be analysed through another lens and offers critique of a person's work as a friend. The friend is an advocate for the success of that work".

It is generally believed, and I tend to strongly agree, that during the process of facilitation the facilitator also experiences his or her involvement with teachers in their practice as educational and enriching (Coffey and Atkinson, 1996:230; Holden, 2002:15). Facilitation provides instances of learning through observation, discussion and other forms of interaction with the teachers and the conditions they are exposed to (Coffey and Atkinson, 1996:230; Holden, 2002:15). Under the heading "Mentoring as Professional Learning" Holden (2002:18) sums up some of the opportunities facilitation creates:

> *[by means of] extended discussions with participants …, and through acting as co-researcher, working with rather than on them, my own understanding of classroom practice and the impact of inquiry-led development on school development has been greatly enhanced. Mentoring itself can be seen as part of an ongoing process of capacity building within a professional network focussed on improving practice.*

What is the role and abilities of the mathematics facilitator in the context of this research? Facilitation in the context of this study is much more complex (Godnough, 2003) than the description given by Perrone (2003). It is not only classroom-based, and encompasses much more than making learning easier – it also involves building ongoing and sustainable educational and personal relationships with other adults (teachers). Dealing with sensitive issues in an honest and open manner is a skill that needs to be developed at an early stage of any facilitation relationship to ensure a healthy relationship of mutual understanding and respect.

As was the case with Godnough (2003:50) as a facilitator of teachers, "my focus was on enabling the process of action research" (see Chapter 4). My research perspective can thus more appropriately be described as praxis since I was "acting upon conditions" encountered, and that needed intervention or improvement.

One of the educationists that contributed extensively to the development of theory and practice of action research in higher education is Zuber-Skerritt (1996, 1993, 1992, 1988, 1987a, 1987b). Zuber-Skerritt's (1993:46) aims as far as action research in higher education (cited in Gray, 2000:95) is concerned, is not only the improvement of learning and teaching, but also management. Action research is thus seen as an instrument to increase reflective practice in higher education teaching.

Kember and Kelly (1993:1) maintain that the process of "making your teaching practice the subject of your research" allows you to "critically examine and modify[ing] it". According to Ashcroft and Foreman-Peck (1994:185), also cited in Gray (2000:95), educators at universities are "more in touch with the content of their teaching than the process of their teaching , and claim that action research can assist" them to "articulate their presuppositions about teaching and learning" They furthermore say that "action research is warranted by the problematic nature of 'imposed changes' in higher education, which make traditional methods of teaching difficult to sustain".

Zuber-Skerritt (1991:113) agrees that university educators "are the most effective people to do research into their own teaching practice … and that knowledge can be advanced by reflective practitioners who generate their theories from critical enquiry into their practice". As such this is an effort as action researcher to improve my own practice by reflecting and critiquing my own teaching and facilitation processes. This is a collaborative process among peer facilitators and our participant teachers as adult learners. Also here we apply action research strategies to improve "the researcher[s], as well as the research situation and research participants" (Arhar & Buck 2000:237-238)

2.3.11 Trust relationships as key to access teacher information

This section deals with the value of building significant trust relationships with teachers in the project and is closely related to my role as facilitator. The intimate relationships formed with our five teachers as collaborative research participants can be seen as instrumental in the success that we achieved in getting other teachers to open up to us. Consequently, it is impossible to ignore the role of building sound or healthy relationships. In fact it served as a prerequisite for successful intervention and a catalyst to help ensure that teachers open up and increasingly become comfortable at allowing us into their domain – the classroom.

Sheldon (2001:1) views trust as "essential among people who engage [in research]". In her paper "A Model for In-School teacher Professional Development: Extending on Action research" Kervin (2003:4) puts a lot of emphasis on maintaining trust with teachers throughout their research. Covey (1989:178 cited in Kervin, 2003:4), views the concept trust as the "highest form of human motivation". According to Loughran (1997:59 cited in Kervin, 2003:4), building a relationship on trust is an integral characteristic of teacher education. He maintains that trust allows participants to "approach learning as a collaborative venture".

My background in adult education, as well as my experience as teacher and teacher trainer helped me to be conscious of teachers' needs and anxieties at all times. Dealings with teachers in fact sometimes proved to be very delicate and taxing. Their insecurities with respect to the implementation of outcomes-based education made matters worse. Similar to Kervin (2003:4) I had to adopt a "code of conduct" to help me maintain an ongoing trust relationship with participant teachers. Some of the issues I adopted were: To show respect at all times; to endeavour to put myself in their shoes; to act as assistant and co-teacher whenever possible to stay in touch with classroom reality; not to divulge information shared during confidential talks; and to be subtle when things did not go well inside the classroom.

There is another dimension regarding respect that needs to be borne in mind, and which, according to Fay (1996:239) actually is a prerequisite for a sound educational relationship. Fay (1996:239) furthermore claims that

> *Respect demands that we hold others to the intellectual and moral standards we apply to ourselves and our friends. Excusing others from demands of intellectual rigor and honesty or moral sensitivity and wisdom on the grounds that everyone is entitled to his or her opinion … is to treat them with contempt. We honor others by challenging them when we think they are wrong, and by thoughtfully taking their criticisms of us. He adds*

> *"[respect implies] the willingness to listen, openness to the possibility of learning from, responsiveness, criticizing when necessary. Respect means to engage with intelligence, sensitivity, and open-mindedness… Respect does not imply that everything they do is "fine for them" or beyond the pale of critical judgment".*

It is really a very delicate and sensitive matter, in the sense that if the teachers as collaborators experience the situation as being too harsh or too critical, relationships might be adversely affected, and they might pull out of the project. However, building a relationship of trust and respect takes time, but once established, serves as a foundation to allow and absorb honest, constructive critique and opinion sharing.

2.4 DEALING WITH RIGOUR AND VALIDITY IN ACTION RESEARCH

Proponents of action research agree that validity and reliability are aspects that cannot be ignored if credibility is to be increased (Borgia & Schuler, 1996:2; Dick, 2000:13; Lather, 1986:270-272; Weiner, 2003:5; Winter, 1989:36). Winter (1989:36) maintains that "Unless it can claim improved validity for its outcomes, why should anyone do action research, and why should anyone else take it seriously?" He furthermore argues that the emphasis should not be on whether the action research findings are valid but on posing the question: "How can we ensure that our procedures are rigorous?" Weiner (2003:5) maintains that with respect to criteria for reliability, validity and research quality, to support action research as rigorous and high quality, "alternative frameworks" are required.

Lather (1986:270) poses the question about what validity criteria best serve praxis-oriented research. In response to this question, he suggests "a reconceptualization of validity appropriate for research" of this nature by focusing on validation criteria such as triangulation, construct validity, face validity and catalytic validity. Weiner (2003:5) too views the "development of alternative criteria for reliability, validity and research quality" as crucial. She argues that "… alternative frameworks are needed … to support action research as rigorous and high quality".

Borgia & Schuler (1996:2) claim that validity is attainable through the use of "multiple perspectives", while Anderson and Herr (1999:12-21) maintain that validity of action research should be tested against the following criteria, namely (1) outcome validity (Was a solution obtained?), (2) process validity (To what extent was the process educative and informative?), (3) democratic validity (To what extent was the research collaborative?), (4) catalytic validity (To what extent did the research change the realities of the participants?), and (5) dialogic validity (To what extent can the research – process, findings, etc., be discussed with colleagues in different settings?).

2.4.1 Triangulation

Triangulation is achieved through the application and combination of research instruments in the study of the same educational phenomenon. By means of triangulation researchers can minimize or counter inherent weaknesses, intrinsic biases and related problems brought about by only using one method, observer or theory. McKernan (1991:189) views triangulation as a "procedure for organizing different types of evidence into more coherent frame of reference or relationship so that they can be compared and contrasted".

Greater validity in action research is possible through "multiple perspectives", according to Borgia & Schuler (1996:2). This they say is achievable through triangulation, which occurs when three or more sources are used to generate data (Borgia & Schuler, 1996:2). DuFon (2002:42) simply describes triangulation as inquiry that involves a variety of qualitative techniques such as "participant-observation, field notes, audio and/or video recordings, interviews and so forth from different sources". Borgia and Schuler (1996:2) suggest quantitative research methods "… such as surveys, checklists, test scores, and report cards …" can also be used for additional perspective. In this research I endeavour to apply various techniques and instruments or the process of triangulation in order to obtain greater validity.

2.4.2 Reflexivity to enhance rigour

Reflexivity is an effort to assess the extent to which the researcher's own experience, background, perceptions, and interests impact on the research process (Le Grange, 2001:91). Similarly, Krefting (1991 cited in Le Grange, 2001:218) describes reflexivity as exploring the influence the researcher's unique personal history exerts on the research study. While agreeing that "the most essential factor is the *reflexivity* of the researcher", McKernan (1991:227) elaborates on the process which he describes as "the ability to think and reflect critically about what he or she has and what he or she still requires". This process of "reflective critique" is what Winter (1989:43) and MacIsaac (1996:4) refer to (see 2.2.2.3) as one of the principles guiding action research dealing with interpretations, biases, and assumptions about researcher judgments.

In the introductory chapter of my thesis, as well as in this chapter (under 2.3.9) I discussed in detail my position as educator and facilitator, and how my research has become an extension of my work related to the West Coast Schools project.

2.4.3 The Cyclic nature of Action Research

The action research process is by nature a cyclic one (Davison, Qureshi, de Vreede, Vogel & Jones, 2002; Dick, 1999; McKernan, 1991; Zuber-Skerrit, 1991). According to Dick (2000:5): “Almost all writers appear to regard it as cyclic (or a spiral), either explicitly or implicitly”, which consequently “provides a mix of responsiveness and rigour, thus meeting both the action and research requirements”. Dick (1999:3) maintains that the cyclic nature of action research causes it to be “responsive and flexible”. According to Davison *et al.*, 2002:5) “Action research is best seen as iterative cycle in which the researcher begins with planning how to carry out the activity…”

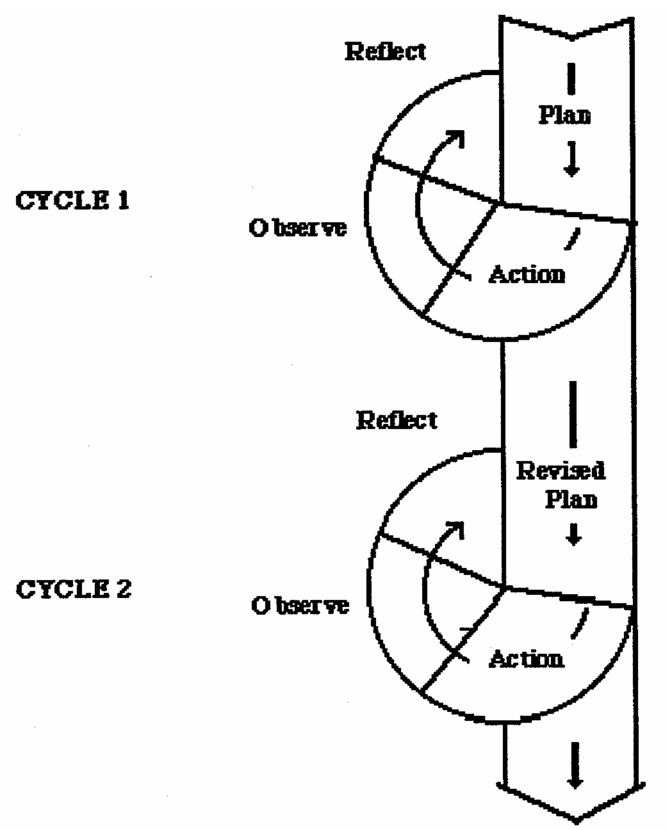


Figure 2.1: Action Research Protocol after Kemmis (cited in MacIsaac, 1996:2)

Dick (2000:13) emphasises that the action researcher should “… focus on rigour: on the quality of your data and your interpretations.” To accomplish this he suggests two, what he calls “guidelines”. Firstly, the action researcher needs to “… use a cyclic (or “spiral”) procedure” in order to be able in later cycles to “… challenge the information and interpretation from earlier cycles”. Consequently, he remarks that, “… your study becomes a process of iteration”, which allows “… you [to] refine your understanding of the situation you are studying”. This “responsiveness” demanded by the research situation Dick (2000:14) views as the “… most important reason for choosing action research...”. Secondly, he stresses the need for the action researcher to “… at all times try to work with multiple information sources. …". He calls this "… creating a dialectic" (Dick, 2000:15), a process that shows similarities to triangulation. For this to happen, the researcher has to use "different informants …" and "… research settings", as well as questioning on a topic to elicit different perspectives. Furthermore, data should be gathered at different times, using different methods and researchers.

While considering the cyclic nature of the action research process it is important to remember McTaggart's (1996:248) reminder that adhering to research cycle does not necessarily imply action research as such. Rather he views action research as " … a series of commitments to observe and problematize through practice a series of principles for conducting social enquiry". Wadsworth (1998:5) describes the cyclic nature of participatory action research as follows: "Instead of a linear model, participatory action research thus proceeds through cycles, starting with reflection on action, and proceeding round to new action which is then further researched". She emphasises the fact that new actions always emerge from the previous ones.

2.5 ACTION RESEARCH CYCLES IN THIS PROJECT

The diagram below, like those used by other action researchers such as Dick (2000), Kemmis (1996), McTaggart (1996) and others, reflects the cyclic nature of my action research process. The continuous and iterative cycles depict the responsiveness and flexibility to the situation encountered at schools in the project. Each cycle starts with a period of assessment, followed by planning strategies for intervention. Thirdly, after intervention, a period of observation follows. This is followed by post-observation reflection, that is, we reflect on what transpired, what worked well and what was not effective. Subsequently, new strategies are planned and acted upon. Each of the cycles lasted about 9 months – from February to October, namely: Cycle 1 February to October 2003; Cycle 2 February to October 2004; Cycle 3 February to October 2005

2.5.1 A Schematic representation of the action research methodology

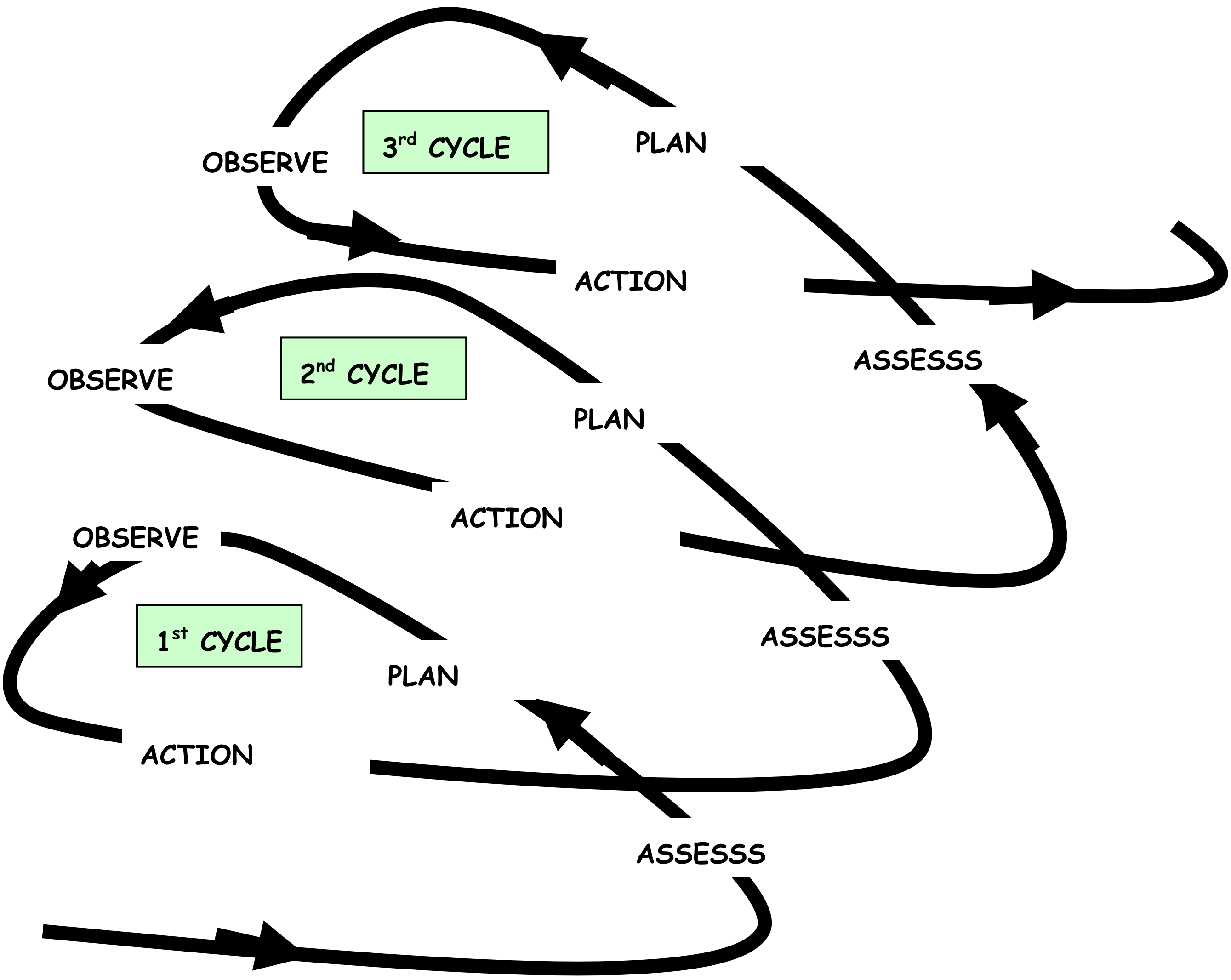


Figure 2.2 A Schematic representation of the action research methodology

2.5.2 Action research time frames

1ST CYCLE	ASSESS	PLAN	ACTION	OBSERVE
February 2003 - October 2003	Learners' participation in grades 7, 8 and 9; Teachers' OBE skills; Lesson planning; uncertainty with new curriculum	Intervention strategies; school visits; lesson observation; learners' test	Workshops; lesson reflection	Teaching moments; learner participation; interaction with learners; grade 9s generally not equipped to write CTAs (Common Tasks for Assessment)

2ND CYCLE	**REFLECT**	**PLAN**	**ACTION**	**OBSERVE**
February 2004 - October 2004	General inability to engage learners; inhibited to apply workshop methods; top down methods not effective; relationships of trust and understanding prerequisites for successful intervention	Closer / more intimate relationship with teacher; co-teaching lessons; demonstrating teaching methods	Teaching skills to teachers – questioning; listening; communication; audio- and video-recordings	Teaching moments ; Questioning skills improved; more group discussions in class; outcomes still not readily shared; Teachers make an effort to listen more to what learners say / message
3RD CYCLE	**REFLECT**	**PLAN**	**ACTION**	**OBSERVE**
February 2005 - October 2005	Opportunity for learner questions still limited; need to create atmosphere more conducive to effective learning; need to create more opportunity for discussion and interaction with maths content; reduce learner anxieties; improve and broaden feedback base: Learner-learner & learner-teacher	Preparing modules for the Senior Phase; 'reading' workshop; class visits; focus increasingly on strong points of participant teachers; what they like; frequent discussions sharing of ideas in a "friend-to-friend" way; emphasis on 'we are a team reflecting on how we teach"; emphasise the positive rather than dwelling on the negative	Implementing modules to grade 7's; two-weekly focus group sessions; lesson observations learner questionnaires; workshops to facilitate or support small group teaching; enhance teachers' computer skills to expand teaching strategies	Teaching moments; Application of maths modules Teachers talk less; learners more involved; less time wasted on board work; learners more exposed to reading and interpretation; more time for discussion; grade 7 more advanced than 9 in certain areas

4TH CYCLE	REFLECT	PLAN	ACTION	OBSERVE
February 2005 – October 2005	Good progress; learner understanding increased dramatically; learner self-concept and enthusiasm evident Some of the modules too long; sequence of module implementation needs to be looked at;	Contexts must be improved; other aspects related to teaching milieu to enhance learning and teaching conditions; creating more time for preparation and creative thinking	Implementing modules to grade 8's; workshop the use of mathematics modules; two-weekly focus group sessions; lesson observations; learner interviews; lesson reflection workshops to facilitate or support small group teaching; enhance teachers' computer skills to expand teaching strategies	Outcomes shared with learners; teacher enthusiasm; teachers more careful with how they phrase questions; learners less inhibited; monitoring of learner groups can improve;

2.6 ANALYSIS OF DATA

It is difficult to describe the challenges associated with the task or process of analysing data in qualitative research. In my opinion it could be described in terms of the following adjectives: intimidating, scary, overwhelming or daunting? The fact remains that it proves to be a daunting task, filled with many uncertainties and grey areas. Dick (2002:24) takes a similar view, maintaining that uncertainty can be mainly ascribed to the fact that human relationships are intricate, and consequently "there is bound to be ambiguities and unknowns in any analysis of classroom events". Bogdan and Biklen (1982:154 cited in Le Grange, 2001:88), view analysis as consisting of "working with data, organising it, breaking it down, synthesising it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others".

The following practical suggestions put forward by Hubbard & Power (1999), are also cited in Dick (2002:25):

1. Data analysis should be built into the research design from the outset;
2. "Index notes" need to be used to make note handling more manageable and focused;

3. An effort should be made to keep up with transcriptions for example of audio recordings;
4. Record keeping strategies should incorporate data collection and analysis of data should be catalogued for later analysis.

Schulz *et al*. (1992:332), with special reference to analysis of field data, view analysis as “an inductive, collaborative, and iterative process”. They followed the process of “extensive debriefings after a set of observations, highlighted what seemed to be of interest, and offered conclusions which answered some of the questions posed” by role-players earlier on.

Hopkins (1985 cited in McKernan, 1991:226) offers the following data analysis procedure: 1. Data collection, which deals with collection of information and generating hypotheses. 2. Validation of data and hypotheses by processes such as triangulation. 3. Interpretation of data. 4. Taking action to improve the situation and further monitoring or observation.

2.7 THE PROCESS OF WRITING UP AND REPORTING FINDINGS

This discussion deals with the intricacies involved in writing about and reporting on research findings. In addition, I focus on the value and enrichment gained though this process. I share Dick’s (2002:25) view that writing up results and findings is indeed a time consuming and difficult process. However, it is a necessary process but when done effectively, I have found that it is an enriching one.

2.7.1 The value of this process

Dick (2002:25) highlights the value of the process of data gathering and analysis as “... bring[ing] new learning and understanding ...”. According to Hubbard and Power (1999 cited in Dick, 2002:25), the “process of writing up research should also bring the individual to new understanding of the issue and classroom”. Altrichter (1993:176 in Dick, 2002:25), maintains that neglecting to report on “teachers’ professional knowledge” to the wider public would adversely affect “development of insight on professional practice”, the “professional status of teachers”, as well as the “quality of educational practice” (Altrichter, 1993:176). Kartoglu (2004:1) is adamant that “data and findings need to be communicated effectively to various audiences and thus applied communication becomes an important part of research”. For him, an inability to communicate the findings of a successful research study diminishes its value.

2.7.2 Suggestions for writing up research

Researchers such as Hubbard & Power (1999) and Altrichter, Posch & Somekh (1993 cited in Dick, 2002:26-27) offer general ideas on how to record research findings: all collected data need to be scrutinized, and lists of all “key incidents or events, and breakthrough moments” should be compiled. The researcher should make an effort to write about “some of those insightful moments” as “vividly as possible” (Dick, 2002:26). With regard to recording responses from other research participants on issues they consider to be crucial, researchers such as Dick (2002) recommend that a research plan be used as a framework.

Altrichter *et al*. (1993 cited in Dick, 2002:27), recommend that classroom researchers need to answer “three interrelated questions when choosing the method of reporting research”, namely what to include, for whom the research is intended, and the method of reporting used. In this case the method of reporting is mostly narrative. What has been included in my research reporting can be ascertained by referring to chapter 6. I believe that the research findings would be of interest to teachers, principals, curriculum advisors, and fellow classroom researchers.

2.8 CONCLUSION

In essence this chapter explained my rationale for deciding upon, and using a particular research methodology, together with the methods I consider to be appropriate. Through a process of elimination I reached the conclusion that collaborative action research was the most effective choice for my collaboration with in-service teachers: it merges theory and practice and joins practising teachers and researchers in a mutual search for ways of improving teaching and learning.

I elaborated on what action research entails as praxis, as opposed to the more conventional positivist and interpretive research paradigms. All of the salient aspects of action research were addressed – these include discovering the meaning and use (of action research), variations and principles guiding this kind of research, and positioning my research in an appropriate paradigm. I also provided a short historical perspective. The different research methods and techniques were explained and the rationale for choosing particular methods was given. Lastly, I dealt with contentious issues such as rigour and validity that have bearing on the credibility of my research.

In Chapter 3 the concept ‘assessment’ is discussed, with particular reference to formative assessment. The link between formative asessment and feedback and how it relates to questioning and listening are explored. Prior to this the underlying theories that inform this research are briefly discussed. This is followed by an analysis of what outcomes-based education entails and how it relates to formative asessment. Consequently, the position and role of the learner in the assessment process, and the impact on classroom discourse are the main focus.

CHAPTER 3: OUTCOMES-BASED EDUCATION AND FORMATIVE ASSESSMENT

"Outcome-Based Education means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organizing curriculum, instruction, and assessment to make sure this learning ultimately happens." Spady (1994:1)

3.1 INTRODUCTION

This chapter attempts to link communication (feedback) and assessment to the outcomes contained in Outcomes-Based Education (OBE), and specifically to those in the Senior Phase Mathematics curriculum, discussed in more detail in Chapter 5 (The Function Concept). My aim is to show how the important role of (formative) assessment as a means and process of facilitating learning and the concomitant achievement of the relevant outcomes relies on effective communication and feedback.

Formatively assessing …

teacher assessment & intervention

self-assessment

by observing and facilitating

peer assessment

This chapter is not meant to be a critical analysis of OBE, like that of Jonathan Jansen (1998: 321-331), or to ponder over the merits and demerits of OBE as an education model (Botha, 2002:361-371), or to question whether OBE indeed signifies a radical paradigm shift or not (Malan, 2000:22-28). It is also not intended to reflect on the controversial way in which OBE was implemented at grassroots level. My aim here is mainly to paint a broader picture showing the ways in which learning in the classroom is affected by particular aspects. It should, however, be evident from the discussions to follow that I see OBE as an educational model with great potential for the improvement of education in South Africa.

Basically this chapter can be divided into three parts. In the first part some of the learning theories I consider to be relevant to this study are discussed, and salient issues regarding the learning process are highlighted. As this is essentially collaborative action research involving teachers as adult learners, learning theories pertinent to adult learning, such as “the facilitation theory” (Dunn, 2002; Laird, 1985), “andragogy” (Brookefield, 1986; Burns, 1995; Candy, 1991; Knowles, 1978; MacDonald, Gabriel & Cousins, 2000; Merriam, 2001); “action learning” (Dunn, 2002; McGill & Beaty, 1995), “constructivism” (Atherton, 2003; Matthews, 2000; Sfard, 1998; Wheatley, 1991) are given particular attention. Some of the theories such as constructivism, action learning, enactivism (Begg, 2000; Davis, Sumara & Kieren, 1996; Reid, 2004) and Bloom’s revised taxonomy are relevant to the learning of both school going learners and adults since these inform learning in both instances.

The second part mainly deals with OBE as education model. With respect to OBE, I briefly examine the rationale for choosing it as an alternative to Christian National Education for South Africa. The essence of OBE and what it entails (Alexander, 2002; Bixler, 2002; Killen, 1999; Malan, 2000; Spady, 1994) are discussed, including its underlying philosophies, such as social constructivism. Finally, the role, position and function of outcomes in terms of learning are scrutinised.

In the third part, I focus on formative assessment in general, giving particular attention to how it relates to mathematics teaching and learning in particular. I examine the ways in which assessment is viewed by various mathematics educationists, and other educationists such as Bodin (1993), Clarke (1989), Izard (1993), and Swan (1993). Controversies that have plagued assessment in mathematics for many years are also explored, drawing primarily on Black & Dockrell (1984), Bodin (1993), Johansson (1993), and Izard (1993). In addition, the need to change to more effective forms of assessment, such as formative assessment, and the effort to do so are analysed. Particular attention is given to the need to assess formatively as opposed to summative assessment (Black & Wiliam, 1998b; Bodin, 1993; Boston, 2002; Nakabugo and Siebörger, 1999; Swan, 1993). In addition, current and recent debates among prominent mathematics and science educationists (Black & Dockrell, 1984; Izard, 1993; Johansson, 1993) are explored. For assessment to facilitate the learning of mathematics and enhance the formation of mathematics concepts at school level especially, it is crucial to know what assessing formatively entails.

In addition, I attempt to describe the act or process of providing formative assessment (Boston, 2002; Lowery, 2003; Swan, 1993). In doing so, I examine the nature and effectiveness of assessment tools and instruments in mathematics education. Since the efficiency of assessment is overwhelmingly dependent on communication, the relationship between formative assessment and feedback is further elaborated upon (Boston, 2002;

Clark, 1989; Ramaprasad, 1983). This issue is also dealt with in Chapter 4 (Feedback). This takes me back to the matter of how questioning is used, not only to ensure that teachers gain insight into learners' thought processes, skills and attitudes, but also to ensure that learners respond beyond merely giving back factual knowledge. This leads naturally to the position and role of the learner in the assessment process, especially with respect to self-assessment and peer-assessment and the impact on communication are addressed.

3.2 THEORIES THAT INFORM THIS RESEARCH

At this stage I elaborate on these in order to position this research more clearly in relation to specific learning theories. It is therefore important to give a clear account of the underlying theories and assumptions of this research, which were outlined in Chapter One. In the discussion that follows, the difference in emphasis between these theories of what learning of mathematics entails should become clear.

The question that needs to be answered is why there is so much emphasis on theory. In discussing adult educational programmes, MacDonald, Gabriel and Cousins (2000:238) maintain that their success "is directly related to its grounding in the theory and principles of adult education".

In exploring the need to lay an emphasis on theory, it seems appropriate to focus on what characterises a theory of learning mathematics and what it encompasses. According to Dubinsky (2005:10), a theory of learning involves "…definitions, examples, counter examples, theorems and proofs". He claims that the effectiveness of a theory is situated in its potential to "help solve problems, prove new theorems, and make applications, both in and out of mathematics". As such a theory should "support prediction", "possess explanatory power", "be applicable to a broad range of phenomena", "help organise thinking about learning phenomena, serve as a tool for analysing data,", and "provide a language for communication about learning" (Dubinsky, 2005:11).

The learning of mathematics is assumed by some educationists to involve the active construction of meaning and sense-making while learners are engaging with and grappling with mathematics content and concepts (Pournara, 2002:43). At the same time the construction of knowledge is facilitated when learners socially interact with others in the classroom. This implies that learning takes place while engaging with peers and teachers, using built-in social mechanisms such as social and mathematical language to facilitate communication, listening, questioning and ultimately feedback. According to Pournara (2002:43), inside the mathematics classroom, "shared understanding is developed between learners and between the teacher and learners, and these are communicated through use of language and mathematical symbols".

Communication is assumed to be an interactive two-way process that involves not only sending and receiving of messages, but also decoding and making sense of such messages (Bresset, Cheever, Townson and Turner, 2001:1). As such it is considered to be an interpersonal and social activity to convey messages from person one to person two with a conscious intent to affect the receiver's behaviour or thinking patterns (Bresset *et al.*, 2001:2), and vice versa. Closely linked assumptions are that three levels of listening exist (Davis, 1994) and that different people operate on different levels of listening. It follows that the receiver's listening skills affect the message received and consequent interpretation and response (see 4.4.2 for more detail). This ties in intimately with the process of formative assessment, through which teacher and learner (or learner and learner) have to make sense of the messages received from each other.

This is directly related to the delicate art of questioning (also touched on in 4.4.3) – not only to elicit information, but also to ascertain whether the listener listened correctly, or whether learning has indeed taken place. In this regard Bloom's revised Taxonomy proved to be quite appropriate and relevant. His different levels of questioning are found to facilitate learning and enhance concept formation (see the discussion in 4.4.6).

The following brief discussion is an effort to focus attention on those learning theories that I found to be relevant to this research study. It is not meant to be an in-depth and critical analysis of these particular learning theories. My aim here is to highlight those critical aspects of each theory that inform or have bearing on this research study.

3.2.1 Constructivism

Matthews (2000:161) contends that "[c]onstructivism is undoubtedly a major influence in contemporary science and mathematics education". In essence constructivism is described as a learning theory that claims that "knowledge is not passively received, but is actively built up by the cognizing subject", and "that the function of cognition is adaptive and serves the organisation of the experimental world" (Wheatley, 1991:10; Matthews, 2000:175). Carr, Jonassen, Litzinger and Marra (1998:5) also mention the fact that constructivism emphasises learner activity and how they construct knowledge as a process of making sense and giving meaning.


Learner activity…


constructing knowledge…


making sense…

Also in this research constructivism plays a significant role and is used as theory to make sense of, and to ascertain what role it plays in enhancing the learning process by using a more balanced approach that includes aspects of both the social and cognitive approaches, that is somewhere between radical and social constructivism. Three prominent people in this field are: von Glaserfeld – a radical constructivist, Piaget who focuses on the "cognizing person', and Vygotsky who emphasises the importance of "social interaction" in learning (Sfard, 1998:499). Atherton's (2003:1) explanation of what constructivism entails emphasises the roles of the social and communicative dimensions of learning. Constructivism is viewed as an alternative learning theory to behaviourism, and according to Atherton (2003:1) it fits in "somewhere between [the] cognitive and humanistic views". This emphasis on the social aspect, points towards a more active role by the learner "in a joint enterprise with the teacher of creating new meanings". This ties in with Vygotsky's view on the importance of "interpersonal exchange" (Sfard, 1998:499) in the learning process. A distinction is thus made between cognitive constructivism, which deals with understanding and making sense, and social constructivism, which emphasises "how meanings and understandings grow out of social encounters" (Atherton, 2003:1). In a learning sense I believe and agree that oral communication, which essentially includes feedback, plays a major role in making these social encounters learning incidents facilitating sense-making and understanding. This aspect is discussed in detail Chapter 4, especially under 4.4.

The role of communication within constructivism is aptly described by Atherton (2003:1) as that which allows "conversational theories of learning [to] fit into the constructivist framework". The active mental involvement of learners is reflected in the teacher's deliberate effort "to enter into a dialogue with the learners, trying to understand the meaning of the material to be learned by that learner". Carr *et al.* (1998:5) similarly argue that constructivism emphasises the need for "learning [to] support collaboration", allowing learners to "talk to one another about their learning". What is important during this process of collaboration and sharing of information is that learners are compelled to "crystallize what may be internally fuzzy into concrete words, and encourages knowledge synthesis and meaning making" (Carr *et al.*, 1998:8)

3.2.2 Enactivism

In essence enactivism addresses the "problem of the relationship between an entity and its surroundings" (Reid, 2005:2). In a nutshell, the concept "enactivism" means "Knowing is being is doing" and is derived from the notion of "knowing in action" (Reid, 2005:1). Enactivism emphasises the process of coming to know (or learn) rather than knowledge per se. It is still viewed as an emerging theory that deals with learning and in a sense also voices some criticism of constructivism (Begg, 2004:8). In many ways enactivism tries to address those issues, such as non-cognitive knowing, not adequately explained by constructivism.

Davis, Sumara and Kieren (1996:153) highlight the complexity of learning as viewed from the perspective of the enactivism theory in their argument that learning should rather be understood "in terms of an ongoing structural dance, "a complex choreography" of events which, even in retrospect cannot be fully disentangled and understood".

Davis (1997) as an enactivist is especially concerned with "the main requirements for teaching mathematics that he sees as congruent with enactivism". (Begg, 2004:9). As indicated previously, he was especially aware of the important role that the way teachers listen to their learners plays in communication. As such he differentiates between evaluative listening (a restrictive way of listening for a particular response), interpretive listening (through which the listener makes sure of the message conveyed to enhance flexibility), and hermeneutic listening (characterised by a higher degree of "negotiation and co-implicated activity" (Begg, 2004:9) in the mathematics classroom. Furthermore, Davis (1996) views listening as often present in play, which he considers to be "an essential human quality that is evident in all we do" (cited in Begg, 2004:9).

3.2.3 Action learning

Action learning theory attempts to marry learning reflectively with action, or as Dunn (2002:2) puts it: "Action learning is the approach that links the world of learning with the world of action through a reflective process within small cooperative learning groups". McGill and Beaty (1995) refer to these small cooperative learning groups as "action learning sets" who gather on a regular basis to address "… individual members' real-life issues with the aim of learning with and from each other" (Dunn, 2002:2). According to Dunn (2002:2), Revans, who is considered to be the founder of action learning, maintains that learning without action is not possible, and vice versa.

Revans (1980, 1982) cited in Dunn (2002:2), maintains that learning can be represented by means of an equation, namely: L = P + Q, where L is short for learning, P for "programmed knowledge", (that is knowledge gained through conventional teaching or transmission), and Q for "questioning insight". According to Dunn (2002:2), Revans and many other educationists view action learning as "… ideal for finding solutions to problems that do not have a 'right' answer because the necessary questioning insight can be facilitated by people learning with and from each other in action learning 'sets'". The resonance of this with the role and function of focus groups (discussed in 2.3.4) is striking.

Action learning is described as an iterative and experiential process. As such it involves learning as a cyclical process. A typical action learning cycle would thus reflect elements such as action, reflecting on the action taken, generalising and planning (Preston and Biddle, 1994:2)

3.2.4 Facilitation theory (as a humanist approach)

Carl Rogers is generally viewed as the person who developed the theory of the facilitative learning theory (Dunn, 2002:1). According to Laird (1985), cited in Dunn (2002:1) this theory is based on the premise “that learning will occur by the educator acting as a facilitator, that is by establishing an atmosphere in which learners feel comfortable to consider new ideas and are not threatened by external factors”. Burns (1995:268) makes a similar point when he says that “[f]acilitative teaching involves creating the conditions under which learning can occur without seeking to control the outcome”. Brookefield (1986:135) adds the important aspect of using learners’ contributions: “Good adult teaching is generally seen as the ability to set a certain emotional climate, to use learners’ experiences as educational resources, to provide plenty of evaluative information to students, and to encourage collaboration and participation”. Other important assumptions are that “humans have inborn eagerness to learn, and that the most significant learning involves changing one’s concept of oneself” (Dunn, 2002:2).

The following characteristics of facilitative teachers and the strategies to enhance learning and increase independence in learners show remarkable similarities with constructivism. Brookefiled (1986:123) maintains that “facilitators do not direct; rather they assist adults to attain a state of self-actualization or to become fully functioning persons”. Burns (1995:268) emphasises the facilitative teacher’s awareness of the learners’ “capacities, needs and past experience” and ability to use this information to “create a learning situation in which the adult learner can meet their needs or solve a problem in an autonomous and independent way”. According to Dunn (2002:2) facilitative teachers are “less protective of their [own] constructs and beliefs”; they show a tendency to be able to listen to learners more often, especially to their feelings; they are “inclined to pay as much attention to their relationship with learners as to the content of the course”; and they “are apt to accept feedback, both positive and negative and to use it as constructive insight into themselves and their behaviour”. Similarly, Brookefield (1986 cited in Currie, 2000:222) mentions the following six principles of effective practice in facilitating learning: participation on a voluntary basis, respect for other persons’ self worth, collaboration between learners and facilitator “engaged in a cooperative enterprise”, praxis which implies “a continual process of activity, reflection, collaborative analysis” and reflection, the enhancement of critical reflection, and self-directedness.

Collaboration …

reflection…

cooperative enterprise …

Within this kind of teaching practice, learners are treated significantly different from the way they are treated in the conventional authoritative classrooms as they “are encouraged to [increasingly] take responsibility for their own learning”, they are allowed to “provide much of the input for the learning which occurs through their insights and experiences”, and, thirdly, they “are encouraged to consider that the most valuable evaluation is self-evaluation and that learning needs to focus on factors that contribute to solving significant problems or achieving significant results” (Dunn, 2002:2).

3.2.5 Andragogy (adult learning)

Burns (1995:233) simply calls andragogy the “science of teaching adults”. Brookefield (1986:90) mentions at least three ways in which andragogy is viewed, namely as “an empirical descriptor of adult learning styles”, as “a conceptual anchor from which a set of appropriately “adult” teaching behaviors can be derived”, and thirdly as “an exhortatory, prescriptive rallying cry” against using the same teaching methodologies as for children. I want to note briefly some of the assumptions from andagogy that are relevant to this study, while taking account of some of the criticism voiced by critics against certain aspects of this theory. Since teachers are viewed as adult learners it is crucial to bear in mind and be knowledgeable about how adult learners are viewed and what adult learning entails. Knowles (1978) is generally credited with being the theorist responsible for postulating this theory in the late 1970s (Dunn, 2002:3; MacDonald, Gabriel & Cousins, 2000:221). I should add that when I argue the importance of treating adult learners as adults, I do not mean to imply that children as learners should be treated with disrespect or as lesser beings.

A distinct difference between adults and children is that adults tend to be much more “self-directing” (MacDonald, Gabriel & Cousins, 2000:221; Murphy, 2005:2). It is this higher degree of self-directedness that “lies at the heart of andragogy” (Burns, 1995:233; Currie, 2000:220). Consequently, andragogy is “student-centred, experience-based, problem-oriented and collaborative” (Burns, 1995:233). Brookefield (1986:149) views self-directed learning as deliberate efforts by adult learners “to acquire skills, knowledge, and self-insight through educational experiences that they are responsible for arranging”. Candy (1991:278) maintains that constructivism is “particularly compatible with the notion of self-direction, since it emphasizes the combined characteristics of active inquiry, independence, and individuality in a learning task.

Knowles (1980:43-44 and 1978:55-59) makes the following assumptions, also cited in Merriam (2001:5) and Brookefield (1986:92) that are relevant to this research: adult learners have vast experience in different spheres and this should be used as an important resource; adult learners should play a significant part in devising and implementing learning programs; adult learners have a "need to be able to see applications for new learning" (Dunn, 2002:3); adult learners expect to be allowed to make considerable input when it comes to ways in which learning would be assessed; adult learners generally expect to have a significant input with respect to "what they are to be educated for, and how they are to be educated" (Dunn, 2002:2-3); and adult learners usually "expect their responses to be acted upon when asked for feedback on the progress of the program". MacDonald, Gabriel and Cousins (2000:238) note that the appropriacy of a programme for its target group is strongly instrumental in its success. This refers to factors such as "the program's modular structure, its comfortable adult environment, the relevancy and applicability of its content and the relevant and useful pre-readings and assignments are all based on adult education principles, and all contribute to learners' satisfaction with the program".

3.2.6 Reification and Participation

Sfard (1998) and Wenger (1998) are two of the mathematics educationists concerned with the theory of reification. Wenger (1998:58) describes reification as a learning process that involves "giving form to our experience by producing objects that congeal this experience into 'thingness' ".

Sfard's view of reification differs somewhat from that of Wenger in the sense that she distinguishes between process and product with respect to reification – a more cognitive point of departure. According to Sfard (1991:4), also cited in Pournara (2002:44), "mathematical entities can be viewed either as processes or as objects". Sfrad refers to these views as "*operational* and *structural* respectively and suggests that it is necessary to be able to adopt both views in order to succeed at mathematics". "Operational" is characterised by Sfard (1991:4) as "dynamic, sequential and detailed" with the emphasis on "processes, actions and algorithms" (Pournara, 2002:44). "Structural" on the other hand is viewed by Sfard (1991:4) as "static" as well as "instantaneous and integrative". Pournara (2002:44) makes the valuable point that "[f]or Sfard these are complementary views hence the need to be able to shift between them as required", maintaining furthermore "operational conceptions precede structural conceptions and that a structural view is not always easy to achieve" (Pournara, 2002:44).

Sfard's reification theory distinguishes three developmental stages of development, namely that of "interiorisation" (reflecting learner's skills to compute and manipulate), "condensation" (deals with a learner's ability to apply knowledge) and ultimately "reification" – when a learner is able to see the mathematical entity in a novel way, that is as an entity in itself "rather than a procedure for calculating a result (Pournara, 2002:44). She speaks of the "vicious circle of reification" (Sfard, 1991:31) when "a learner cannot convert a lower level process into an object unless she has to perform a higher level process on it" (Pournara, 2002:45).

According to Wenger (1998), and cited in Pournara (2002:45) participation and reification are complementary processes, in the sense that through participation, reified products are allowed to be "reappropriated". Pournara (2002:45) elaborates by saying that "One can only make sense of reified products through participation and one cannot begin to participate unless one has tools and objects (i.e. reifications to operate with and on", and for Wenger "participation is social because the individual … is engaged with reified forms that have emerged within a community".

3.2.7 Situated learning theory

Situated learning theory deals with knowledge construction of humans in the course of everyday experiences (Elmholt, 2001:2). This theory was developed by Lave and Wenger in 1991. According to Jean Lave's theory of situated learning, learning usually takes place as a function of the particular activity, the context in which it occurs as well as the culture, implying that is situated. Brown and Duguid (1994 cited in Carr *et al*., 1998:5) maintain that learning "in whatever form, is necessarily situated in some context or culture, whether the learning is real or simulated". Situated learning is related to several theories that preceded it, such as 'Gibson's theory of affordances, Vygotsky's social learning theory and Schoenfield's ideas on mathematics problem-solving.

According to Carr *et al.* (1998:6) the following assumptions are central to situated learning theorists' beliefs on learning and knowledge construction:

- Knowledge is the result of an authentic or realistic activity;
- Learning is viewed as "a process of enculturation in a community of practice". This points towards the importance of social interaction as critical component;
- Learning entails the development of "an identity as member of a community of practice";
- Meaning is seen as "socially constructed through negotiations";
- "Learning in situ engages different socio-cognitive processes than learning in schools".

Wenger (1998:3) cited in Elmholdt (2001:3), sees the fact that humans are social beings as a critical aspect of learning. He views knowledge as a “matter of competence with respect to valued enterprises”, and knowing as “a matter of participating in the pursuit of such enterprises”. The meaning that we assign to things or phenomena is viewed as “our ability to experience the world and our engagement with it as meaningful” with meaning as the ultimate product of learning.

Situated learning thus claims that in order to understand what occurs during the learning process, the culture and context in which it occurs need to be taken into consideration, and since learning is by nature situated, educationists are obliged to ascertain what types of learning are supported by the situation. Carr *et al.* (1998:6) maintain that several “theoretical reasons” exist “for considering situated learning approaches to educational practice”, namely that it prevents “decontextualized, oversimplified” teaching as stated by Brown, Collins and Duguid (1989). According to the Cognition and Technology Group at Vanderbilt (1993 cited in Carr *et al.* (1998:6), situated learning theory “provides scaffolding for generative and self-directed approaches and avoids inert knowledge”.

In essence these are the theories that to a large degree helped me develop a better understanding of the learning process not only with regard to learners, but also adults. The theories that attempt to explain adult behaviour and learning, such as andragogy and facilitation, were particularly useful in that they broadened and deepened my understanding of how to build relationships with teacher participants in the study.

3.3 RATIONALE FOR CHOOSING OBE TO RENEW EDUCATION IN SOUTH AFRICA

Outcomes-based Education, to a large extent underpinned by constructivism, was introduced as a ‘new’ educational philosophy in 1996 in an attempt to rid the South African Education system of the disparity and lack of equity that prevailed during the apartheid years. The general consensus in the post-apartheid government and wider public was that Christian National Education (CNE) was not adequately addressing the needs of all South Africans, especially those who had been disadvantaged by what was then referred to as “gutter education”. Apart from political reasons, a different and more effective system of education was required to prepare learners “for a world beyond academia” (Alexander, 2002: 1). Learners who completed 12 years of CNE were generally unskilled and not trained to be directly absorbed into the workforce. Botha (2002:365) provides some support for this view in his argument that research “has consistently shown that South African learners lack substantial problem-solving and creative abilities”.

CNE was strongly underpinned by behaviourist learning theories, and overwhelmingly characterised by transmission of knowledge from teacher to mostly passive learners. Differentiation with regard to the diversity and different learning needs of learners was very limited at best. A different educational philosophy and system was necessary not only to address the needs of all the learners in the country and bring about greater equity, but also to take account of what was happening globally. As Botha (2002:361) argues, "[e] ducational change was required to provide equity in terms of educational provision and to promote a more balanced view of the South African society", and that "OBE as a model was chosen as the most likely to address the crisis in South African education" (2002:362).

Malan (2000:22) argues that "Outcomes-based education is currently favoured internationally to promote educational renewal and has been implemented in countries such as Canada, the United States and New Zealand". Spady maintains that "[t]he OBE efforts of today are a direct response to the many demands for change of what some call our outdated, 'Industrial Age' system of educating children in an era of high technology, global communications, and rapidly expanding information systems. These changes involve fundamentally refocusing and redirecting our education system from an emphasis on means to an emphasis on ends, from procedures to purposes, from time spent to outcomes accomplished, from roles of personnel to goals for learners, from teaching to learning, from programs to performance, from curriculum to results, and from courses taken to criteria met." (1996:1). These ideas coincide with reasons put forward by the democratically elected post-apartheid government to entirely change the education system and to choose OBE as the most appropriate model to counter wrongs in South African Education.

Since my research occurred within an Outcomes-based context, it is essential that I describe and analyse the salient features of OBE and their impact on this research. One such feature is formative assessment.

3.4 WHAT IS OUTCOMES-BASED EDUCATION?

In this part of the critical review, the focus falls on the learning outcomes for Mathematics in the senior phase and formative assessment as the appropriate tool to assess learners.

My view of OBE is similar to that of Bixler (2002:1) who maintains that outcomes-based education "makes a great deal of sense". He sums up the central enterprise in OBE as follows: "Define a set of competencies that reflect the needs of society, then make sure all students meet or exceed them before they graduate. This simple idea, if implemented correctly, has the capacity to revolutionize the way we teach our students and prepare them for the future".

The latter part of the quotation resonates with my strong belief that we should refrain from training our learners for the final senior certificate examinations (grade 12), but rather prepare them for life. Alexander (2002:1) likewise considers “the theory behind the development of OBE [to be] simple and clear cut”, since “OBE sets clear goals and then designs curriculum that enables students to meet those goals”. She also mentions Needham (1995) who describes OBE as “stating what you want students to be able to do in measurable terms, then designing curriculum that lets them learn how to do it.”

3.4.1 Characteristics of Outcomes-based Education

It should be evident by now that OBE is defined by outcomes (Devlin, 2000; 1; Killen, 1999: 2; Malan, 2000: 27; Spady, 1996: 1). Learners are informed at the outset of what is expected of them in terms of achievement and the levels and criteria of such achievement. OBE “allows for expanding learning opportunities beyond traditional seat time as learning time” (Malan, 2000: 27). Similarly, Botha (2002: 4) maintains that OBE “began with a commonsense idea, namely that the quality of education should be judged by focusing on learner outcomes or results” and “that OBE is primarily concerned with focusing on what learners actually learn, and how well they learned it”.

According to Spady (1994) the true power of OBE, and what OBE actually encapsulates, manifests itself in the purposes, premises and principles on which it is built. Spady (1994:9) distinguishes two key purposes that reflect OBE’s “underlying “Success for all students and staff” philosophy”, namely: “Ensuring that all students are equipped with the knowledge, competence, and qualities needed to be successful after they exit the educational system”, and “Structuring and operating schools so that those outcomes can be achieved and maximised for all students”.

Spady (1994:9) states that the two OBE purposes are based on what he calls, three crucial premises or assumptions, backed by extensive research, namely that all learners are able to learn and succeed, but not at the same rate or in the same fashion. Secondly, that successful learning leads to more successful learning. Thirdly he says that schools have the powers that “control the conditions that directly affect successful learning”.

Furthermore, Spady (1994:10) speaks of four underlying principles that allow practitioners of OBE to “put the two purposes and the premises into action”. These principles include 1. Clarity of focus (This deals with having a clear idea of the learning outcomes to be attained and the competencies learners need to demonstrate) – 2. Expanded opportunity (This compels the teacher to allow the learner more than one chance to learn crucial aspects and to demonstrate whether learning occurred) – 3. High expectations entail “increasing the level of challenge to which students are exposed and raising the standard of acceptable performance" (Spady, 1994:12). Learners must reach for it to be complete, that is they must stretch themselves in order to attain the required standard. – 4. "Design down" implies that the teachers start with the curriculum and planning at the point where they would like learners "to ultimately end up and build back from there" (Spady, 1994:18).

3.4.2 What is meant by outcomes?

Since OBE is defined in terms of outcomes, it is important to consider what it is and how different people (Devlin, 2000; Killen, 2000; Spady, 1994; Zlatos, 1994) view it. Spady (1994:76) explains outcomes in terms of the learning that has taken place: "Outcomes are the actual results of learning that students visibly demonstrate. They involve the integration and application of content, competence, and confidence in actual performance settings when or after formal instructional experiences are over." Based on Spady (1988), Devlin (2000:1) describes an outcome in the following way:

> *An outcome is not the name of a concept, or the name of a competence, or the name of an attribute. Outcomes actually happen, somebody does something. Until they do it, an outcome has not been realised. An outcome is an actual demonstration in an authentic context … a culminating demonstration of the entire range of learning experiences and capabilities that underlie it. It occurs in a performance context that directly influences what it is and how it is carried out. The word 'based' means to direct, define, derive, determine, focus and organise what we do according to the substance and nature of the learning result that we want to have happened at the end.*

Zlatos (1994:26) views outcomes as intrinsic to OBE: "OBE's approach is to define clearly what students are to learn (desired outcomes), measure their progress based on actual achievement, meet their needs through varying teaching strategies, and give them enough time to help to meet their potential".

Killen (1999:1) distinguishes two types of outcomes inherent in all education systems. He makes the following distinctions: "The first type includes performance indicators such as test results, completion rates, post-course employment rates, etc. the second type of outcome is less tangible and is usually expressed in terms of what students know, are able to do, or are as a result of their education." The latter is what is normally referred to in terms of OBE. This is also the case with respect to this study.

For reasons of clarification the differences between the old and the new, (Du Toit, Mathfield and Prinsloo, 1996:18) are given in terms of objective-based and outcomes-based curricula:

OBJECTIVE-BASED CURRICULUM	**OUTCOMES-BASED CURRICULUM**
• Focuses on what the teacher will do	• Focuses on what the learner will do
• Finds the intent of teaching	• Describes the results of teaching
• Focuses on opportunities provided for learning	• Emphasises how learning is used, especially when applied to new areas
• Estimates the amount that can be learned in a given period of time	• Requires flexible allocation of time

Du Toit *et al*. (1996:18)

Table 3.1 Objective-based curriculum versus Outcomes-based curriculum

3.4.3 Senior Phase Outcomes for Mathematics as Learning Area

At this stage of the discussion it might be appropriate to reflect on the different outcomes distinguished in the official South African Government Gazette and documents from the Education Department. The Government Gazette, dated 31 May 2002, Volume 443 (No. 23406) makes mention of three different outcomes, namely critical, developmental and learning outcomes.

These critical and developmental outcomes are said to be entrenched in the South African Qualifications Act (1995), although Le Grange and Beets (2005) claim that there is no real evidence to indicate that critical outcomes are derived from the South African constitution. These critical outcomes, however, focus on the quality of the learner the education system should generate. The critical outcomes are generic and aimed at developing learners with respect to: identifying and solving problems, and making decisions that are critical and creative.

The Government Gazette (2002:23) states that learning outcomes are derived from the critical and developmental outcomes. Learning outcomes are defined as descriptions of what learners should know (including skills and values), demonstrate and be able to do at the end of a General Education and Training band, namely from grade R to grade 9. It also emphasises the notion that the "learning outcomes should ensure integration and progression in the development of concepts, skills and values through the assessment standards".

3.4.4 Dealing with Knowledge in the OBE classroom: The role of the teacher

In OBE there is a definite shift, from an emphasis on the importance of teaching to an emphasis on the process of learning and whether learners have achieved the intended outcomes or not (Alexander, 2002; Killen, 1999; Mason, 2000; Spady, 1994). Nyland (1991:31) emphasises this shift when he says that: “Outcome-based education focuses on outputs rather than inputs”.

Consequently the role of the teacher has shifted to being a facilitator to make the classroom more learner-centred. Mason (2000: 343) writes: “In an outcomes-based education (OBE), teachers are understood primarily as facilitators of learning, rather than as transmitters of a given body of knowledge”. Advocates of OBE “have stressed the role of teachers as facilitators of the development of competences at a level higher than drilled propositions or low level skills” (Mason, 2000:344). These levels seem to be linked to Bloom’s (revised) taxonomy of learning that distinguishes six (hierarchical) levels of cognitive development (elaborated upon in Chapter 4.4.6).

Alexander (2002:5) also highlights the shift that OBE advocates in classrooms away from being teacher-centred to being more learner-centred:

> *The learner and his achievements, weaknesses and strengths, become important to the teacher and the attainment of the outcomes of the program… The focus of the teacher becomes assessing the achievements of the learner … to help the learner master the agreed upon outcomes …The teacher’s role [thus] changes from a gatekeeper of the knowledge to a partner in education.*

Mason (2000:345) also argues that “teachers should be concerned to seek continually a careful balance among propositional [factual], procedural [developing abilities and competencies, and acquiring skills] and dispositional knowledge” since these knowledge types are “inextricably linked to each other”.

3.5 ASSESSMENT IN OBE

3.5.1 What is the role of assessment generally?

What do mathematics educationists say assessment is? What do they say the role of assessment is in the learning process? Izard (1993:185) explains assessment in terms of the function it performs in terms of assessing learner performance and skills mastered. Clarke (1989:4) concentrates on the value and use of the information contained in the process of assessment. Swan (1993:195-198) emphasises the diagnostic nature of assessment and maintains that its “design should naturally reflect its intended purpose”. Bodin (1993:116) sees assessment as a process that should be viewed as follows: “To assess means to organize (or to look at) a situation in such a way that it enables us to gather information which, after processing, can reveal something that is reliable about personal knowledge (or about the collective knowledge of a group.”

Assessment generally occupies a crucial role in OBE, and is geared toward ascertaining whether learners have indeed achieved the desired outcomes, and to what extent outcomes have been achieved. The process of ascertaining the state of affairs – that is whether learning or how much has taken place – is diagnostic by nature. Consequently, there is a deliberate shift away from relying overwhelmingly on summative assessment (at the end of a section of work), involving exclusively written examinations and tests, excluding instruments such as projects, tasks, etc. Before having a closer look at formative assessment, I first want to look at the debates around assessment.

3.5.2 Controversies around assessment

As far back as 1984 Black & Dockrell (cited in Izard, 1993:188) “recognized that teachers require extensive in-service work on assessment techniques if improved assessment strategies are to be implemented”. This quotation is very relevant to this study, because this is exactly our concern as expressed earlier on. It touches on that which is a concern for many mathematics educationists, namely that of validity of assessment. As such Bodin (1993:117) maintains that the major difficulties in assessment are not only concerned with “the identification and limitation of competencies”, but also with “concerns about validity”.

Why has there been a shift from summative assessment toward a greater emphasis on formative assessment? When looking at the role of summative assessment as instrument used by authorities to ensure that so-called standards are maintained, it is apparent that it becomes a measure to pressurise teachers to follow rigid guidelines which generally hamper effective learning. This is evident from the following discussion.

It is obvious from literature from mathematics educationists such as Izard (1993:187) that learners tend to “believe that the study of mathematics is the development of skills required by their … (examination board) under test conditions”. According to Gasking (1948), cited in Izard (1993:185), “external examinations exert considerable pressure on the subjects taught, on the topics within those subjects, and on the teaching strategies which are used”. Johansson (1993:169) ascribes this to “a culture of assessment dominated by quantitative comparisons between results” instead of “a comparison between results and goals” [learning outcomes]. He elaborates on the problems experienced with achieving set outcomes [goals] as follows:

> *goals are more often created according to what it is realistic to believe that they can learn under given conditions. When goals lie far above what is possible to reach, the assessment will be adapted to what can be reached. The comparison made in this way will be within a very fragmentary and superficial assessed curriculum, not relative to a well constructed intended curriculum.*

In this regard Bodin (1993:114) argues that "one cannot ignore the fact that students' perceptions, to a large extent, results from teachers' judgements" and that the "procedures and processes of assessment are largely responsible for the phenomena of exclusion".

Another matter that complicates effective assessment, and which ties in with the idea of exclusion mentioned above, is the fact that the diverse individual needs of all the learners have to be catered for. For Bodin (1993:139), it is important that assessment be diagnostic, and as such "must take into account learners' differences. He emphasised the fact that assessment "must be varied, if not individualized". The following statement is important and has consequences for classroom management, namely that "The illusion of justice that consists of treating in the same way all the year long students whose knowledge state is not the same, is an important obstacle to a real formative assessment.":

3.5.3 The need to change to more effective assessment

This section is closely connected to the discussion under 4.5.2 as some of the controversies mentioned served to drive transformation in assessment to eradicate or counter the inadequacies experienced in traditional assessment. The need for transformation towards more effective assessment generally, and in mathematics education in particular, had been the focal point of discussions and debates for quite a number of years. In this regard, Even (2004:3) contends that "at the heart of the current attempt of the mathematics community to reform student assessment lies the assumption that assessment data could be a powerful tool to improve learning."

Mathematics educationists and practitioners such as Bodin (1993), Ginsburg, Jacobs and Lopez (1993), Lowery (2003), and others had been concerned especially with the close connection between teaching and learning, the role and application of effective assessment instruments and tools, and interpretation and use of results gathered from assessment to inform teaching and learning. According to Lowery (2003:15) "Assessment is the central aspect of classroom practice that links curriculum, teaching, and learning". Bodin (1993:116) also refers to this connection between learning, teaching and assessment by saying that "there is a dialectical link between our perception of what knowledge is and about possibilities for assessing it". Ginsburg *et al*. (1993:157) stress the intimate link between teaching and assessment, arguing that "[i]nstruction and assessment are inseparable. If our teaching stresses rote learning, then our tests must attempt to measure it."

With respect to assessment reform Lowery (2003:15) asserts that the "aim is better assessment, not more". As such "reform efforts in mathematics education challenge teachers to reconsider traditional forms of assessment and to explore and implement alternative approaches". Lowery (2003:16) is adamant that assessment reform is crucial, since mathematics teachers can no longer "afford to rely strictly on traditional formats". She maintains that "Alternative forms of assessment offer more opportunities to reveal a student's perceptions and conceptions of mathematical knowledge". She furthermore states that most "forms of alternative assessment ask students to perform, create, produce, or do something; tap high-level thinking; and involve problem-solving skills. These forms use tasks that represent meaningful instructional activities, involve real-world application, are scored qualitatively, and require new instructional assessment roles of teachers".

Other aspects cited as shortcomings in past research on assessment in mathematics teaching deal with unjustified emphasis on the importance of 'answers', instead of focusing on thought and other processes to solve problems. In this regard Ginsburg, Jacobs and Lopez (1993:157) argue that "[t]eaching to get the right answer in the shortest possible time with the least possible amount of thinking is no longer a useful goal in mathematics. Calculators and computers can execute tedious calculations far more efficiently than can humans."

Rote learning and teaching learners to following recipes to reproduce transmitted facts have always been viewed as counter productive. Even after twelve years the following observation by Ginsburg *et al*. (1993:157) still holds true: "At the present time, assessment is still dominated by standard tests focusing on rote learning and mechanical use of procedures" which are "inadequate to the task of revealing what the [teacher] most needs to understand in order to plan instruction: the student's thinking processes and strategies, and the student's learning potential."

Bodin (1993:113) concentrates on the difficulties encountered with respect to questioning. These problems could be applied to both verbal and written questioning. He mentions that to vary the position of a particular question in a test "may modify significantly the rates of correct answers". Secondly, small changes made to a question, for example changing one or more words, "can produce strong differences in the results". Thirdly, the way in which questions are structured "may convey wrong ideas about the knowledge of concern". Furthermore, "The formulation of questions may carry so much weight that it is implicit that a correct answer is more a sign of similarity … than an indication of the knowledge" displayed by the learner". Lastly, he claims, based on research findings, that the behaviour of a learner "on one form of a test cannot be predicted on the basis of his results on another form” These salient points focus attention on the need for the reliability of written tests to be questioned.

3.5.4 Why is there a need to assess formatively?

In this section I briefly want to focus on the need to assess formatively in the OBE mathematics classroom. This section is in part addressed in 4.5.3. Based on my experience and regular contact with teachers in their classrooms, their understanding and skills related to formative assessment are still limited. The potential of formative assessment is thus not yet realised and applied.

Certain practices, such as concentrating on finding the right answer (see 4.5.3), is not feasible or adequate anymore. Bodin (1993:133) makes the important point that traditionally “assessments often focus on the rate of good answers obtained, but wrong answers and non-answers are also worthy of being examined”. The emphasis thus has shifted to the processes involved in finding solutions and problem-solving strategies used Ginsburg *et al.* (1993:165) maintain that asking learners to “spell out the processes used to solve problems” gives “more credit for this aspect of problem solving than to the answer itself”. Bodin (1993:133) makes a telling point when he says that: “Above all, the procedures used by students when answering questions should be studied”. Swan (1993:195) writes that this is possible through assessing formatively, by means of which the learners’ achievement can be recognised “so that appropriate follow-up may be designed and provided”. This ties in closely with Bodin’s (1993:133) view that “it is most important that we move from a quantitative view of assessment to a qualitative one”.

Another important reason for moving towards formative assessment, especially in mathematics is to counter the untenable situation where “assessment is still dominated by standard tests focusing on rote learning and mechanical use of procedures” (Ginsburg *et al.*, 1993:59). As such they maintain that this approach to assessment is inadequate to the undertaking of ascertaining what the teacher most wishes to understand and gain insight into in order to plan and strategise future teaching and learning incidents, namely the learner’s “thinking processes and strategies” as well as the learner’s ‘learning potential” (Ginsburg *et al.*,1993:158)

3.5.5 What needs to be assessed?

Piaget (cited in Ginsburg *et al.*, 1993:158) was especially concerned with learners’ mental or cognitive dimension. He was thus more interested in the thinking processes involved or applied in solving mathematics problems, or as (Ginsburg *et al.*, 1993:158) put it, more interested in “uncovering and describing basic thought processes”. The active role of the learners is also emphasised by involving them in the act of spelling “out the processes used to solve problems”, and for teachers to give “ more credit for this aspect of problem-solving than to the answer itself (Ginsburg *et al*., 1993:159). Bodin (1993:138) admits that assessment of knowledge is important for diagnosis, but adds that it is the “scale of the area of knowledge” that should be taken into account. Romberg (1993:97) introduces another factor saying that assessment is concerned with whether learners “have acquired the intended knowledge”. He poses two “fundamental epistemological questions”: “What knowledge do ‘we’ want students to have?” and “How does a student come to know?”. It is clear from this that he views assessment as instrumental in facilitating the process of learning.

3.5.6 Formative Assessment

This brings us to the concept of ‘formative assessment’. However, before addressing the specific nature of formative assessment it is essential to examine assessment in its wider context and how it pertains to mathematics as learning area. Webb (1992: 662) in an effort to develop a theory of mathematics assessment expresses the viewpoint that “… the nature of mathematics is distinctive enough and mathematics classroom practices … different enough to suggest that mathematical assessment should be distinguishable from other content area assessment.” Webb (1992: 662-663) defines mathematical assessment as “the comprehensive accounting of an individual or group’s functioning within mathematics or in the application of mathematics”.

As I pointed out in the introduction to this chapter, in this research study the use of feedback as an integral component of formative assessment in Mathematics teaching and learning is explored. In the same manner as Mehrens (1998:2), I want to address the issue as to “what evidence we have regarding the consequences of [*formative*] assessment” as far as the learning of mathematics is concerned. The use of feedback in a constructivist approach to the teaching and learning of mathematics needs to focus in on how the “form and content must be changed to better represent important thinking and problem-solving skills” (Shepard, 2000: 5), and change teachers’ and learners’ views on the role and use of assessment to facilitate both teaching and learning. The importance of formative assessment in the learning and teaching processes is emphasised by the following quotation by Orlich *et al*. (1990: 30):

> *The rationale for formative [assessment] evaluation is to provide data [information] to the student and teacher so that they may make corrections [changes] – immediately, if not sooner! When both students and teacher realize that instructional [learning and teaching] activities are being monitored constantly, they tend to become more responsible and productive. The instructional*

> *[teaching] climate and total program environment become positive and supportive. This is precisely the kind of learning climate that the teacher always ought to foster when teaching. Conversely, classes have "gone on the rocks" because the teacher was not evaluating [assessing] student activities over short periods of time, but waited until the very end of the course or unit to accomplish a one-shot final evaluation.*

According to Nakabugo and Siebörger (1999:288), "Formative assessment is a misnomer, as it is not a description of a mode of assessment but rather a description of a use to which assessment is put, namely to inform educators and learners about a learner's progress in order to improve learning." This implies that the use of formative assessment could result in improved learning. Numerous research studies done at an early stage of using formative assessment revealed that "improved formative assessment helps low achievers more than other students and so reduces the range of achievement while raising achievement overall." (Black & Wiliam: 1998b:3). A more recent study showed that both low achieving learners and learners with learning disabilities benefited from continuous assessment in the sense that in the case of both groups, learners' learning was enhanced (Black & Wiliam, 1998b:3).

Formative assessment emphasises ongoing learner support and focuses on feedback into learning and teaching. It aims at making the learning process more meaningful, by ensuring that understanding, concept formation and application of knowledge and skills acquired during a lesson or series of lessons, are constantly monitored. Learners not only gain insight into their progress, but the resultant feedback would also allow the teacher "to plan immediate remedial action" (Curzon, 1985:267), by altering methodologies (teaching strategies) or by revisiting some aspects that were not well understood. It can thus be viewed as "cumulative judgement" which forms the "basis of the final assessment" (Curzon, 1985:267) of the learners' abilities.

Another important feature of formative assessment is that it should "provide feedback in a rather immediate sense" (Orlich *et al*., 1990:29). The focus should be on particular aspects, to allow the teacher to gain insight into these problem areas, as far as the learner is concerned, such as conceptualisation and concept formation, comprehension (identify and explain), degree of insight gained, knowledge acquired (ability to describe, verbalise, measure, recall), application of knowledge (the ability to use, manipulate, change, assess), problem-solving, reasoning ability, analysis (ability to critique, infer), ability to synthesise, argue, reconstruct, design), the ability to make inferences, and to evaluate (support, attack, appraise or clarify). This assessment type should allow the teacher to "quickly identify and correct problems" (Orlich *et al*., 1990:29).

The pertinent question to be posed here is whether effectively applied formative assessment would ultimately result in improved learner achievement in mathematics. This would only be possible if the questioning elicits 'true' feedback from the learners which the teacher can utilise to adapt strategies and use alternate methods to optimise learning. Proper questioning would allow the teacher to ascertain what learners understand, what insights have been developed and whether misconceptions are present. (Black & Wiliam, 1998b)

Formative assessment should thus essentially be employed to help teachers to monitor their learners' progress and the problems they might encounter that hamper progress and understanding (Black and Wiliam, 1998; Stiggins, 1999; Nakabugo and Siebörger, 1999). It mainly involves tasks that deal with diagnosis and remediation to facilitate improved learning. Furthermore, formative assessment is considered to be an integral part of teaching, and as such "needs to be considered as an ongoing dynamic process" (Kulieke, Bakker, Collins et al, 1990) to ensure that learners' needs are adequately diagnosed, and also ensures thorough understanding of the rate at which a learner learns. The general description of formative assessment thus is that it is broadly diagnostic by nature, as it should reveal concepts, skills and processes that the individual learner needs to work on further.

As far back as 1999 Stiggins (1999:1) had the following to say regarding the assessment learning relationship: "The time has come to fundamentally rethink the relationship between assessment and effective schooling", especially with regard to "how we use assessment" to ensure learner achievement and success. In the same manner Senk, Beckman and Thompson (1997: 211) maintain that "improving classroom tests may be the surest way to improve the quality of assessment in high school mathematics". Senior phase mathematics teachers in Circuit 6 generally need to undergo effective in-service training to successfully use formative assessment in their classrooms, as well as guidance to facilitate the transition from a more summative to a more formative assessment strategy.

Research studies have shown that there is a positive relationship between formative assessment and improved learner performance and achievement. (Black & Wiliam, 1998b). Numerous research studies (see, for example, Black & Wiliam, 1998a; Stiggins, 1999) have revealed that "improved formative assessment helps low achievers more than other students and so reduces the range of achievement while raising achievement overall." (Black & Wiliam: 1998:3).

3.5.7 Providing formative assessment?

Formative assessment seems to be more accurately described when compared with summative assessment. Summative assessment can be viewed as an effort to summarise a learner's learning after a period of time, such as at the end of a semester or academic year (Boston, 2002). These bigger tests or examinations are not devised to afford the instantaneous, contextualised feedback useful for aiding the teacher and learner during the learning process. Formative assessment on the other hand, occurs when teachers feed information back to their learners in ways that facilitate learning, providing room for learners to likewise engage in self-reflection (Fairtest Examiner, 1999). Likewise, Boston (2002:4) argues that the "… task of summative assessment … remains quite different from the task of formative assessment [which is] to monitor and improve progress … over time in multiple problem-solving situations".

For the assessment to be considered formative, it should satisfy the formative assessment criteria as set out in the Government Gazette Vol. 396 No. 18998, dated June 1998.

It should namely:

- Assess the learners' achievement and progress
- Form an essential aspect of the learners' total evaluation
- Be ongoing
- Be diagnostic – monitor learners' strengths and weaknesses
- Be used to pace learners and provide enrichment for fast learners
- Be transparent – learners should be aware and understand
- Ensure that work assumes significance for learners
- Be conducted more informally
- Form part of informal daily assessment – concentrating on different aspects, ensuring that content is not the only focus
- Encourage and teach learners to appraise their own work

Black and Wiliam (1998b), also cited by Boston (2002:2), strongly recommend that teachers often and effectively apply questioning strategies and classroom conversation techniques as opportunities to improve and enhance learners' knowledge, insight and understanding. They suggest that teachers should use questions that facilitate reflection and promote problem-solving strategies, rather than simple questions that only require facts and knowledge. They emphasise involvement of all learners and make the following suggestions: Learners should be called upon to share and discuss their thinking, share their viewpoints, explain their strategies to resolve an issue, raise their questions, and problems in pairs or small groups (cooperative learning). Someone in the group should then share their thinking with the whole class. Teachers should endeavour to pose questions in such a way that more than one answer or solution to a question is possible. Different outcomes to the same questions should then be debated. Learners could also be asked to write down detailed problem strategies to a problem, which would then be shared by reading aloud.

They also suggest that teachers assess learners' understanding and insight by engaging in the following activities: Allow learners to express their understanding of terminology, concepts or learning area jargon prior to and after the lesson or teaching incident. At the end of a lesson have learners summarise the main ideas they remember. Whenever the occasion arises, have learners complete problems or questions similar to those discussed earlier in the lesson to reinforce certain skills, and check these through self- or peer assessment. Create opportunities for learners to be interviewed individually or in a group context to ascertain their thinking and strategies with respect to problem-solving.

In order to address most of the issues related to effective formative assessment careful planning is required. Swan (1993:200) therefore talks of 'six dimensions" that need to be taken into consideration when devising assessment instruments to ensure that the learning process is really enhanced, namely:

- The achievements being assessed
- The appropriate method of assessment
- The degree of "openness" of the task
- The degree of autonomy and flexibility required
- The extent and coherence of the task
- The context in which the task is set.

The following adapted table taken from Lowery's (2003:17) paper, entitled "Assessment insights from the classroom" shows alternative forms of assessment to optimise formative assessment, enhance teaching and facilitate learning. It gives one a bird eye's view of all the possibilities with respect to assessment instruments and tools available, together with the particular didactical purpose it might serve. By applying as wide a variety of assessment tools as possible, a wider range of needs of different learners can be met, or as Lowery (2003:18) puts it: "… to create a complete picture of the students' mathematical knowledge".

ASSESSMENT INSTRUMENT / TOOL / PROCESS	**PURPOSE**
Journal writing / writing prompts	To assess development of mathematical concepts; from writing activities teachers can gain insight into learners' thinking and reasoning
Projects and investigations	To develop and apply concepts
Performance assessments and use of manipulatives	To demonstrate concept attainment through the use and mastery of manipulatives
Concept mapping	To provide insight into learners' mathematical thinking

ASSESSMENT INSTRUMENT / TOOL / PROCESS	PURPOSE
Problem-solving	To develop logical thinking; exploring options; motivate interests; promote critical thinking
Diagnostic activities	To determine knowledge gaps; learns' level of development; learners' readiness to tackle a particular section of the curriculum
Class discussion	To observe interaction; learner participation; assess learning informally
Learner conferences & conversations	To assess learners' abilities and skills to relate mathematics to areas outside the classroom (in real life) and in different contexts
Classroom challenges through games	To enhance and motivate interest; assess participation and learning
Integration with other subjects	To use projects and mathematics content material to integrate other fields involving a variety of mathematics concepts
Rubrics & checklists	To customise assessment to individual needs of tasks or assignments
Verbal questioning integrated with teaching	To expose learners to abstract levels of questioning; ascertain learners' depth of understanding during activities; develop higher order thinking skills
Cooperative learning (small group discussions, investigation & activities)	To advance the social component together with cognitive development; develop team work
Portfolios	To represent learning through samples of learner work; qualitative and quantitative progress of learner's efforts
Warm-ups & mental activities	To assess problem-solving strategies; to put learners into a mathematical framework; to reinforce certain concepts
Homework	To extend exposure to mathematics beyond the classroom; assess transfer of learning; demonstrate application; determine understanding and comprehension of outcomes
Testing – different formats, quizzes; puzzles	To determine learner growth patterns; develop higher order thinking skills; assess mastery or / and or transfer of concepts and skills
Notebooks or workbooks	To assess learners' work habits; completion of tasks and exercises; obtain visual impressions of learners' understanding of mathematics related concepts
Peer & self assessment	To enhance peer learning; become self-critical; ensure higher degree of involvement with content and concepts

Adapted from Lowery (2003:17)

Table 3.2 Purposes of assessment

3.5.8 Sharing of assessment criteria or standards

Why do teachers have to share criteria with learners? When is it appropriate to share these criteria? If learners are to be assessed, is it important for them to be familiar with the criteria and outcomes relevant to that particular part of the course? These are some of the questions to be addressed in this section.

From research studies analysed by Wiliam (2000:20) it is evident that learners "need to understand the standards against which their work will be assessed". A research study undertaken by Frederiksen and White (1997 cited in Wiliam, 2000:20), "shows that the criteria themselves are only the starting point". Initially the criteria might not have the same meaning or significance for the learner as intended by the teacher, consequently it is imperative that the learners are given the opportunity to find out what the significance or meaning is in terms of the context of their own efforts. Wiliam (2000:20) maintains that criteria should be used in a manner that inculcates a sense of quality in learners and cites Frederiksen and White's (1997) method whereby

> *"[m]arking schemes are shared with students, but they are given time to think through, in discussion with others, what this might mean in practice, applied to their own work" and that "… the criteria will provide a focus for negotiating with students about what counts as quality in the mathematics classroom."*

3.5.9 The role of the learner in formative assessment

The role of learners in assessment, especially with respect to self-assessment and peer-assessment, should not be underestimated (Bright and Joyner, 1999; Kulm, 1994; Moon & Schulman, 1995; Stepanek, Jarrett & Peixotto, 1997; Wiliam, 2000). According to Black and Harrison, 2001:43) "It has been argued that 'self- and peer-assessment by students ought to form a part of any development of formative assessment in classrooms". Those who advocate self-assessment emphasise the fact "… accuracy is a secondary concern – what really matters is whether self-assessment can enhance learning" (Wiliam, 2000:20). Through self-assessment learners are given the opportunity "to reflect on their learning experiences", "become more conscious of their own learning", "gain understanding of their own strengths and weaknesses", and to "become active partipants" (Stepanek, Jarrett & Peixotto, 1997:20) in the assessment process.

Bright and Joyner (1999:1) view learner self-assessment as a vehicle to assist the teacher to cope with the increasing demands such as large class numbers, helping all learners to develop "significant conceptual understanding of mathematics". They maintain that learners "need to become more facile at self-assessment of understanding so that they can assume greater responsibility for their own learning", and "effective … assessment provides a context within which this might be accomplished".

How does this process of learner self-assessment benefit the teacher? It helps in various ways, according Stepanek, Jarrett & Peixotto (1997:20). It helps the teacher to gain insight into learners' efforts and performance and forms an integral part of facilitating learning. In this sense it is also crucial for teachers to take cognisance of the learning theories discussed previously. Furthermore, self-assessment enhances communication in the sense that it focuses learners' attention on aspects in which they experience problems, allowing them the opportunity "to articulate their needs [and misconceptions] to the teacher". According to Kulm (1994), also cited in Stepanek, Jarrett & Peixotto (1997:21) learner self-assessment moments can be viewed as opportunities "for teachers to address the dispositions of their students through their interactions and instruction", at the same time allowing learners to observe how "… their attitudes affect their performances". This coincides with Bright and Joyner's (1999:8) stance that many learners "view assessment that goes beyond "right/wrong" as intimidating, perhaps because they rarely understand that reflection about ones's learning is important".

Learner self-assessment also has the potential to supply information regarding learners' learning preferences (Stepanek, Jarrett & Peixotto, 1997:21), thus assisting teachers in gaining insight in how to approach, and devise suitable activities. By means of this strategy activities, tasks, or assignments can be used to boost learners' "… confidence and comfort level[s] in areas where they have more difficulty" (Stepanek, Jarrett & Peixotto, 1997:21).

According to Wiliam (2000:22) "Effective questioning is that which engages all students in thinking, rather than remembering, and doesn't allow students to relax simply because they've just answered a question". The inter-relationship between learning outcomes, questioning, feedback and thus formative assessment (assessment standards) is evident from the following statement by Wiliam (2000:22):

> *Rich questioning and effective feedback focus on the teacher's role – first being clear about where we want students to go to, asking appropriate questions to find where they are, and feeding back to students in ways that the students can use in improving their own performance. Sharing criteria with learners and student self-assessment focus on the learners' role – first being clear about where they want to get to, and then monitoring their own progress towards that goal.*

3.5.10 The formative assessment-feedback relationship

The intrinsic part that feedback forms of effective formative assessment needs to be highlighted and elaborated upon (Boston, 2002; Ramaprasad, 1983; Sadler, 1989). Feedback – as part of formative assessment - is generally described in the paper by Boston (2002:2) as usually given by the teacher to the learners to arouse awareness in them as to "their desired goal and their current knowledge, understanding, or skill and guides them through actions necessary to obtain" the required outcomes.

The significance of the feedback inherently offered by effective assessment is reflected by the nature of its function to – as assessment instrument – ascertain whether learning has taken place. Izard (1993: 188) thus describes assessment as having "the function of providing valid evidence of learning achievement to inform students, to facilitate provision for further learning … Teachers are able to develop and improve the educational process if they have identified and responded or acted upon the strengths of their pupils and know which areas of study require attentions." Stepanek, Jarrett & Peixotto (1997:3) emphasise that formative assessment should be used mainly to "… provide both teacher and student with valuable feedback about the student's progress". Clarke (1989:4) also highlights the close relationship between assessment and feedback when he claims that "The information provided by assessment should do more than portray a learner's level of performance. It should inform the actions of all participants in the learning situation." He stresses that "Links must be forged between the assessment, the instruction it reviews, and the instruction it anticipates."

Conventionally, feedback as part of communication, is initiated by the teacher. This, however, should not diminish the crucial contribution learners themselves can make with respect to formative assessment by assessing themselves and their peers. In this regard Boston (2002:2) agrees that although "feedback generally originates from a teacher, learners can also play an important role in formative assessment through self-evaluation".

Boston (2002:2) mentions two experimental research studies undertaken by Fontana and Fernandes in 1994 and Frederick and White in 1997 that revealed that learners who grasped and had insight into the learning outcomes and assessment criteria, and were provided opportunities "to reflect on their work have shown greater improvement than those who do not".

3.5.11 Assessment and questioning

How can the feedback-assessment relationship be a fruitful one without effective questioning? Although this matter is highlighted in Chapter 4, and discussed in terms of Bloom's revised Taxonomy, it needs to be discussed here for reasons that should become clear from the discussion which follows. Basically I also want to focus on how teachers might deal with learners' responses and how questioning could be used to prompt learners to respond.

This assessment-questioning relationship is addressed by Bodin (1993: 139) who claims that "[a]n assessment question must be considered as an indicator of the state of students' knowledge". When questioning in terms of feedback is considered, there is much more at stake than the way in which the question is phrased or whether it is of a higher or lower order. Questioning as I understand it should be roughly viewed as a process involving the following:

Question (from teacher) – response time allowed – learner sense-making and response – teacher's ability to listen, approach and response appropriately to what the learner said.

Very often learners' responses differ from what the teacher had in mind. Generally teachers are geared towards the answer they have in mind, and ignoring the potential of different or wrong answers from learners as instances of learning. According to Bodin (1993:133), "Assessment often focus[es] on the rate of good answers obtained, but wrong answers and non-answers are also worthy of being examined. Above all, the procedures used by students when answering questions should be studied". Confrey (1991:122) explains that the teacher should "seek out in their [learners' responses] systematic qualities which are typically grounded in the conceptions of the learner". This would help the teacher to "increasingly understand the sensibleness of their approaches from their point of view." Confrey (1991:122) agrees that learners' responses "possess the seeds of alternative approaches which can be compelling, historically supported and legitimate if we are willing to challenge our own assumptions", and that "these deviations provide critical moments for researchers to glimpse and then to imagine how students are viewing an idea."

When learners do not respond to questions we do not know what they think, how they perceive, or how they interact with mathematical concepts. Research by educationists such as Black and Harrison (2001), Brophy and Good (1997), Davis (1997) Dillon (1988), and others identified various ways of promoting and encouraging learner participation and response. The Department of Education (2002:16) claims that learners' responses are enhanced when the classroom atmosphere in which they find themselves make them feel secure and when there is no threat of being harshly criticised or teased for giving an incorrect response; if appropriate prompts are supplied to boost their confidence to at least express an opinion; when the teacher chooses a respondent by name rather than have someone volunteer; when a waiting period of three seconds or longer is allowed.

3.6 CONCLUSION

I have to a large extent succeeded in identifying some of the underlying theories that inform this research, that is, theories related not only to my role as researcher and facilitator, but also those which address the teacher's position in the mathematics classroom as well as those aimed at explaining how learning takes place. What these have in common is that they see humans not only as cognitive beings, but also as psychological and social entities, and that learning and the process of making meaning are intimately linked with context and interaction with others.

In this chapter I reflected on the complex nature of the learning process and how formative assessment can be utilised to enhance learning and teaching. The salient features of particular theories that underlie the learning process with respect to both children and adults as learners were discussed in an effort to position this research theoretically. At the same time I endeavoured to come to grips with what a theory of learning mathematics must entail.

It was essential to explore the essence of constructivism as the major learning theory underlying OBE. OBE, as opposed to more conventional transmission of facts, requires new assessment strategies such as formative assessment to optimise or enhance learning of mathematics. I strove to show the inter-connectedness of communication (questioning and feedback), assessment, learning, teaching inside the OBE 'paradigm' with respect to mathematics teaching. The OBE philosophy that underlies our current education system was analysed with respect to purposes, premises and principles.

This chapter is followed by Chapter 4 which focuses in on the concept "feedback". Not only do I explore the meaning and origins of feedback, but the role of feedback with respect to communication, questioning, listening and learning is also addressed. A deliberate effort is made to show the intricate and integrated nature of formative assessment with feedback.

CHAPTER 4: FEEDBACK: FROM THEORY TO PRACTICE

No, but "cyber" is there. Look at terms like "feedback". Everybody knows what feedback is. Cybernetics did that. Things of that sort. I think cybernetics connects underneath. It's implicit. Underneath, it's completely alive. But not explicit. In some cases I find it more important that something is acting implicitly, than explicitly. Because the implicit has much more power.

Heinz von Foerster (Waters; 1999: 81)

4.1 INTRODUCTION

Bryan giving feedback at a focus group session … 19 August 2004

This chapter attempts to trace the genesis and foundation of the concept 'feedback' in general and its intricate relationship with aspects such as communication, listening and questioning (Mandel & Vontver, 2001) as part of formative assessment in particular. Statements by scholars such as Lehner (1987), Monga (2002), and Rich (1999) give a sense of the role, and significance of feedback in giving meaning to communication between human beings.

Rubin and Campbell (1998:11) like Von Foerster see the role and significance of feedback as follows: "Feedback to a professional is like water to a fish: it's everywhere; its essential; and it's taken for granted – until it fails." Monga (2002:1) views feedback as "a fundamental part of the communication process". She also maintains that optimal use of feedback substantially diminishes obstructions to communication, whether giving or receiving it. She stresses the fact that feedback does not simply happen intuitively, but that people in organisations, such as teachers "must learn specific techniques on how to give and receive feedback effectively" (2002:1). This implies that for communication to be successful, feedback has to be given skilfully and efficiently, and those concerned have to learn ways to handle it (Lehner, 1987:1; Monga, 2002:1). Adler and Rodman (1997:13) agree that feedback per se "doesn't guarantee [that] understanding will occur".

Another important aspect of feedback is highlighted by Gunderman and Williamson's (2002:446) perspective, namely that "Feedback influences everyone's sense of whether they have been successful or not, and so influences how they think and act in the future."

In this chapter, apart from positioning feedback in terms of the process of communication, I also explore its inherent dependence on listening and questioning strategies as prerequisites for successful feedback. Consequently, it becomes necessary to explore how listening and questioning hamper or facilitate feedback. Essentially, the relationship between feedback and assessment is central in this whole study. Thus I focus on aspects such as positive and negative feedback, immediate and delayed feedback, and the process of giving and receiving feedback, as factors that might retard or facilitate learning in mathematics education.

4.2 ORIGINS OF THE FEEDBACK CONCEPT

Feedback originated in the field of cybernetics (Bar-Yam, 2000: Littlejohn, 1992: 45; Nickols, 2000:1; Von Glasersfeld, 2000:93-95; Vaughn, 2002:1). During the 1950's the study and application of feedback was a major concern of the field of cybernetics, "as part of the understanding of control and regulation (homeostasis) in artificial and biological systems" (Bar-Yam, 2000:2). Littlejohn (1992: 45) describes cybernetics as " the study of regulation and control in systems, with emphasis on feedback" and that it mainly "deals with the ways systems gauge their effect and make necessary adjustments". Says Vaughn (2002:1): "Cybernetics focuses on how systems function and how they control their actions, and how they communicate with other systems or with their own components." The communication, here, refers particularly to feedback. Vaughn (2002:1) acknowledges in his paper entitled "Cybernetics", that cybernetics has quite a number of different definitions, but that he prefers the one by Littlejohn (1992: 45) who views it as the "study of feedback".

According to Bar-Yam (2000:1), Nickols (2000:1) and Von Glaserfeld (2000:94), Norbert Wiener is considered to be the father of cybernetics since it (cybernetics) is built on work originally done by him. Cybernetics deals with miscellaneous elements, that relate to feedback and the significance thereof "in a system's response to the environment" (Bar-Yam, 2000:2). As such cyberneticists see feedback as "information about the results of a process (its outputs) which is then returned back into the process (a circular feed or recursive loop) and used to adjust and change the process itself" (BOLA, 2002:1). In terms of knowledge Pangaro (2000:1) claims that cybernetics is greatly concerned with the "unavoidable limits of what we can know: our own subjectivity and in this regard is 'fittingly' called applied epistemology".

The traditional cybernetic view of feedback as expressed by Bar-Yam (2000:1) and other cyberneticists such as Nickols (2000) and Von Glaserfeld (2000) differs markedly from how it is currently used in the social and related sciences such as Business and Education. At the same time, however, it is evident from literature (Nickols, 2000:1; Bar-Yam, 2000:81; Stirton, 2001:1) that the viewpoints and interpretations expressed in these fields are intimately linked. Bar-Yam maintains that "Feedback is a circular process of influence where action has effect on the actor." (2000:1) He uses the following example to illustrate this point:

> *… a thermostat that controls the temperature in a house uses feedback. It contains a controller that turns the furnace on and off which heats the room. The thermostat also measures the temperature in the room to determine when to turn the furnace on and off. The control of the furnace changes the temperature in the room, which is measured by the thermostat which controls the temperature. The goal … is a reasonably uniform temperature which is specified by the position of the temperature dial.*

The proponents of cybernetics (Bar-Yam, 2000:81; Buchanan, 1997:2; Nickols, 2000:2; Huitt: 1998:1; Stirton, 2001:1) maintain that many processes in biological, economical and social systems apply feedback to ensure that the status quo is maintained in the same manner as the feedback that occurs within a thermostat.

Huitt (1998:1) also considers feedback to be crucial in terms of systems. According to him feedback "refers to the process of receiving input from the environment based upon the actions or output of the system". Umpleby, quoted in Huitt (1998:1), introduces a different emphasis, seeing it as information related to the "results of a process which is used to change the process itself". Umpleby also distinguishes between "negative feedback" (which minimises error or deviation from the ideal or desired state), and "positive feedback" that leads to increased divergence from the original condition or state (Huitt, 1998:1).

Nickols (2000:1) writes that feedback emanated in the "hard sciences, with applications in electronics, computers, servomechanisms, and various cybernetic devices". Nickols (2000:1) also maintains that feedback as "well-defined technical" term, in the process of adopting and adapting it to the social sciences, lost some of its original meaning in the manner that it has been employed within the behavioural sciences. As an example he uses feedback given as part of "an employee's … performance review". In his opinion much of what passes for feedback there is not feedback at all. "At its worst, it is a mix of unfounded criticism, irrelevant personal judgement, …" (Nickols, 2000:1). He furthermore states: "There is very little merit in the prevailing behavioural science view of feedback", since according to him it is “far removed from its technical meaning and, being far removed, robs us of the full benefit of a very powerful concept.”

The cybernetic view of feedback is very wide and also has relevance with respect to the learning process. Feedback is perceived as an integral part of the learning process, and thus cybernetics also focused on how human beings know, what they know, as well as the limitations of knowledge (Bar-Yam, 2000:3).

4.3 FEEDBACK AS PERCEIVED BY THE SOCIAL SCIENCES?

Various conceptions and definitions of what feedback entails exist. These notions vary according to the ways in which feedback is used or applied in different fields such as cybernetics or the social sciences. Some of the definitions focus only on feedback as it relates to systems (Bar-Yam, 2000:2; de Rosnay, 1997:1; Huitt, 1998:1; Littlejohn, 1992:45; Nickols, 2000:2; Stirton, 2001:1), whilst others concentrate primarily on feedback as it impacts on communication and how it changes human behaviour, and fosters self-development (Fielden & Goh, 2003:1; Kornhauser & Sable, 2000:1; Long, 1996:152; Murdoch, 1999:10; Rich, 1999:1).

The following definitions of feedback relate to the way in which it is used in the human sciences. Rich (1999:1) describes feedback simply as a “type of communication that we give or get”, as well as a way to let people know how effective they are in what they are trying to accomplish. He continues by saying that feedback “provides a way for people to learn how they affect the world around them, and it helps us to become more effective". Kawashima *et al*. (2000:698) similarly equate feedback to “knowledge of results” that “facilitates learning and is often a good motivation for many performances in our daily life”. Hole’s (1999:1) definition of feedback also resides in its purpose or function, namely that it allows teachers or facilitators to identify ways as to how to improve their teaching or facilitation skills and ultimately improves learning.

Lehner (1987:1) views feedback in terms of “important data” that is received or given to significant others. This, what he calls “personal data feedback”, allows the individual to become more conscious of “what” and “how” he or she does things, responds to a situation, etc. According to Lehner (1987:1), this ultimately increases the individual’s capacity to accordingly “modify and change” his or her own behaviour, resulting in more effective and constructive interactions with other people.

Users of feedback often classify feedback in terms of the situation and purpose for which it is used, while others also emphasise the effect on interpersonal relationships. Dinana (2003:1) views effective feedback as expressing meaning, strengthening of relationships and validation of the feedback process with respect to future communication. Yates (2002: 3), on the other hand, refers to "motivational" feedback which informs the receiver about what was good, and "developmental" feedback which focuses on what can be changed or improved. Bovee and Thill (quoted in Sanchez, 2003:2) also describe feedback in terms of the wider encompassing role it occupies within the communication process, namely that it indicates "significant communication barriers, differences in background, different interpretations of words, and differing emotional reactions."

Some researchers and educationists also use different adjectives, such as 'constructive', 'corrective', 'negative' or 'positive' to distinguish between the function or role of the intended purpose of feedback. Naylor (2002:1) and Morgan (1997:6) speak of "corrective feedback", while Black & Dylan (1998:22) speak of "formative feedback" leading to "positive learning gains". BOLA (2002:2) equates "interpersonal feedback" to communication to reflect and adjust behaviour. This kind of feedback provides information to the receiver about how he or she is being perceived, and how they affect significant others. The term constructive feedback, is used by Kramer (1977:102), Frase (2001:176-180) and others as an incentive for the receiver. Curzon (1985:83) speaks of information feedback in cybernetic terms as "the return of a signal which indicates the result of an action and which can be used to determine future actions".

The importance of feedback within organizations is stressed by Kornhauser and Sable (2000:1) when they refer to it as "intra-organisation feedback". Cyberneticists such as De Rosnay (1997:2), Littlejohn (1992:47) and Von Glasersfeld, 2000:93) distinguish between positive feedback and negative feedback in systems. The positive vs. negative distinction, also frequently appears in education literature (Beatty, 1999:1; Morgan, 1997:8-9). These concepts and distinctions are discussed in greater detail under 4.5. More definitions of feedback by proponents of the cybernetics are discussed under the following heading.

4.4 FEEDBACK IN COMMUNICATION: QUESTIONING AND LISTENING

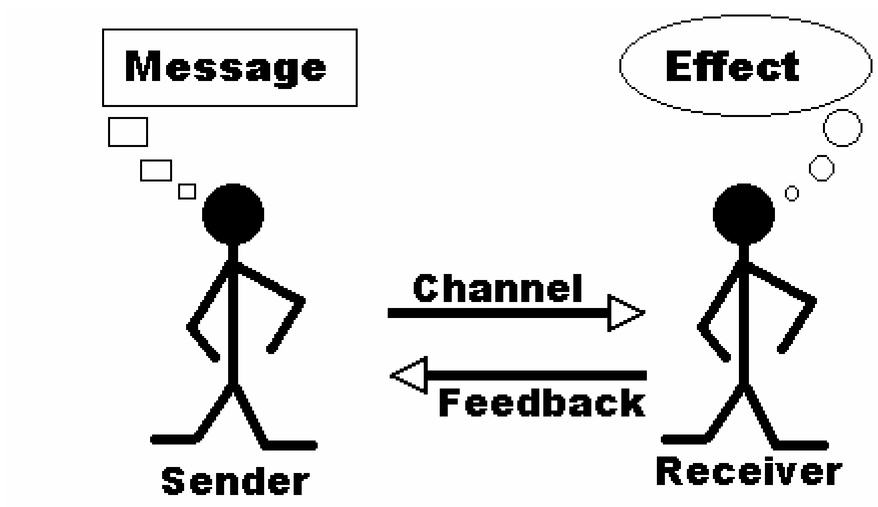
In the social sciences such as education and business, feedback is generally viewed as an integral part of communication (Adler & Rodman, 1997:11-16; Bressett, *et al*., 2001:2; Mandel and Vontver: 2001:1). Mandel and Vontver (2001:1) view giving and receiving feedback as one of the most effective ways to facilitate growth within the learner, to "reinforce" apt behaviour and to boost achievement. Kirmse (2001:3) states that feedback when used optimally "can considerably increase the effectiveness of oral communication" and can also be instrumental in creating an atmosphere conducive to cooperative learning.

According to Bressett *et al*. (2001:2) and Adler & Rodman (1997:13), interpersonal communication involves much more than perceiving verbal or non-verbal behaviour, or the exchange of spoken words. Erven (2002:4) emphasises feedback as the “receiver sending back to the sender the message as perceived”, and claims that lack of feedback makes communication a one-directional process. This would certainly be an inadequate way of communicating.

Similarly Adler & Rodman (1997:13) describes feedback as the “discernible response of a receiver to a sender’s message”. Sanchez (2003:1) views communication as consisting of “four key components”, which “include encoding, medium of transmission, decoding, and feedback”. According to him the process can only take place with a sender (where the communication process starts) and receiver (with whom the process ends) present – which does not necessarily always end here in the case of a dialogue. He describes feedback not only as “the final link in the communication process”, but also as “a key component” that allows the sender to evaluate the effectiveness of the message” (Sanchez, 1997:1).

This important role of feedback as integral component of interpersonal two-way communication is also emphasised by Bresset, Cheever, Townson, Turner (2001:1); Curzon (1985:85) and Erven (2002:2). The communication-feedback relationship is aptly described by Carty (2001:3) when saying that “communication is a feedback sensitive activity, analogous to the thermostat circuitry that controls an air conditioning system”.

Erven (2002:1) offers a simplistic model of the communication process. His model (in Figure 4.1) depicts the major components present in the communication process.



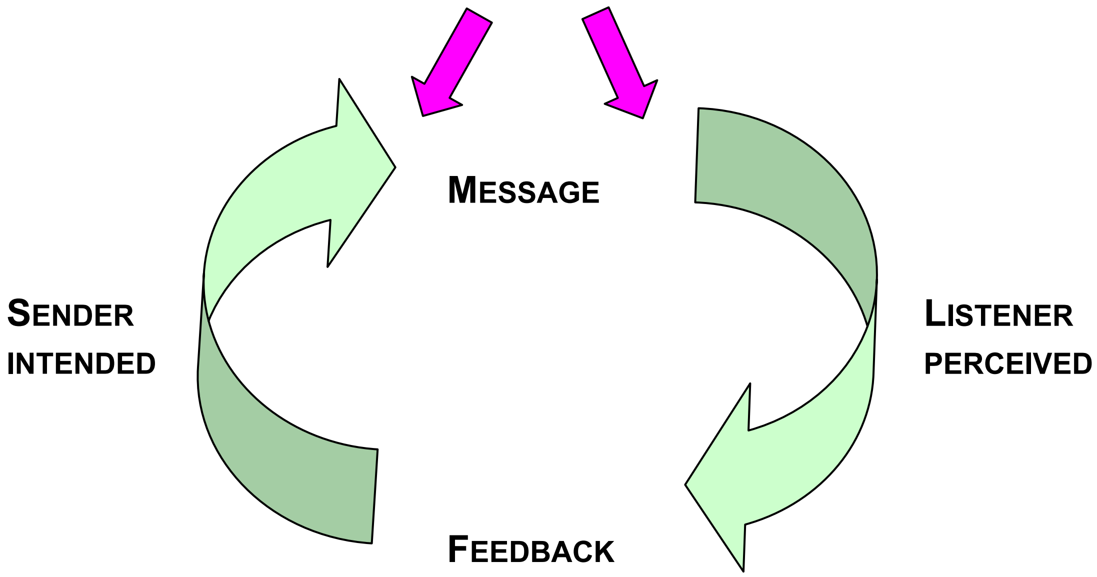
(Adapted from Erven, 2002:2)

Figure 4.1 Erven’s model of feedback

According to him, the communication process is initiated by a person, referred to as a "sender". The sender conveys a "message" to one or more people, referred to as the receiver(s). For the message to reach the receiver, certain routes, which he calls "channels" must be available. The sender himself decides which channel to use in the process. He distinguishes between verbal and non-verbal channels and may involve one or more senses. Erven (2002:2) maintains that communication does not end once the message has been sent via the appropriate channel to the receiver. It is at this stage that "the sender becomes a receiver and the receiver becomes a sender through the process of feedback".

Shannon's Communication Model mentions barriers, such as distractions, difficulty of message, etc. to communication that might exist between sender and listener, preventing the intended message to reach the listener. The "message" refers to the verbal or non-verbal information that is communicated to the listener. Feedback is viewed in terms of verification of understanding of the message by the receiver (Team Coordination Training Student Guide, 1998:5) In this diagram communication is depicted as a circular process in which feedback occupies a significant position. In other sources, however, it is represented as a linear process without feedback. According to McKain-Fernandez (2003:2), Shannon's linear model of communication was soon applied by disciplines such as psychology, linguistics and communication to human interaction.

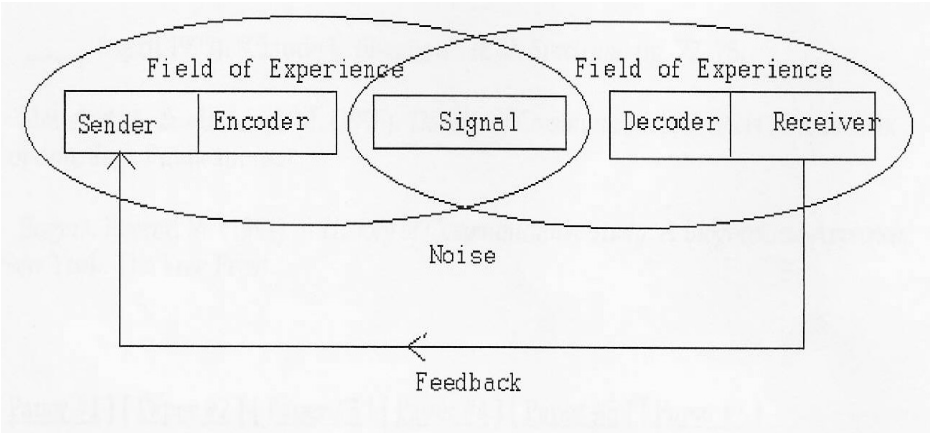
Shannon's communications Model
BARRIERS TO COMMUNICATION



From Team Coordination Training Student Guide (8/98)

Figure 4.2 Shannon's communications Model

Schramm (McKain-Fernandez (2003:2) also adapted Shannon's Communication model to address crucial aspects such as "communication, reception, and interpretation of meaningful symbols". Schramm, cited in McKain-Fernandez, (2003:2) was convinced that interaction by means of communication was possible only if "the field of experiences of the sender and receiver overlap, in order to challenge and extend the knowledge to the receiver". McKain-Fernandez mentions that the degree of success of interaction depends on the (quality) feedback the "receiver would give to the sender once the message has been transmitted". The overlapping of experiences emphasised by Schramm is evident in the following diagram:



McKain-*Fernández (2003:2)*

Figure 4.3 Schramms diagram

In figure 4.4 Maidment (1997:2) provides the following circular two-way communication model

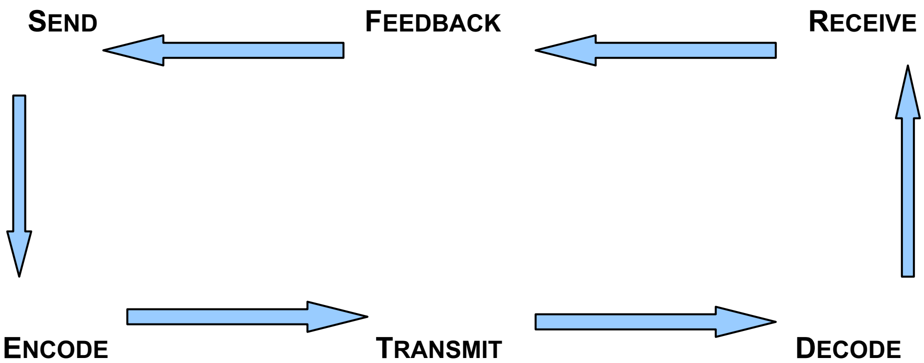


Figure 4.4 Communication model

Bresset, Cheever, Townson and Turner (2001:1) describe communication as a "two-way process of sending and receiving messages". They view communication as "interpersonal" and as such define it as "a message sent by a person to a receiver with a conscious intent of affecting the receiver's behavior" (2001:2). They use the following diagram to explain communication.

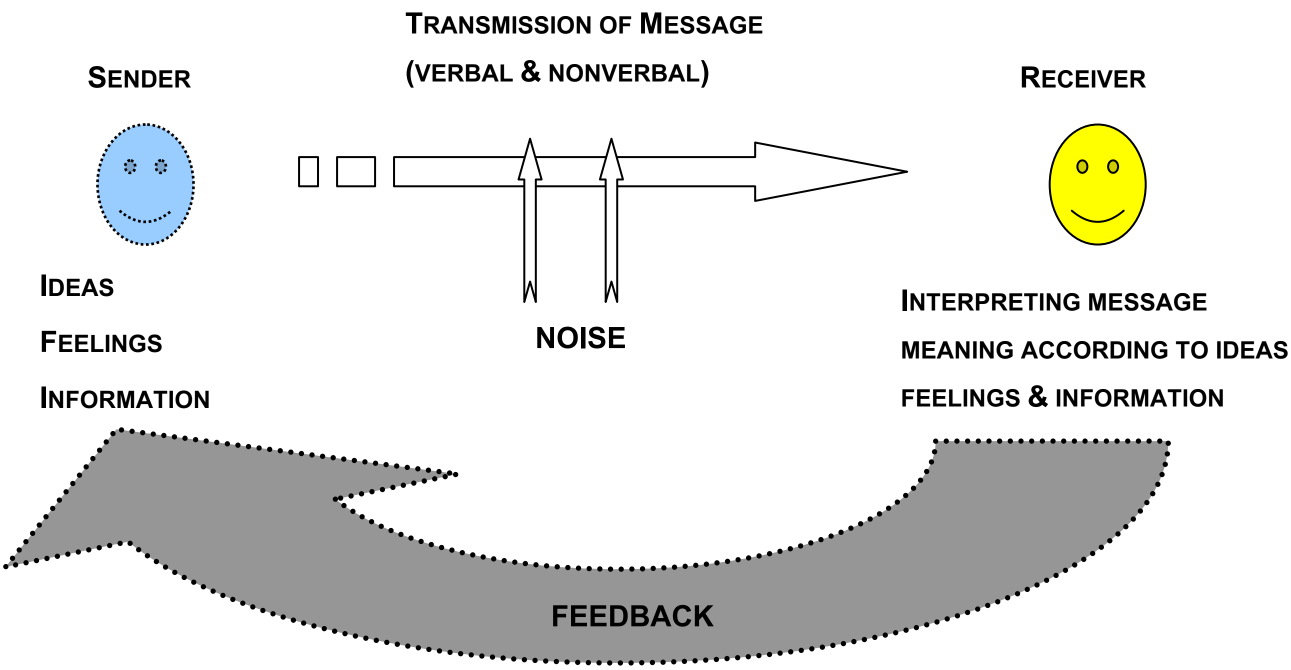


Figure 4.5 Interpersonal communication model

Bressett *et al*. (2001:2) identify what they referred to as "seven basic elements" that define the communication process, namely:

1. The intention, ideas, feelings of the sender and the way he/she decides to behave, all of which lead to his/her sending a message that carries some content.
2. The sender encoding his/her message by translating his/her ideas, feelings, emotions, and intentions into a message appropriate for sending.
3. Sending the message to the receiver.
4. The channel through which the message is translated.
5. The receiver decoding the message by taking it and interpreting its meaning. His / her interpretation depends on how well the receiver understands the content of the message and the intentions of the sender.
6. The receiver responding internally to this interpretation of the message.
7. The amount of noise that interferes with communication.

Communication is clearly a very complex process. It is clear that the message is closely linked to the person that sends it, and as such is coloured by intention, feelings and emotions. I believe that these attributes influence the meaning of the feedback received from the sender. It is significant that Bresset *et al*. (2001:3) refer to feedback as one of three skills required for successful communication – the other two being (a) the sending and receiving of clear messages, and (b) effective listening in order to grasp that which is communicated (Figure 4.5)

4.4.1 The feedback-listening connection

Researchers such as Davis (1997:355-376), Erven (2002:5), Long (1996:156-157) concede that listening proves to be a difficult and complex aspect of communication. Erven (2003:5) advocates active listening and views responding appropriately to feedback received from another person as the most significant listening skill. This skill according to Erven should involve posing questions, eye-contact, focus on verbal utterances, and encouragement to verbalise thoughts. Long (1996:156) contends that "[o]f the components of communication, listening is the one most people have developed least." Carpenter and Fennema (1992:143) mentioned that "listening to their students was the critical factor" in their teaching practice, since it allows them [the teachers] insight into learners' thinking and learning needs.

Long (1996:156-157) distinguishes, what she calls, five "basic types", of listening, namely (1) "Nonlistening" that is characterised by a lack of "conscious attention"; (2) "Pretend Listening", where the receiver pretends to be listening, with most of the actual listening elements such as eye-contact, acknowledgement of what is said, etc. present. Because of certain distractions, however, the receiver is not actually listening. (3) "Selective Listening", where the receiver screens or selects certain messages by focusing on some and ignoring others. (4) "Self-focused Listening", which deals with the perspective of the receiver. This listening type concerns forming of opinions, interpreting, and experiencing the information as it affects the receiver or listener. (5) "Empathic (Other-Focused) Listening", centres on "hearing the messages and accurately understanding the *sender's* perspective… understanding the experience of the other person, in terms of that person's thoughts, feelings, and/or behaviors".

Cart (2000:1) focuses on the universal importance of listening by considering listening as "the most powerful simple activity" that can have "transformational" effects in any environment such as "in families, marriages, workplace and in the classroom". According to Brown and Yule (1983), cited in Van Duzon (1997:1), listening is not such an easy process as Cart makes it out to be. They view listening as a "demanding process, not only because of the complexity of the process itself, but also due to factors that characterize the listener, the speaker, the content of the message, and any usual support that accompanies the message."

Brown and Yule (in Van Duzon, 1997:2) mention seven basic processes that come into play during the listening process. The listener first decides on a reason for listening, and then deposits that what has been verbalised in the short term memory. Consequently the listener attempts to organise the received information by also recalling relevant background information to give meaning to the message. It is only after this, they claim, that meaning is assigned to the message. At the same time the listener checks what exactly it is that has been understood and what information to keep in the long-term memory and what irrelevant information to dispose of from the message that was introduced into the short-term memory.

Bresset, Cheever, Townson and Turner (2001:3) are concerned with the pivotal role which listening occupies with respect to how humans relate meaningfully with one another. They maintain that effective listening is directed towards "the words, feelings and meanings behind what someone says", since it facilitates understanding and insight. Built into effective listening, they emphasise, is either verbal or non-verbal encouragement compelling the speaker to carry on. Bresset *et al*. distinguish three different levels of listening, namely, "Hearing", which is regarded as the lowest level and implies some comprehension of what is being said without meaningfully responding. The second level they term "listening" which implies a certain degree of awareness regarding meaning of what is heard – the response however is minimal. Thirdly, they consider "perceiving" as the most advanced stage of listening, and is "critical, appreciative, and creative". Listening in this instance entails "being attentive to the sender and processing the message thoroughly by relating it to experiences, ideas and feelings" (Bresset, 2001:4).

Some of the most important advantages of effective listening mentioned by researchers such as Gamble and Gamble (1998), Van der Merwe (1991) and Stewart (1986), are cited by Olivier and Du Plooy (2000:200), namely that listening "prevents misinformation", "increases knowledge by providing information, insight and understanding"; being a good listener "builds the speaker's self-esteem, trust" and increases morale.

4.4.2 The feedback-listening connection extended to include mathematics education

The discussion that follows will show how the manner in which teachers listen to their learners could facilitate or hamper learning, since limitations in listening skills manifest itself in inadequate feedback to learners. The three levels of listening that Davis (1997:356-365) distinguishes, are briefly touched upon as well as the didactical value of each.

According to Davis (1997:356) "each teaching episode is characterised by a particular manner of listening". His main concern is with "using vocabulary as an instrument for change" and to "offer listening both as an effective means for interpreting classroom phenomena and as useful starting place for transforming mathematics teaching practice" (Davis, 1997:357). His viewpoint of the transformational impact of listening is similar to that of Cart (2000:1). Davis distinguishes three levels of listening, namely "evaluative" listening, "interpretive" listening and "hermeneutic" listening.

The evaluative level of listening is regarded by Davis (1997:359) as “limited and limiting” because the listener or educator listens “for something in particular”, deliberately or unintentionally ‘ignoring’ other relevant information that might be helpful or useful to better understand what learners mean. This way of listening implies a certain kind of prejudice – the listener’s mind is already made up, that is “the listener judges what the other is saying against the template of his/her own certainties” (Breen, 2004:3). Frequently, teachers judge learners’ responses or ‘answers’ in a limited sense that centres on only what is right or wrong, excluding valid views or methods that might differ from their own.

Davis regards interpretive listening to be different and on a more advanced level of listening. He describes it as “not listening merely to assess the knowledge students have acquired, but to assess the subjective sense being made” (Davis, 1997:365). In addition it also involves “listening constructively” and “constructing the learners as they construct the mathematics” (Davis, 1997:365). In essence, thus, the listener attempts “to hear what the other is saying in order to interpret where they are and how they are feeling” (Breen, 2004:3). This remains a limited form of listening since the teacher’s main focus is on “accessing rather than assessing the learners’ ideas” (Breen, 2004:3).

The third level of listening Davis (1997) calls “hermeneutic listening”. Listeners who operate on this level of listening “… open themselves to others without holding on to their own assumptions …”, thus entering “… into a shared project of coming to a joint understanding of each other’s position” (Breen, 2004:3). Davis (1997:369) refers to it as a “mode of attending” characterised by “negotiated and participatory” interaction with mathematics learners. He views this type of listening as “imaginative participation in the formation and the transformation of experience”. According to Davis (1997:370) hermeneutic listening requires “the willingness to interrogate the taken for granted and the prejudices that frame our perceptions and actions”. At the same time it is “intended to imply an attentiveness to the historical and contextual situations of one’s actions and interactions” (Davis, 1997:370).

Listening is thus much more than a physiological process, it also touches on the emotions and creates expectations. Seldin (2000:1) emphasises the fact that “when people feel heard and understood, they tend to feel better” and that commitment to becoming a better listener, together with “respect, empathy, and validation” are important to create an atmosphere conducive to learning.

4.4.3 Using questioning to facilitate feedback

What is the purpose of using questions in the mathematics classroom? How is questioning linked to feedback? In what way does questioning facilitate feedback? How can learners be encouraged through questioning to give feedback on specific issues the teacher wants feedback on? Are learners in fact allowed to ask questions? Do learners ask questions? What kind of questions do learners ask? Do these questions attempt to determine the purpose of learner questioning? They are also closely connected to the words of the teacher, Dennis Duncan, as mentioned by Cotton (1989:2), who claims that “Questions – not answers – are at the heart of education.”

The role of questioning as effective instrument to facilitate communication (Dillon, 1988:45; Long, 1996: 170) and to gather information regarding learner understanding, insight and conceptualisation (Dillon, 1988: 18), through feedback is evident from the discussion that follows. The crucial role of appropriate questioning (Harrop & Swinson, 2003:49-57) to enhance feedback is emphasised by a great number of practitioners and educationists such as Black & Harrison (2001:16), Cotton (1989:2), Kirmse (2001:3), Mandel and Vontver (2001:3), Brophy & Good (1997:370-377), Davis (1997:355-367), Dillon (1988:7-81), Long (1996:170).

The seminal role of questioning in classroom discourse is highlighted in the following statement by Hickman (2002:1): “Realizing the effect of classroom discourse patterns, particularly patterns of questioning, on the material to be learned and the learning process itself is crucial to making appropriate adjustments conducive to achieving the maximum benefits of education in a classroom environment.”

Kirmse (2001:3) says that using “feedback can considerably increase the effectiveness of oral communication. This applies particularly to the question and answer type of communication.” Questioning here is described as a didactical skill that needs to be developed. According to QUILT (2002:2) “Classroom questioning may be the most used – and misused – instructional method. Most questions do not prompt students to think, but rather elicit rote responses at a simple recall level.” This corresponds with my classroom observation that teachers do not always think about or prepare verbal questions prior to lessons to elicit particular responses and to give direction towards achieving certain outcomes.

Appropriate questioning can be applied in the classroom to ensure that feedback from the learner to the teacher is a true reflection of the real state of affairs (Brophy and Good, 1997:378; Mandel and Vontver, 2001:3) Dillon (1988:45), however, sees questioning as not only the teacher’s tool to ascertain whether learners have learnt what was taught, but also as “devices for planning and for evaluating the classroom process”. Black & Harrison (2001:16) write that some participant educators involved in a project at King’s College to develop formative assessment in their science classrooms “had not realised that questioning which provoked classroom dialogue was an important instrument for assessment”. The concept ‘assessment’ is discussed in detail in chapter 4.

Brophy and Good (1997:378) emphasises the right reasons for posing questions by saying that “questions that present interesting challenges and invite friendly exchanges of views are likely to maximize motivation and yield productive responses”. He suggests that learners be allowed to respond to peers’ questions since this may compel learners to listen with greater care. Research by Wright and Nuthall (1970 cited in Brophy and Good, 1997) showed that when educators redirected questions to students’ peers in science classes, better performance resulted.

4.4.4 Limitations of current questioning techniques

This discussion about the shortcomings that characterise questioning techniques in the classroom, centres on the findings and discussions as found in literature by Dillon (1988), Hickman (2002) and Lubinsky and Schachter (1998). As a teacher I recognise this pattern of questioning as being similar to that in my own classroom and that of the teachers I work with in the West Coast Winelands Project referred to in chapter 1 and chapter 6.

Limited and inadequate use of classroom questioning is closely linked to the “patterns of discourse in the educational process” (Hickman, 2002:2). In this regard Cazden (1988:29) refers to “… the three-part sequence of teacher initiation, student response, teacher evaluation (IRE)…” as the pattern of classroom discourse that occurs most frequently throughout all school grade levels (also quoted in Hickman, 2002:2). In the IRE model, as opposed to the “classroom discussion model” (Hickman, 2002:4), the teacher normally initiates interaction by means of questioning. Lubinsky and Schachter, referred to by Hickman (2002:2), highlight two concerns about the use of the IRE model in the classroom, namely that it constitutes a top down power relationship between teacher and learner and reinforces the notion that every question should have an answer. Consequently this “IRE structure of discourse sets up an imbalance of power in a number of ways. Most obviously, all interactions are teacher initiated; this sends a message to the students that teachers have the right to speak at any time, while students must wait to be engaged and recognized by the teacher” (Hickman, 2002:4). Dillon (1988:12-13) refers to this as “constraints of discourse” and part of the “cycles of interaction” in which the learner occupies a subordinate position. He maintains that it is normal for learners not to pose questions. This state of affairs is due to the fact that learner “… questions are fairly excluded by the cycles, rules and norms of classroom discourse” (Dillon, 1988:13).

Learners’ disadvantage with respect to how classroom discourse is structured, is explained by Dillon (1988:13) when he analyses the observed classroom discourse cycle as follows:

> *When the teacher and students are busily talking back and forth, the cycle of talk is closed to all but student answers. That is because the cycle typically begins*

> *with a teacher question. It then turns tightly from (a) teacher question to (b) student answer to (c) teacher evaluation of answer plus next question. In their one turn, students can do nothing but answer; and they have no other turn to talk.*
>
> *The cycle for a student question turns quite differently. First of all it does not begin with a student question. Like any subordinate in other social contexts, the student must gain permission to ask a question.*

Furthermore, the teacher in the IRE discourse pattern also has the authority to judge what knowledge is appropriate, as well as to determine the rate at which the lesson progresses. Opportunities for learners to raise related aspects of topics under discussion are remote and often do not exist. The same holds true in the case of “personal concerns or even difficulty in processing previous information because the model for language interaction focuses on teacher priorities and actions rather than making room for student needs and insights” (Hickman, 2002:4).

This pattern of questioning, according to Davis (1997:359), Hickman (2002:2), Cazden (1988:64), Dillon (1988:21-23), has the further disadvantage that it does not elicit degree of learning that really occurs, or what learners really understand and the insight they gained. Hickman (2002:2) writes that “this pattern of questioning does little to verify if any real learning has taken place”, since questions are mostly “aimed at eliciting an answer predetermined by the teacher, as opposed to a true investigation or discussion of some open ended issue.” These limitations are intimately linked to Davis’s levels of listening discussed under 3.4.2. Hickman (2002:3) continues by saying that the IRE in a sense prevents learners from offering novel answers or solutions or ideas, or providing links to “relative experiences, to express critical viewpoints, or to take any risks which might lead to more comprehensive understanding of the concepts being taught”. This level of questioning corresponds to Davis’s lowest level of listening, namely evaluative.

4.4.5 Questioning techniques that enhance feedback

Questioning is an important part of any didactical situation, and as such a very well-researched topic. Cotton (1989:2) agrees by calling classroom questioning “an extensively researched topic” Dillon (1988:45) talks of questions as “pedagogical devices”.

The use of questioning to effect or facilitate learning is crucial and forms the basis of sound teaching methodologies. Researchers and educationists such as Brophy and Good (1997: 371-375) advocate that questions should be kept clear and unambiguous. Learners should be allowed to consider factors that have bearing on a particular question themselves. Some question types such as ‘yes’ or ‘no’ do not serve much of a purpose, in fact it “limits the participation of the student to a 50/50 role of being correct" CASAA (2002:1). According to Brophy and Good (1997:372-374) good questions are not only formulated on a higher level, but should also facilitate a higher degree of systematic thinking about the content under discussion, and learners should ultimately leave the teaching moment with connected insight and meaning.

Riddell (1993:1) makes the following suggestions to teach learners to think and increase feedback: (1) higher-order questions should be constructed prior to a lesson; (2) a question should have "a single idea or concept", and (3) "yes" and "no" answers should be avoided. Riddell (1993:1) also advocates the advancement of (i) "comparisons" such as "same as", "different from"; (ii) "evaluations" indicated by key words such as "which, why, how"; (iii) "applications of concepts; such as "how a theory is applied"; (iv) "problem-solving", involving proofs. Apart from allowing ample waiting or response time, teachers should also be adept at rephrasing questions when learners are not able to answer a particular question.

4.4.6 Bloom's revised taxonomy and levels of questioning to facilitate learning

Why apply Bloom's revised Taxonomy to this study of feedback in general and questioning in particular? I am aware of the criticism levelled against his taxonomy, namely that it is "formulated in behavioural terms", secondly that it is derived from an "inadequate theory of human language" (Curzon, 1985:106), and thirdly that his cognitive-affective dichotomy is described as misleading.

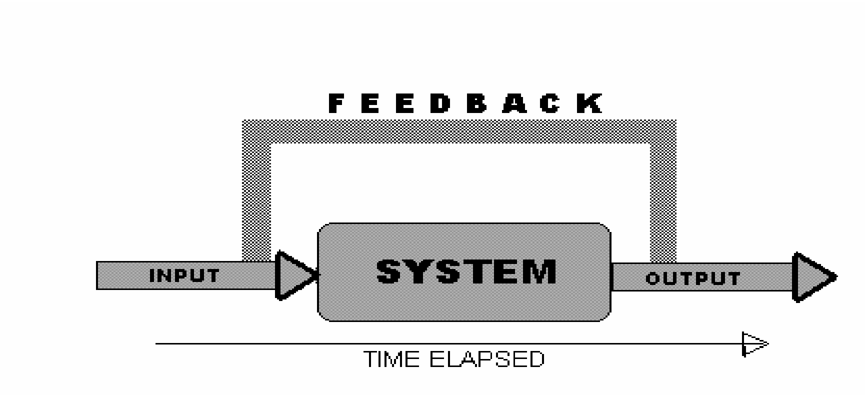
Bloom's taxonomy, however, remains one of the most widely used theoretical frameworks of educational objectives. In spite of all the criticism levelled at Bloom's taxonomy it provides "an organised framework within which objectives can be stated and classified" (Curzon, 1985:107). It helps the teacher to organise learning area content in a balanced way and has compelled examiners and teachers to constantly pose the question of what is actually being assessed. According to Bell and Fogler (1995:1) Bloom's Taxonomy "is widely used by educators … to judge the depth and appropriateness of their coverage of course material".

Currently the Western Cape Education Department through its curriculum advisors actively promote the use of Bloom's Taxonomy with respect to questioning. At one of the senior phase mathematics network meetings at Steynville Secondary school in March 2004, teachers were advised to use it as a guide to ensure that questions cover a broad spectrum of competencies. Questions should be formulated or phrased in such a way so as to assess learners on different levels, that is not only assess knowledge (recall of information), but also insight and comprehension (to understand and make sense), application (use of information in novel situations), analysis (to see patterns, order and make connections), synthesis (make generalisations or predictions from facts) and evaluation (to make choices based on logical arguments of competency.

4.5 FEEDBACK AND CONTROL

4.5.1 Negative and positive feedback in Cybernetics

Proponents of cybernetics such as Bar-Yam (2000) de Rosnay (1997), Heylighen (1997), Huitt (1998), Littlejohn (1992), Nickols (2000), Pangaro (2000), Vaughn (2002) maintain any transformational system (such as the thermostat) is characterised by what they call ‘inputs’ and ‘outputs’. The inputs are normally the consequence of the effect of the surroundings on a particular system. Simultaneously, the inputs of the system exert influence on the surroundings in which it operates. However, “[i]nput and output are separated by a duration of time, as in before and after, or past and present.” (De Rosnay: 1997:1)

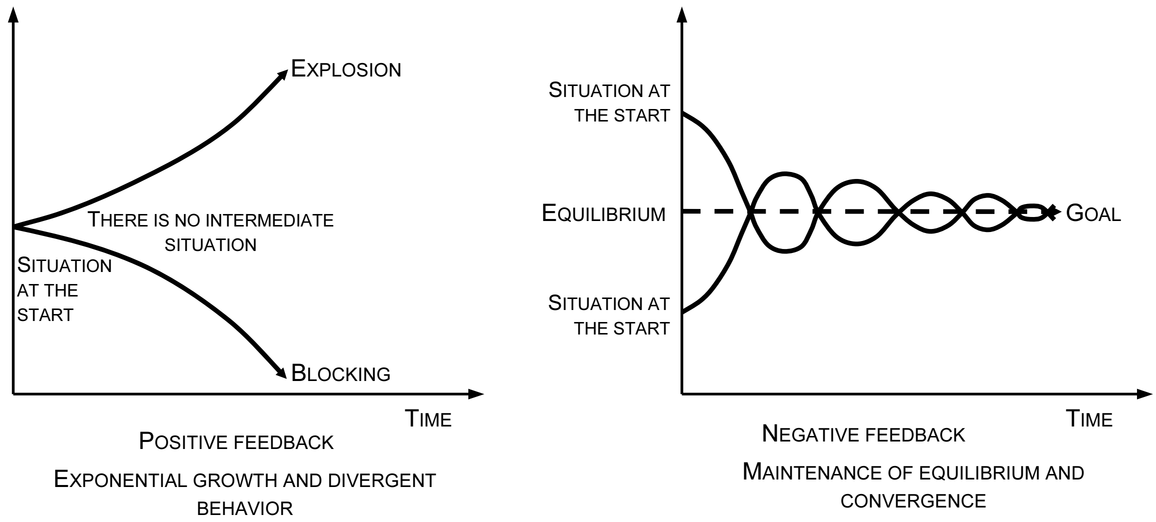


Adapted from (De Rosnay, 1997:1)

Figure 4.6 Feedback loop

De Rosnay (1997:1) states that in a typical feedback loop, as represented in Figure 4.6, information about the result of a change, conversion or an action is returned to the input of the system as input data. He continues by saying that “If these new data facilitate and accelerate the transformation in the same direction as the preceding results, they are positive feedback – their effects are cumulative”. These new data may also cause a result or outcome in a direction contrary to the preceding outcome. In this case the data are referred to as “negative feedback”. In the case of positive feedback “exponential growth or decline” may be evident. Littlejohn (1992: 47) refers to this phenomenon as “amplifying or maintaining deviation”, whilst De Rosnay (1997:1) describes it as “divergent behavior”. The latter is identified as a snowball effect, either by ongoing growth or explosion, or complete obstruction of activities.

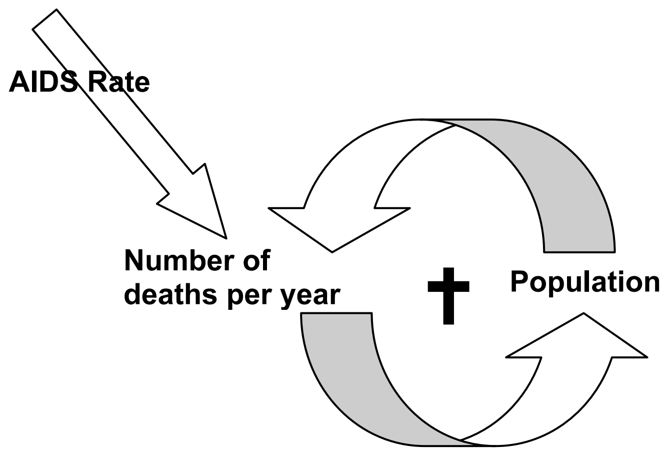
Examples of ongoing growth stated by De Rosnay (1997:1) are the following "chain reaction, population explosion, industrial expansion, capital invested at compound interest, inflation, proliferation of cancer cells". Examples of ongoing behaviour in the opposite direction, causing the system to come to a halt, are "bankruptcy and economic depression", the HIV infection rate on a population.



De Rosnay, 1997

Figure 4.7 Feedback chain reaction

The influence of AIDS on a population could be represented as follows:



Adapted from De Rosnay, 1997 (Principia Cybernetica)

Figure 4.8 Positive feedback loop

The above diagram represents a positive feedback loop, which if no intervention occurs, will result in destruction of the social system, through "explosion" or "blocking" of all social functions. This means that positive feedback if allowed to proceed uncontrolled would result in "indefinite expansion or explosion … or total blocking of activities" (de Rosnay, 1997:1), such as a shortage of teachers, or factory workers. This would adversely affect the general growth of a country such as South Africa. Negative feedback exerted on the system, in the form of protective sex, sticking with one partner or anti-retro-virals, would prevent the system from imploding.

While positive feedback may cause the system to run out of control, negative feedback is thus experienced as having a regulating effect. Curzon (1985:84) writes that negative feedback "leads to corrections [aimed at] restoring a system to equilibrium", whilst positive feedback "results in attempts to improve a system before variations occur; but if uncontrolled, it can result in an unstable 'runaway' and a breakdown of the system". Similarly, according to De Rosnay (1997:2) negative feedback results in "adaptive, or goal-seeking behavior: sustaining the same level, temperature, concentration speed, direction". He continues by saying that in certain instances the goal of a system could be "self-determined" and "preserved in the face of evolution: the system has produced its own purpose (to maintain, for example, the composition of the air or the oceans in the ecosystem or the concentration of glucose in blood". In other instances the outcomes of systems, for example, as far as "automats and servomechanisms" (De Rosnay (1997:2) are concerned, are determined by people who made them.

Cyberneticists thus view positive feedback as information that is returned to the communication process with the resultant effect of reinforcing and encouraging the original results – that is, not only to help it continue, but also to increase it. Negative feedback, on the other hand, is a return of information, that results in "adaptive and goal-seeking behaviour" (BOLA, 2002:1). Nickols (2000:6) maintains that "positive feedback acts to confirm behaviour and negative feedback acts to disconfirm it. What is essential to understand here is that the classification of feedback as positive or negative is made by the person perceiving it."

4.5.2 The relationship between feedback and control in education

The cybernetics as movement is traditionally concerned with the study of control as it is applied to complex systems (Stirton, 2001: 1). Hood (1986: 112) defines control as it applies to the cybernetics as "the capacity to keep the state of a system within some desired subset of the set of all possible system states". According to Stirton a number of consequences follow from this. Firstly, a system needs to be regulated to prevent it from disintegrating or reeling out of control. Secondly, it is not "an all or nothing concept, but can exist in degrees". For instance "any one-way communication involves control of a receiver by a sender" (Stirton, 2001: 1). Thirdly, "control of a situation can be distributed or shared among a number of controlling sub-systems".

The components of, what is referred to as a control system, are listed by Curzon (1985:86) in general terms. He distinguishes the following: A control feature that indicates the performance for which standards are required to be set; a sensory device that measures that particular feature; a control unit that compares and assesses digression from the envisaged outcomes, and that brings into play a corrective mechanism; and lastly "an activating unit which will change the basic operating system". Curzon (1985:82) admits that terminology such as "control" and "manipulation of the environment" raises the eyebrows of many educators, since it is normally associated with restrictive education practices. He concedes that "in any system, such as that constituted by a class and tutor, some control is essential and some manipulation of environment is needed if organizational objectives" are to be achieved or accomplished adequately.

As far as teaching and learning are concerned the mathematics teacher as facilitator has to be "manager, planner, executive and controller" (Curzon, 1985:85-86). 'Controller' is not meant in a negative sense as an authority to restrict the learner, but rather as someone who, "undertakes the direction of the lesson", working towards certain defined learning outcomes, and aiming at attaining the said outcomes. Control in this sense does not exactly have the same meaning as in the case of the controller inside the thermostat that controls the temperature in a house. Curzon (1985:85) maintains that the teacher's so-called control function should not be seen as "an end in itself", but serves as a means whereby both teacher and learners "are able to perform a specified function", namely to achieve the learning outcomes.

4.5.3 Immediate or delayed feedback

Research literature reveals that timing of feedback is crucial (Bashford & Walsh, 1998:15; Bligh, 1972:65 ; Curzon, 1985:44; Sewart, 1980:172). If feedback is delayed for too long it might not have the desired effect. Because of limited classroom contact time and big numbers of learners, for instance, immediate feedback is often not possible.

Educationists such as Bashford & Walsh (1998:15); Bligh (1972:65); Rowntree (1987:) and Sewart (1980:) advocate that timely or immediate feedback is crucial, but that delayed feedback also has a role to play. Gagnè emphasises the fact that feedback forms an essential element of effective teaching by saying that all facets of learning require feedback for it to be considered completed (Curzon, 1985: 44).

Feedback thus necessitates communication to the learner, which according to Curzon should occur as promptly and accurately as possible. Rowntree (1987:24) claims that the learner may require a response from the teacher "fairly rapidly if it is to confirm or modify" that particular learner's understanding or method. Sewart (1980:172) speaks of "instant feedback" or "swift feedback". In the same vein Bligh (1972:65) articulates that teachers and learners require feedback "as soon as possible if they are to make use of the information it contains". Bashford & Walsh (1998:15) admit that, "One of the most difficult challenges in education is to provide adequate feedback to students in a timely manner." Furthermore, they mention Skinner's finding that "maximum potential for learning" takes place when learners receive immediate feedback to their efforts. Their concern is with the fact that immediate feedback within classroom context is very often not possible because of the limited number of class periods per week or 7 day cycle. They claim that communication "is also constrained by the opportunities for individual communication during class meetings"(Bashford & Walsh, 1998:15). They found that class discourse does not necessarily compel learners to think independently, nor does it permit learners the chance to test their ideas against that of the educator, nor to obtain an evaluation of the said ideas.

4.6 THE RELATIONSHIP BETWEEN FEEDBACK AND ASSESSMENT

Feedback forms an integral part of assessment (Brophy and Good, 1997:378; Curson, 1985: 256-257; Mehrens, 1998: 2; Orlich *et al*., 1990: 30; Stepanek, 2002:2) in the Mathematics and Science classrooms. Although assessment is discussed in great detail in Chapter 3, it is essential at this stage to briefly highlight the interdependence with respect to feedback and assessment generally. As we are essentially looking for ways to improve formative assessment, we tend to agree with Breen (2004:2) that these ways "include the necessity for feedback to any learner being based on the particular qualities of his or her work, as well as advice on what he or she can do to improve, avoiding comparisons with other learners".

Curzon (1985:256-257) argues that "the management of teaching necessarily involves monitoring and assessment", and that feedback to both learner and teacher was "essential for the control of that process". He goes on to say that "[i]f the teacher's role is accepted as involving the creation for effective learning, then the regular assessment of those conditions and their outcomes would seem to be necessary" (*ibid*). The close relationship that exists between assessment and feedback is also stressed by Loacker, Cromwell and O'Brien (1986:52), who hold that "For assessment to be learning, feedback is critical". They also maintain that feedback "offers the teachable moment, the opportunity for change", while the elements of assessment turn these opportunities into learning (Loacker, Cromwell and O'Brien, 1986:52).

According to Mandel and Vontver (2001:2), the teacher should at all times be aware of the learner's achievement. Information to provide adequate feedback may be obtained observing the learner's presentations, through effective questioning, by means of monitoring the learner's subject related performances, gauging the learner's interactions with pears, and "reviewing materials produced by (the) learner".

Rowntree (1987:24) comments on the usefulness of feedback by saying that "[f]eedback from assessment only begins to be useful when it includes verbal comments" and "comes in many forms of varying degrees of usefulness". Assessment may provide learners feedback as to how well they have performed or how successful they were. Simultaneously it may present the teacher with feedback as to the effectiveness of his or her teaching methods (see Black and Wiliam, 1998:3; Curzon, 1985:267; Nakabugo and Siebörger, 1999:288; Rowntree, 1987:24). The intimate relationship between formative assessment and feedback is reflected by Stepanek (2002:2) when she describes formative assessment as assessment that "provides feedback that can be used to guide teaching and learning". As such "the dialogue between learners and a teacher should be thoughtful, reflective and focused to evoke and explore understanding, and in such a way that all pupils have the opportunity to think and express their ideas" (Breen, 2004:2).

Brophy and Good (1997:378) maintain that feedback has a dual function, namely to serve as motivation and to inform learners about their progress. According to a study done by them in 1974, educators often neglect to offer feedback, especially to those who under-achieve.

4.6.1 The art of giving and receiving feedback

Researchers such as Curzon (1985:82-85), Lehner (1987:1) and Monga (2002:1) agree that a thorough understanding of feedback is crucial to effective feedback communication. Consequently, it is essential that certain techniques on giving and receiving feedback be learned. Monga (2002:3) makes the point that "[j]ust having feedback is not enough; knowing how to handle it, and how to give and receive it properly must be practised".

Yates (2002:1) advocates that "we all benefit enormously from receiving feedback". He furthermore maintains that at the same time people in certain professions "grow as professionals" when they "offer feedback to help others" (ibid). He also holds that giving feedback "is analogous to holding up a mirror" since, according to him, it helps the individual to view herself or himself in the way others might view her or him. In the same vein, Erven (2002:4) describes feedback as "the mirror of communication" since it is "what the sender has sent" and Yates (2002:1) argues that feedback should help the receiver to gain better perspective or insight into how others perceive him or her. He continues by saying that the importance of feedback resides in the fact that "past behaviour is a reliable indicator of future behaviour and unless something intervenes to alter our perspective, we will not change" (Yates, 2002: 1).

Mandel and Vontver (2001:2) consider giving and receiving feedback as “one of the best ways to facilitate an individual’s personal and professional growth, reinforce appropriate behavior, and improve performance”. They also maintain that “[i]n order to use evaluation results to improve performance, we have to provide feedback … and to give feedback we have to evaluate” (Mandel and Vontver, 2001:2),

4.6.2 The link between feedback and learning outcomes (specific outcomes)

In mathematics as in other learning areas teachers are geared towards achieving certain specific or learning outcomes. It is obvious that feedback has a crucial role to play in determining whether learning outcomes are in the process of being achieved or whether they have been achieved (Kavanagh, 2002:1). Feedback should include evaluative comments showing learners ways to improve, alternate ways and strategies to tackle problems. Feedback moments should be used to gather evidence of the degree of learning that occurs or create follow-up opportunities (Kavanagh, 2002:1).

According to Curzon (1985:84), all teaching activities could be explained in system terms. He explains the interrelationship between feedback and attainment of learning outcomes that occur in a classroom as “a set of interrelated elements, characterised by a particular structure and behaviour.” The structure essentially refers to the interplay between learner and teacher. Curzon, furthermore, explains the behaviour of the classroom system as that of a “goal-seeking body” geared towards certain ‘pre-determined’ learning outcomes. He views all teaching activities as being geared towards controlling and transforming the classroom system of which he is a part, and which involves “changing of the level of class attainment” (Curzon, 1985:84).

4.7 GUIDELINES FOR GIVING FEEDBACK

Feedback is a well-researched topic, and a widely used phenomenon. As such a number of guidelines had been identified to make feedback more effective, meaningful and constructive (Bressett, 2001:4; Hathaway, 1998:43-55; Lehner, 1987:1; Mandel & Vontver, 2002:3; Monga, 2002:2). Mandel & Vontver (2001:2) refer to reasons as to why teachers may not frequently offer feedback and why learners may not like to receive it:

- Many teachers have had few models of constructive feedback to emulate.
- Many teachers and learners have had bad experiences with negative feedback.
- Many teachers and learners fear that feedback might damage their relationships.
- The teacher may not know enough about performance to give specific feedback – observation and evaluation are essential to provide this information.

The following are some of the guidelines that occur in literature dealing with feedback. These guidelines closely tie in with the view expressed by Bens (2000) that "[f]eedback is always meant to be positive. Its goal is to improve the current situation or performance – its goal is never to criticize or offend. The structure of giving feedback is a reflection of this positive intent." In similar vein, Kornhauser and Sable (2000:1) contend that "feedback must be delivered in a manner that motivates the recipients and persuades them that the advice offered is both appropriate and worthwhile". Beatty and Bremley (1999:1) are adamant about the effects of effective feedback: "It teaches. It motivates. It facilitates change. It improves performance". Mandel & Vontver (2001:4) believe that the teacher should "[s]uggest correct performance rather than emphasiz[e] what was done wrong". Bens (2000) also emphasises feedback as an act of demonstrating care and empathy. This means that it should be given solely with the positive intent of helping and improving the other person.

It is important that the learner's (listener's) readiness to receive feedback should be considered to enhance effectiveness (Yates, 2002:2). Feedback should be specific (Bressett *et al.*, 2001:4), giving "tangible examples of the performance you want them to change or continue" (Maurer, 1994:16). The teacher should thus ensure that the reason for feedback is understood (Morgan, 1997:8). The amount of feedback given at a particular time or instance should be limited to ensure that the learner can cope with the amount of information provided (Mandel & Vontver, 2001:4). Lehner (1987:3) agrees that "[t]o overload a person with feedback is to reduce the possibility that he may use what he receives effectively." He continues by saying that "[w]hen we are given more than can be used we may be satisfying some need for ourselves rather than helping the other person."

At the same time the teacher should "communicate recommendations in ways that individual receivers will understand" (Morgan, 1997:10). Self-growth of the teacher and growth of the listener should be the main purpose of the exercise (Yates, 2002:2). Self-review should be encouraged and should begin by encouraging the learner and build on his or her insights, and strengths (Yates, 2002:2).

Beatty and Bremley (1999:2) maintain that feedback can only be productive if "it serves two functions", namely to discover people's strengths and weaknesses, and secondly to teach. The teacher should ensure that feedback from the learners is understood and correctly interpreted through active listening (Yates, 2002:2). Yates (2002:2) is adamant that teachers should refrain from offering negative or harsh feedback in front of other learners.

Practical suggestions could be put forward as to what could be done differently (Bressett *et al.*, 2001:4; Morgan, 1997:9). For instance, feedback should be specific rather than general, and should point out precisely what occurred (Mandel & Vontver, 2001:4). The feedback would consequently be based on fact rather than impressions. The teacher's feedback should in essence be constructive and should outline the positive aspects (Yates, 2002:2). The teacher should thus focus on that which can be changed. Also according to Bens (2000) the person giving feedback should concentrate on that which can be changed by making suggestions for improvements that is realistic and not beyond the receiver's grasp. Consequently, teacher feedback comments should consist of suggestions for improvements that the learner would be able to implement or apply.

The teacher should make an effort to own the feedback by using "I" and not "you". Morgan (1997:8) mentions Alberti & Emmons (1970) who said that "I" and "I need" communicate expectations whilst words like "you" apportion blame and invites defensive responses. The emphasis must be on what is observed, and should be descriptive, instead of evaluative or judgmental (Lehner, 1987:2; Maurer, 1994:18; Yates, 2002:2). Feedback that is too vague or broad or general, such as "Your approach is good" is not conducive to building a positive self-concept. Learners should not be branded by name-calling, such as "Do you always have to make a mess of things?", "You're messy!", "You're careless". Unhelpful comments such as this may lead to confusion and may arouse emotions such as anxiety, anger and frustration and reduce learners' motivation (Beatty and Bremley, 1999:1). After such feedback the learners will still not know what is expected of them or how to change, what changes to make to something they have done wrong or how to improve (Derby, 2003:1). Beatty and Bremley (1999:1) agree that feedback should rather "be depersonalised" by focusing on the mistake or behaviour.

Gunderman and Williamson (2002:447) agree that "providing feedback in a way that puts learners down may prove counterproductive. It can damage learners' self-esteem and produce a level of anxiety that actually interferes with learning". The teacher should give the learner an opportunity to explain, and should make an effort not only to listen actively, but also use attentive body language as well as paraphrasing key aspects (Bens, 2000). By appropriate questioning, ideas can be drawn from the learners, for example, to come forward with their own ideas and suggestions. This links up with Davis's (1997) notion on hermeneutic listening.

It is suggested that before feedback is given, the teacher should check whether he or she understands the situation correctly, for example, (Bressett et al, 2001:4; Derby, 2003:1; Kramer, 1977:104). Consequently, the feedback should also be put in context, because "[i]f we launch into the feedback without saying how important it is, the other person's attention is directed on figuring out the severity of the discussion rather than on listening to you" (Maurer, 1994:16). The teacher could make use of probing questions to the learner to avoid misjudging and misinterpretation of the situation (Morgan, 1997:8). The teacher should ensure that feedback from the learners is understood and correctly interpreted through active listening (Yates, 2002:2). It is crucial that the teacher check the feedback received from the learner to ensure that his or her understanding is not only accurate but also fair, and to prevent misjudging the problem or situation (Bens, 2000:3). This would allow the teacher to accurately and effectively respond to the learner's needs.

Timeous or timely feedback is crucial for it to be effective (Bressett et al, 2001:4; Kramer, 1977:104; Lehner, 1987:2; Maurer, 1994:16; Morgan, 1997:9; Yates, 2002:2). This implies that feedback needs to be given very close to the time the incident occurs or directly after the situation being referred to. In certain cases feedback should be immediate, that is immediately after an error or misunderstanding is observed or detected. Morgan (1997:10) claims that "teachers should gauge the timing and method for delivering feedback", but also "assess how much feedback to deliver at any given time". Teachers thus should ensure that their feedback is understood (Yates, 2002:22).

Listening carefully to the person for whom feedback is intended is an integral part of responding effectively to the learner's needs. In this regard Maurer (1994:22, 28) simply says: Hear the other person's point of view. Listen with open ears. Ask questions that help you understand his/her point of view". It is clear that Seldin (2000:1) also views listening as an essential skill that precedes effective feedback. She offers the following suggestions for improving one's listening skills: The person to give feedback should be committed to becoming a better listener. This would imply to really listen and understand. Body language and verbal language should indicate his or her intent (I'm trying hard or I really want to understand what you are saying). Environmental distraction and interruptions should be minimised (for instance do not interrupt the learner and ask the other learners to listen and to refrain from talking). The person or teacher to give or receive feedback should have an open mind and avoid pre-mature assumptions and analyses and listen for the whole message coming from the learner. She deems a "listening check" to be important – "Let me be sure I understand. Do you mean …….?" (Monga, 2002:2; Seldin, 2000:2), as well as asking for feedback to make sure that he/she understands the message or problem being encountered ("Did I get it?").

4.8 CONCLUSION: HOW IS FEEDBACK VIEWED IN TERMS OF THIS RESEARCH STUDY?

Feedback does not only form part of nor is it merely linked to the communication cycle. It is interwoven in the process of communication, especially with respect to the learning of mathematics where common social meanings of concepts often interfere with meanings assigned to mathematics concepts. This also applies in cases where some words in everyday life such as ‘function’, ‘relation’, ‘unknown’, ‘variable’, etc. are extended to take on new mathematical meanings.

Without feedback meaningful interaction and learning would be limited. The role of feedback in this research study corresponds with the cybernetics perspective that describes it as an “experimental epistemology concerned with the communication within an observer and between the observer and his *(or her)* environment” (Buchanan, 1997: 3). The study also acknowledges the enactivist view which emphasises the connectedness between an organism (whether animal or human) and its environment. Thus, this study of feedback, as part of communication to facilitate formative assessment, is not only underpinned by constructivism, but also by enactivism (see Chapter 1), as well as cybernetics.

In a sense the use of negative feedback in the mathematics classroom is meant to restore equilibrium and regulate learning. Inappropriately applied negative feedback, however, may hamper or block learning and may even lead to the formation of negative mathematics self-concepts. Positive feedback unlike in other cybernetic systems should not block learning, and it is hoped that it will ultimately lead to ongoing growth and “explosion” as far as learning is concerned. I also hold the view that the diagrammatic representations given in Figures 4.1, 4.2, 4.3, etc. do not fully depict the integrated nature of feedback in the communication process and formative assessment.

The main focus in this research is on ways to increase or improve the quality of feedback to facilitate understanding, insight and conceptualisation, and ultimately learning. In order to achieve this, the current state of classroom communication has to be critically analysed. Important aspects of communication, especially listening and questioning will be focused on, to ascertain how these impact on feedback. Feedback in this study thus focuses on the feedback the mathematics teacher receives from the listener (the learner), how accurately this is interpreted, and the degree of appropriate response by the teacher.

This chapter is followed by chapter 5 which deals extensively with different facets of the function concept. Not only is making sense and assigning meaning through mathematical language or jargon highlighted, but approaches to facilitate understanding by applying appropriate methodologies in the senior phase mathematics classroom are scrutinized. In this manner communication, with special emphasis on feedback and questioning in terms of curriculum and learning area content, is explored to reach greater understanding.

In Chapter 5 the “function concept” as part of the senior phase curriculum is explored, in an attempt to link it to the outcomes (in OBE) and assessment standards already discussed in Chapter 3. Questions such as the following are addressed: What is meant by the concept ‘function’? Where does the function concept fit into the current senior phase curriculum?

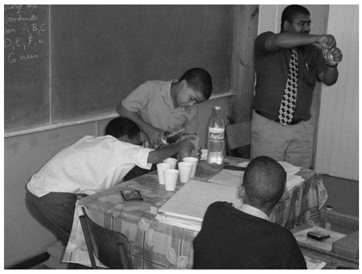
How is the function concept viewed in terms of realistic mathematics and outcomes-based education? What are the major conceptual problems encountered by learners? What is the prior mathematical knowledge required by senior phase learners? How do textbooks deal with the function concept? How is the function concept viewed within the context of this research? Thus communication in terms of mathematics concepts, questioning and feedback is further explored.

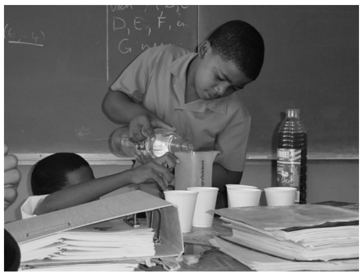
CHAPTER 5: THE FUNCTION CONCEPT

There is general agreement among mathematics educators that the topic of functions is one of the most important that children encounter…Indeed, it has been suggested that little is possible in the way of higher mathematical learning until the concepts and problems in this area have been understood. (Kalchman & Case, 2003:1)

5.1 INTRODUCTION

In order to contain my research and, at the same time, to give it greater depth, I decided to focus on a particular aspect of the senior phase mathematics syllabus, namely the 'function concept'. Instead of dealing with feedback (in terms of communication and formative assessment) it appeared to be more productive to link the research to particular learning area content.





The question which naturally arises is why I chose the function concept. The answer relates directly to findings that teaching and learning this concept have long been experienced as problematic (Confrey and Doerr, 1996; Dreyfus, 1996; Harel and Dubinsky, 1992). Dreyfus (1996:2) contends that "[s]ince the seventies, students' learning of the function concept has been a central topic of mathematics research." Learners often experience difficulties in grasping aspects or concepts such as 'variable', 'continuous', 'discrete', or developing skills such as drawing inferences, or moving from graph to table to function formula. Many teachers experience problems dealing with or teaching the function concept in a more realistic and contextualised manner. In the same vein DeMarois and Tall (1999:257) argue that the function "has become a central concept in school and university curricula around the world" and that it can be used as a "powerful foundation for logical organisation".

Three years prior to this they presented findings that the function concept had been a major concern for the "mathematics education research community" for quite a number of years (DeMarois and Tall, 1996:297). Earlier Dubinsky (1993:527) had argued that "functions form the single most important idea in all of mathematics, at least in terms of understanding the subject as well as for using it".

For Knuth (2000:48), "the introduction of algebraic and graphical representations of functions can be seen as a crucial moment in mathematics learning". It is after all that stage of mathematics learning during which the learner "uses one symbolic system to expand and understood another" (Leinhardt, Zaslavsky and Stein, 1990:2). Finding a suitable school mathematics topic to research and focus on in the senior phase, such as the function concept, to inform the role of feedback with respect to how mathematics is communicated and learned, thus, was not that difficult – for four main reasons.

Firstly, the function stands out as a particularly crucial aspect of the school mathematics curriculum, and understanding it would have an impact on the learners' success in further mathematics studies as pointed out by mathematics educationists –amongst others Cates (2000), Mann (2000), Verhage *et al*. (2000), Willoughby (1997). Mann (2000:1) describes the concept of function as of "critical importance in mathematics", whilst Willoughby (1997) calls it "one of the most important and pervasive concepts in mathematics". Mann (2000:1) goes so far as to say that it is "essential for success in calculus, differential equations and beyond". Cates (2000:1) takes an equally strong view in maintaining that "[f]undamental to the study of mathematics, the function concept has been identified as the single most important concept from kindergarten to graduate school." For Dreyfus (1996:1), the reason for its importance is its seminal role: "The function concept appears and reappears like a thread throughout school mathematics from grade 1 to grade 12 and beyond. In many school curricula it ties trigonometry and geometry together … the importance of the notion of function in mathematics stems from its unifying role".

A second reason for focusing on the function concept relates to the fact that learners encounter endless problems in understanding, interpreting or applying different aspects related to functions. Verhage *et al*. (2000:37) describe "the teaching and learning of functions" as one of the "problem areas" in school mathematics. There has certainly been a great deal of research in this regard. As Kalchman and Case (1997:4) note, there is "extensive literature on young children's difficulties in understanding functions". This issue will be revisited later in this chapter (see 5.6).

A third reason is the manner in which some teachers deal with the function concept. Willoughby (1997) agrees that learners frequently encounter "trouble with the function concept because of the abrupt and abstract way in which it is introduced." Fourthly, teachers' content knowledge regarding certain crucial aspects of the function concept appears to be inadequate or missing.

In this chapter I attempt to explore what the function concept entails as an essential part of the senior phase mathematics curriculum. In an effort to do this, I attempt to answer questions such as the following: What is understood by the concept "function"? How did the function concept develop over the years? How is the function concept analysed in terms of what it entails? With respect to the RNCS and specifically Learning Outcome 2, what confronts learners as far as the function concept is concerned? What prior knowledge should senior phase learners (especially grade 7s) have? What are the major conceptual problems encountered by learners? How do textbooks deal with the function concept? How is the function concept viewed within the context of this research?

5.2 THE CONCEPT OF FUNCTION

Functions can become very complex. For this study, however, the focus will be on senior phase (Grades 7 to 9) mathematics content covered within the South African school curriculum. The curriculum content from grade R to 9 is discussed in greater detail in 5.4. The discussion that follows is intended to explore different perspectives, researchers' dealings with the function concept as well as some of the more relevant studies embarked upon by mathematics educationists. At this stage it might be relevant to consider what Vinner (1992:197) contends is necessary to understanding a concept such as 'function', namely that "to acquire a concept means to form a concept image for its name", that is to "understand a concept means to have a concept image for it. Knowing by heart a concept definition does not guarantee understanding the concept." Interestingly Duit, Treargust and Mansfield (1996:18) mention that often what researchers or teachers refer to as the learners' conceptions, "are actually their own conceptions of students' conceptions". As such correct interpretation of what learners actually think and understand becomes crucial.

Verhage *et al*. (2000:42) emphasise, in line with realistic mathematics education (RME) and outcomes-based education, the importance of dealing not only with linear functions in this phase, but also to include more complex functions (quadratic, exponential, etc.) parallel to one another. This points to "a shift (away) from purely disjunctive" to a more "horizontal" way of dealing with functions. This approach is, however, still not evident in the classrooms where I currently work as facilitator, and different aspects related to the function concept remain compartmentalised and generally not integrated.

According to DeMarois and Tall (1999: 257), the concept of function "is often suggested as an organising principle in mathematics". They quote Yerushalmy and Schwartz, 1993:41) who "believe that function is the fundamental object of algebra and that it ought to be present in a variety of presentations in algebra teaching and learning from the outset". Sierpinska (1992:572) maintains that "[t]he most fundamental conception of function is that of a relationship between variable magnitudes. If this is not developed, representations such as equations and graphs lose their meaning and become isolated from one another."

Various mathematics educationists agree that the function concept can be made more accessible to younger learners if the approach is initially much more concrete, and moves gradually to the more abstract (Willoughby, 1997). Tall and Vinner (1981) mention the claim by several mathematics educationists that the "modern set-theoretic" definition of what a function entails – and frequently used in classrooms and textbooks – is much too formal and abstract for learners, consequently they tend to ignore or forget this definition when it comes to solving problems (cited in O'Callaghan, 1998:23). In exploring this problem, Vinner & Dreyfus (1989:359) argue that the definition of a function as a relationship between different variables is not only more applicable but also more meaningful to learners, since it built on their prior intuitive function concepts.

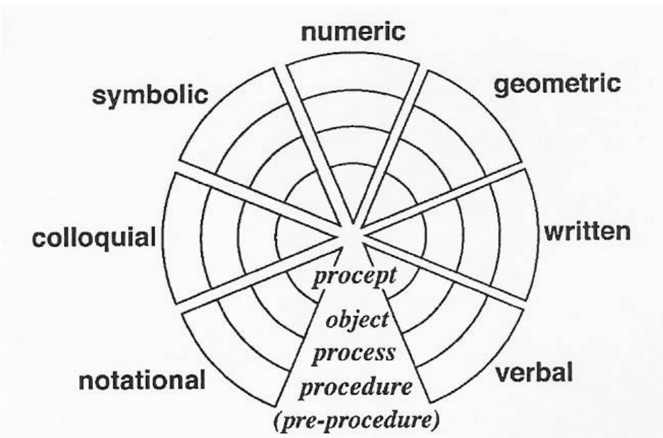
Vinner and Dreyfus (1989:359-360) in their paper entitled, "Images and definitions for the concept of function" categorise learners' viewpoints of what a function entails in the following way: 1. A function described as a correspondence between two sets with each element in the first set assigned to exactly one element in the other. 2. A function viewed as a "dependence relation between two variables (y depends on x)", 1989:360). 3. A function seen as a "rule". 4. A function explained as "an operation or a manipulation". 5. A function portrayed as "a formula, an algebraic expression, or an equation".

In his paper, entitled "Computer-Intensive algebra and students' conceptual knowledge of functions", O'Callaghan, (1998: 24-25) explains the dynamics of what he calls the "function model". The function model is intimately linked to problem-solving processes. It comprises four "component competencies", namely "modelling, interpreting, translating, and reifying". Modelling as a procedural skill reflects the ability to represent a (realistic) problem-situation mathematically by means of a function, either as an equation or expression, table of data, or a graph. Selden and Selden (1992) view this as a very common application of the function concept. "Interpreting" (Fey, 1992) is described as the second problem-solving skill and could involve a range of interpretations related to specific points, or more global features (O'Callaghan, 1998:25) such as increase, decrease, range, domain, etc. This was also Monk's (1992:175) area of interest when he researched the way learners deal with functions, as well as issues related to conceptualisation processes. He specifically focuses on those factors adversely affecting learners grasp of functions. The third problem-solving skill is "translating" which (O'Callaghan, 1998:25) refers to as the ability to change from one representation of a function to another, for instance from graph to table to symbols (equation or function formula).

DeMarois and Tall (1996) analyse the function concept in terms of “facets” and “layers”. A “facet” refers to the “breadth dimension” or slices, and thus the facets “of a mathematical entity refer to various ways of thinking about it and communicating it to others, including verbal (spoken), written, kinaesthetic (enactive), colloquial (informal or idiomatic), notational conventions, numeric, symbolic, and geometric (visual) aspects” (DeMarois and Tall, 1996:298). They use these aspects as a framework for, and starting point to analyse the function concept. In their conference paper of 1999, entitled “Function: Organizing principle or cognitive root?” they refer in more detail to the facets they focussed on as “the function *notation* (including the meaning of f(x)), the *colloquial* use of a function machine as input-output box, the standard *symbolic* (algebraic formulae), *numeric* (table) and *geometric* (graphic) … with *written* and *verbal*”. DeMarois and Tall (1996:299) also mention “written and verbal descriptions” as two further facets, together with “the function notation” as “the notational facet”.

DeMarois and Tall (1999:257) represent these facets as “sectors of a disc” similar to a disc consisting of a number of concentric circles “in which movement towards the centre is seen as compression through the layers *pre-procedure [pre-action]*, *procedure[action]*, *process*, *object* and *procept*”. Learners who operate at the pre-procedure have not yet reached the procedural layer, whilst those at the latter layer can operate independently by “carrying out a sequence of step-by-step actions”. Learners who are able to operate at the process layer “can accept the existence of a process between input and output without needing to know the specific steps, and see two procedures with the same input-output as the same process” (DeMarois and Tall, 1999:258). Learners at the object layer are able “to treat the idea as a manipulable mental object to which a process can be applied”. Finally, the inner-most procept layer signifies the skill to shift between process and mental object in a flexible manner.

The accompanying diagram taken from DeMarois and Tall (1996:298) is a structural analysis of the concept of function into layers and facets:



DeMarois and Tall (1999:258)

Figure 5.1 Structural analysis of the function concept

In respect of the term “layer” DeMarois and Tall (1996:298) refer to “various levels of the depth dimension in the development via cognitive process to mental object”. As such “*action*, *process*, and *object* are considered as three layers of increasing depth”. This is linked to “Dubinsky’s Action-Process-Object construction in which mental actions (on objects) become repeatable processes which are encapsulated as objects” according to Dubinsky and Harel (1992 cited in DeMarois and Tall, 1996:298). This also corresponds to Sfard’s (1998) process of reification as discussed in Chapter 3.

In terms of thinking about and understanding the function concept, the term “procept” is considered important (DeMarois and Tall, 1996; DeMarois, 1996; DeMarois and Tall, 1999). According to Gray and Tall (1994:121) “An elementary procept is the amalgam of three components: a process [such as the addition of two numbers] that produces a mathematical object, and a symbol that presents either the process [such as 5+8] or the object”. At the same time the skill “to think flexibly about a concept, such as function, as both a process and an object is referred to as proceptual thinking” (DeMarois, 1996:2), as opposed to procedural thinking which implies “thinking that is dependent on the selection and performance of appropriate procedures”. Tall (1996:12 cited in DeMarois, 1996) explains saying that “Procedures allow individuals to do mathematics, but learning lots of separate procedures and selecting the appropriate one for a given purpose becomes increasingly burdensome. Procepts allow the individual not only to carry out procedures, but to regard symbols as mental objects, so they can not only do mathematics, they can think about the concepts”. As such DeMarois (1996:2) maintains that learners who approach mathematics in this way are at a disadvantage since by relying “on procedural thinking [they] are doing much more difficult mathematics”. Consequently, for these learners doing mathematics “… consists of disconnected cognitive units of algorithms triggered by a specific problem format”.

5.3 A SHORT HISTORY OF THE FUNCTION CONCEPT

The function concept as we know it today was developed over many centuries and the actual use of the term function occurred only much later (Cooney and Wilson, 1993; Ponte, 1990; Smit, 1999). According to Cooney and Wilson (1993:133) “Function-like activities can be traced all the way back to the mathematics of ancient civilizations”. Smit (1999:51) and Kline (1972 cited in Cooney and Wilson, 1993:133), state that mathematics calculations by Babylonians (around 2000 BC) found on tablets of clay reflected that they had a definite sense of the concept of functionality. These tables were apparently used for finding “reciprocals, squares, square roots, cubes and cube roots”.

One of the oldest graphs drawn is said to date back from the year 1000 representing position of the planets against time. According to Smit (1999:51), Descartes (1596 – 1650), a French mathematician, was the first to connect an algebraic expression such as $y = mx +$

c with a geometric shape such as a line, and his application of "co-ordinates to express the relationship between variables [which] opened the door to the development of the function concept". In the 15^{th} and 16^{th} centuries Galileo and Kepler researched problems related to motion, looking for appropriate tools to describe model perceived outcomes. Furthermore, contributions in developing algebraic notation by Viéte and Descartes are seen as significant in as far as it contributed towards the current development of the function concept (Klein, 1972, Malik, 1980), cited in Cooney and Wilson (1993:134).

The term *function* which is derived from Latin was apparently first used by Leibniz (1646-1716), a German mathematician (Ponte, 1990:3), which included information regarding function related concepts such as co-ordinates to denote a point on a curve, and gradient of a curve. Leibniz also introduced function related terms such as *constant*, *variable* and *parameter*. Bernoulli (1669 - 1748), a Swiss mathematician, viewed a function to be "any expression consisting of a variable and constants" (Smit, 1999:51), of the nature ax + b. Ponte (1990:3) points out that Isaac Newton (1642 – 1727) "was one of the first mathematicians to show how functions could be developed in infinite power series, thus allowing for the intervention of infinite processes. He used the term "fluent" to designate dependent variables, "relata quantitas" to indicate dependent variables, and "genita" to refer to quantities obtained from others using the four fundamental arithmetical operations".

As is evident from the above discussion, "The most significant evolution in the mathematical definition of function occurred before the 20^{th} century" (Cooney and Wilson, 1993:132). Kleiner (1989:282 cited in Cooney & Wilson, 1993:132) refers to this process of development and evolvement of the function concept as "a tug of war between two elements, two mental images: the geometric (expressed in the form of a curve) and the algebraic (expressed as a formula)", and comes up with what he calls "the "logical" definition of function as a correspondence (with the mental image of an input-output machine)". Cooney and Wilson (1993:133) note that the "notion of a function first as a correspondence between variables and then as a mapping between arbitrary sets, rather than a geometric curve or an algebraic formula, became dominant in the mathematics of the 20^{th} century".

5.4 THE FUNCTION WITHIN THE SOUTH AFRICAN MATHEMATICS CURRICULUM FROM FOUNDATION PHASE (GRADE R – 3) TO SENIOR PHASE (GRADES 7 TO 9)

The concept of function is closely linked to learning outcome 2, which states that learners should be "...able to recognise, describe and represent patterns and relationships..." and solve problems "using algebraic language and skills" (Revised National Curriculum Statement (RNCS), 2002:25). This learning outcome according to the RNCS not only emphasises the “describing of patterns and relationships through the use of symbolic expression, graphs and tables”, but also refers to the identification and analysis of “regularities and changes in patterns and relationships” to allow learners to “make predictions and solve problems”. Apart from developing appreciation for “the aesthetic and creative qualities” of mathematics, the development of the following qualities or skills are also emphasised, namely “generalising, explaining, describing, observing, inferring, specialising, creating, justifying, representing, refuting and predicting” (RNCS, 2002:25).

Foundation Phase mathematics educators are expected to “lay the foundation for developing algebra in the Intermediate and Senior Phases” (RNCS, 2002:26). Educators teaching this phase are obliged to adopt practical methods, such as the use of physical objects and drawing(s) to allow learners to effectively “describe, extend and create” geometric as well as numeric patterns. It is furthermore stated that apart from “simple number sentences” formal algebra should not be dealt with here.

In the intermediate phase (Grades 4 to 6) mathematics dealings with numeric and geometric patterns are broadened, with particular emphasis on the relationship between consecutive values or terms, and between the position or place of the term and the term itself (RNCS, 2002:54). These activities are intended to “develop the concepts of variable, relationship and function” in order to enable learners to explain the rules generating the particular patterns. The use of “different, yet equivalent, representations of problems and relationships” is stressed with respect to this specific phase, with reference to “words, flow diagrams, tables and simple graphs” (RNCS, 2002:54).

The RNCS (2002:89) states that in the senior phase, the emphasis of “Patterns, Functions and Algebra” should be on formalising those rules that generate particular patterns. Investigating numerical and geometric patterns to establish relationships between variables still enjoys prominence in this phase. Learners should also continue to work towards expressing or verbalising rules that govern such relationships by means of algebraic terms or symbols.

5.5 FUNCTIONS IN TERMS OF REALISTIC MATHEMATICS EDUCATION AND OUTCOMES-BASED EDUCATION

Realistic mathematics education (RME) is linked to the mathematics teaching reform that occurred in the Netherlands in the 1980s, initiated by Freudenthal (cited in Van den Heuvel-Panhuizen, 1996:10). Freudenthal advocates that mathematics should be intimately linked to real world experiences, stay in touch with learners and be relevant and applicable to what happens in the community. He viewed reality as “the framework to which mathematics attaches itself" (Freudenthal, 1973:77). This means that learners' encounter with mathematics should be of "human value" (Van den Heuwel-Panhuizen, 1996:10). Freudenthal (1968:7) is adamant that mathematics should not be regarded as subject content, but rather as type of human enterprise, saying that "[w]hat humans have to learn is not mathematics as a closed system, but rather as an activity, the process of mathematizing reality". He stresses the futility of teaching mathematics in ways far removed from learners' daily experiences. Instead of starting with abstractions of theoretical definitions, educators should concentrate on appropriate "contexts that can be mathematized" (Van den Heuvel-Panhuizen, 1996:12).

Gravemeijer (1994:82) emphasises that the process of mathematizing needs to be realised through effective strategies that promote mathematical characteristics connected to mathematization. These include the following:

- for generality: generalising (looking for analogies, classifying, structuring);
- for certainty: reflecting, justifying, proving (using a systematic approach, elaborating and testing conjectures etc.);
- for exactness: modelling, symbolizing, defining (limiting interpretations and validity);
- for brevity: symbolizing and schematizing (developing standard procedures and notations). (Gravemeijer, 1994:82)

RME is underpinned by three principles, namely what Freudenthal (cited in Kwon, 2003:2) calls "guided reinvention", didactical phenomenology and emergent models. The reinvention principle implies that learners should be given the opportunity to be exposed to similar conditions to those existed when mathematics was invented (Drijvers, 2003:52; Gravemeijer, 1994:83). This is described by Kwon (2003:2) as providing learners with "experientially realistic situations, and by facilitating informal solution strategies", allowing the opportunity "to invent more formal mathematical processes".

Freudenthal's (1973) second principle, didactic phenomenology, centres on the type of relationship that exists between the social phenomenon represented by a particular mathematics concept, and the concept(s) itself. The focus here is pertinently on how social phenomena can be made accessible with respect to reasoning, calculation and problem-solving, through mathematical interpretation and analysis. According to Gravemeijer (1994:443) possible teaching and learner activities are suggested in support of individual learner activity and participation, and large group discussions engaging most learners in progressive mathematisation. The third principle that underlies RME centres on "bridging the gap between informal knowledge and formal mathematics" (Kwon, 2003:2). The concept 'model' is elaborated upon in 5.2.

In South Africa mathematics educators in the senior phase (as is the case in the other phases) are expected to use outcomes-based methodologies (see Chapter 3) when teaching the function concept. In order to make the process more realistic, and in line with a process that resembles that in the discussion in the preceding paragraphs, they have to select appropriate contexts to allow "learners to use algebraic language and skills to describe patterns and relationships in a way that builds awareness of other learning areas, and human rights, social, economic, cultural, political and environmental issues" (RNCS, 2002:88). The following contexts are provided as examples:

- Understand formulae used to calculate pensions and medical aid rates.
- Consider how graphs in the media can be manipulated to misrepresent trends and patterns.
- Study reproduction patterns in animals that produce Fibonacci numbers.
- Understand and use formulae for calculating quantities in natural science (e.g. air pressure, resistance, voltage).
- Use mathematical models to represent relationships within an ecosystem.
- Study symmetrical patterns that occur in nature (RNCS, 2002:89).

The use of realistic and contextual mathematics, specifically with respect with the function concept is discussed in greater detail in 5.9. There I focus on the methodologies and strategies applied in developing appropriate material in an effort to facilitate understanding and learning of mathematics in the senior phase.

5.6 PRIOR KNOWLEDGE REQUIRED BY SENIOR PHASE LEARNERS

Learners entering grade 7 as the first year of the senior phase mathematics course should have been exposed to and been equipped with certain basic skills that relate to the assessment criteria mentioned below. These assessment criteria attempt to assess learner progress, skills acquired and understanding as contained in Learning Outcome 2, which deals with patterns, functions and algebra. Action or key words and phrases for grade 6 that describe the focus as stated in the RNCS Grades R-9 (Schools) Policy (2002:47) are the following:

- *Investigating* numeric and geometric patterns
- *Extending* numeric and geometric patterns
- *Finding* relationships or rules

- *Describing* observed relationships or rules in their own words
- *Determining* output or output values for particular values by means of verbal descriptions and flow diagrams
- *Writing* number sentences describing problem situations
- *Solving* number sentences by inspection or by trial-and –improvement
- *Checking* solutions by substitution
- *Discussing* and comparing to determine the equivalence of different descriptions of the same relationship or rule presented verbally, by means of flow diagrams, number sentences and tables

Verbs such as 'investigate', 'describe', 'solve', 'check', 'discuss' clearly point to learners' active involvement in the learning process and indicate a clear shift away from teaching and teacher dominance in the classroom. A question that intuitively springs to mind is the following: What is the correlation between these key words and Blooms' hierarchy of questioning levels? Great emphasis seems to be placed on communication, as words like "verbal descriptions", "verbally", "through discussion and comparison" appear frequently.

It is evident from the RNCS that learning and teaching should be intimately linked within a suitable or appropriate context also referred to in 5.5. Teachers are requested to use "contexts that may be used to build awareness of human rights, social, economic, cultural and environmental issues" (RNCS, 2002:47). Another aspect that is emphasised is the use of natural and cultural contexts, and room for learners to be allowed to create and apply their own ideas, especially with respect to exploring and devising patterns.

5.7 CONCEPTUAL PROBLEMS ENCOUNTERED BY LEARNERS

It is evident from literature (mentioned in the discussion below) that deals with algebra research in general and the function concept in particular that the learning of algebra reveals numerous problems that learners encounter. Drijvers (2003:41) mention the following difficult issues (generic to all aspects of algebra including the function concept) that relate to the learning of algebra:

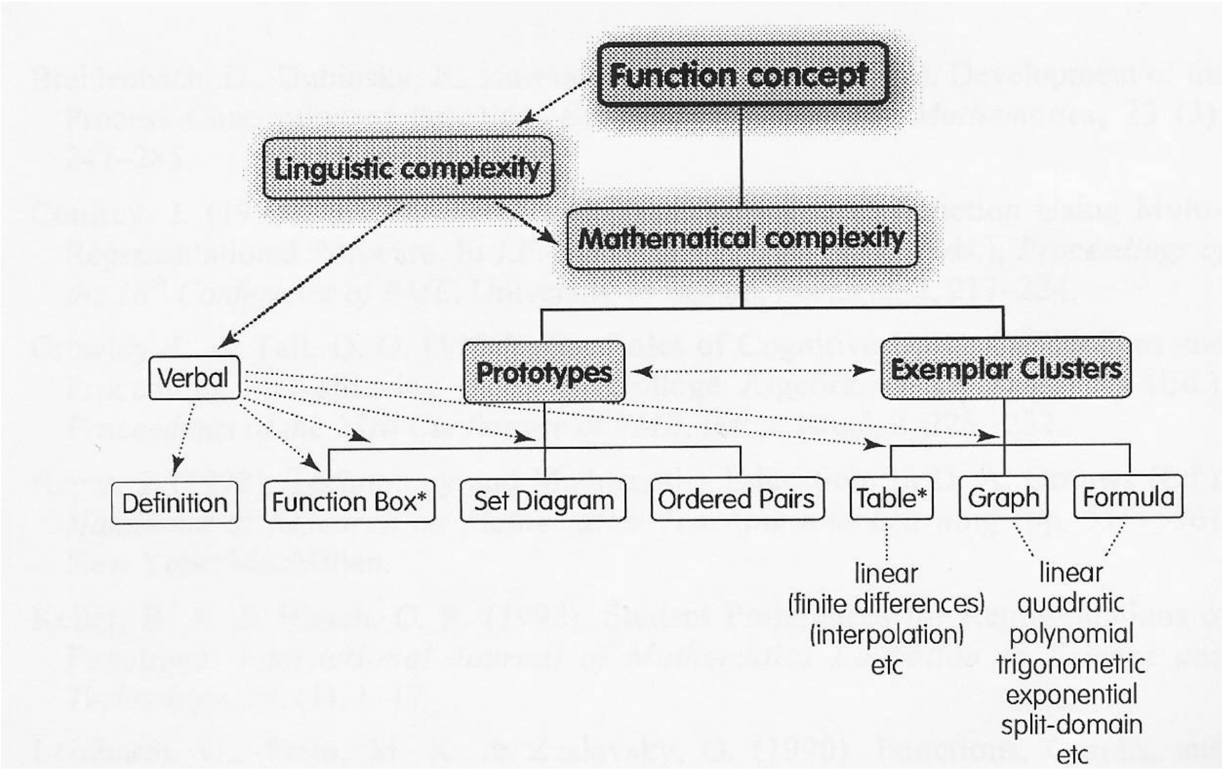
1. The formal, algorithmic character of algebraic procedures that the student can not relate to informal and meaningful approaches;
2. The abstract level at which problems are solved, compared to the concrete situations they arise from, and the lack of meaning that the student attributes to the mathematical objects at the abstract level;

3. The need to keep track of the overall problem-solving process while executing the elementary algebraic procedures that are part of it;
4. The compact algebraic language with its specific conventions and symbols;
5. The object character of algebraic formulas and expressions, where the student often perceives them as processes or actions, and will have problems with the accompanying 'lack of closure' obstacle.

There is extensive research material on learners' difficulties in grasping issues related to functions. Several critical aspects related to learners' conceptual understanding of functions are focused on by mathematics educationists such as Akkoç and Tall (2000), Aspinwall, Shaw and Presmeg (1997), Clement (1985), Davis (1984), Dreyfus (1996), Eisenberg (1992), Kalchman (1997), Kalchman and Case (2003), Kerslake (1977, 1981), Moschkovich, Schoenfeld and Arcvi (1993), Sfard (1998), Tall and Vinner (1981) and Vinner (1992). Meel (2004:1) remarks that although the function concept "is fundamental to mathematics, many students hold primitive understandings and firmly rooted misconceptions". He also cites Davis (1984) and Tall and Vinner (1981) to support his point.

5.7.1 Learners' conceptual understanding of the function concept

Learners' difficulties do not only relate to the conceptual understanding of function but also include problems with respect to linguistic and representational complexity. In their paper entitled "The simplicity, complexity and complication of the function concept", Akkoç and Tall (2000) research how mathematics learners deal with "the linguistic and representational complexity of the function concept". They use the diagram below to explain the complex nature thereof. They maintain that learners' 'implicit understandings of knowledge" together with their "previous experiences" tend to lead to conceptualisation problems as these result in "a highly complicated array of personal meaning that both help and hinder their interpretation of the mathematical concept" (Akkoç & Tall, 2000:1). They represent the different aspects that relate to the function concept in the following diagram:



Akkoç and Tall, 2000:7

Figure 5.2 Function concept analytical diagram

5.7.2 Difficulties translating from one presentation to another

Sasman, Olivier and Linchevski (1999:1) report that learners "had difficulty finding function rules and made many errors, including the proportional multiplication error". There are a number of researchers who reached similar conclusions. Sfard (1992:60) observes that learners experienced difficulties bridging the gap between the algebraic and graphical representations of functions. Yerushalmy (1997:431) note that most teaching approaches neglected the interchanging or translating from one type of presentation to another, that is from graph to table to formula. Kalchman and Case (2003:4) write that moving from "graphic to algebraic representations appears to be particularly difficult".

Artique (1992) similarly dealt with learner's ability or inability to integrate or link different representations of a particular function. Zachariades, Christou and Papegeorgiou (2001:1), also cited in Aspinwall, Shaw & Presmeg (1997) conclude that "in many cases the graphical (visual) representations can cause cognitive difficulties, because the perceptual analysis and synthesis of mathematical information presented implicitly in a diagram often makes greater demands on a student than any other aspect of a problem".

5.7.3 Facilitating gradual exposure to the function concept

As is evident from the following research findings, teachers generally have problems facilitating younger learners' gradual exposure to the function concept. Vinner (1992) in his research addressed learner difficulties with respect to concept images of functions. Eisenberg (1992) researched how a sense for functions developed within learners. The function concept was also applied in research by Moschkovich, Schoenfeld and Arcvi (1993) to investigate the intricacies related to the learning process. Aspinwall, Shaw and Presmeg (1997) maintained that graphical representations frequently result in cognitive difficulties, as a result of the greater demands made on learners by perceptual analysis and synthesis of information.

In addition to the problems mentioned above, Kalchman and Case (2003:4) report on research findings by various mathematics educationists that relate to younger learners' inability to grasp function related concepts. Younger learners struggle to comprehend that algebraic symbols actually represent particular variables, according to Freudenthal (1982). Piaget, Grize, Szeminska, and Bang (1968) reported that these learners generally also experience difficulty grasping "the notion of a contingency relationship between two quantitative variables, unless they see this relationship demonstrated in a concrete, physical context" (Kalchman and Case, 2003:4). Confrey and Smith (1994), as well as Kalchman (1997) have found that even in cases where learners seem to grasp that a particular variable (t – time) is linked to a corresponding value of a variable (d – distance), they seem to be unable to focus on "the movement or rate of change in each variable" (Kalchman and Case, 2003:4).

5.7.4 Problems related to practical issues

Kalchman (1997), Kerslake (1977) and Mansfield (1985) mention learners' inability to move from discrete to continuous functions. I found that teachers as well as learners often could not readily distinguish between continuous and discrete functions. Clement (1985) reports on learners' inability to differentiate between graphical features such as slope and highest value. Many were "unable to treat the graph as an abstract representation of [a] relationship [and] appear[ed] to interpret it as a literal picture of the underlying situation" (Hadjidemetriou & Williams, 2005:2). Leinhardt, Zaslavsky and Stein (1990) describe yet another problem, namely, learners' propensity to represent functions in a linear way in situations where is it not appropriate. Further problems relate to the use of co-ordinates. Kerslake (1993) found that learners often swopped the x- and y co-ordinates, as well as their inability to transfer knowledge to analogous but new situations.

From research (Confrey, 1991; Confrey and Doerr, 1996; Ginberg, 1977) it is evident that the difficulties learners generally encounter with respect to understanding, grasping or conceptualising and making sense of mathematics are matters for concern. On the other hand, the ways in which teachers respond, in particular their approach or attempt to remedy through appropriate intervention, are even more disconcerting.

In this regard Confrey (1991:121) refers to research done with respect to the diagnosis of errors made by learners, which “indicated that overly quick and localized responses to errors can result in a failure to see how individual mistakes can be linked together and remedied more effectively as classes”. Researchers such as Confrey, 1990; Perkins and Simmons, 1987; Driver and Easley (1978 cited in Confrey, 1991:121) have found that established learners “hold mini-theories about scientific and mathematical ideas that the theories and their forms of argument must be understood and directly addressed if students are to come to more acceptable understanding” of any concept. Closely connected to this are the studies that Even (1998:105) refers to that indicate that many learners “deal with functions pointwise, i.e. they can plot and read points, but cannot think of a function as it behaves over intervals in a global way”. Studies by researchers such as Bell and Janvier (1981) and Monk (1988), cited in Even (1998:119), have revealed “that a global approach to functions is more powerful than a pointwise approach”. Even as far back as 1981 Bell and Janvier (1981:34) expressed concern about the fact that global features of graphs, “such as the *general shape of the graph, intervals of rise or fall*, or of *maximum increase*” were neglected.

Commenting on teaching approaches, Yerushalmy (1997 cited in Zachariades, Christou and Papageorgiou (2001:1) states that very often “teaching approaches [for instance] do not take into consideration the movement from one type of representation to another, which is a complex process and relates to the generalization of the concept at hand”. The function concept is certainly an important feature of basic mathematics. As such the question arises whether all or most learners in the senior phase would be able to understand or grasp related content if it were to be presented, taught or facilitated in a way that enhances conceptualization. Williams and Ryan (2000), cited in Hadjidemetriou and Williams (2005:1) contend that “research knowledge about students’ misconceptions and learning generally needs to be located within the curriculum and associated with relevant teaching strategies if it is to be useful for teachers”. According to Even (1998), also cited in Hadjidemetriou and Williams (2005:1), this entails “transformation and development of such knowledge into pedagogical content knowledge”. This implies methods and strategies of “representing and formatting the subject that make it comprehensible to others” (Shulman, 1986:10)

5.8 APPROACHES THAT FACILITATE LEARNERS' CONCEPTUALISATION

Kalchman and Case (2003:4) pose the following relevant question in an effort to address learners' conceptualisation problems: "If one wishes to help children develop a cognitive structure in which the foregoing problems are minimized, how might one proceed?" Willoughy (1997) reasons that it is possible to facilitate learning of the function concept, and maintains that it is quite helpful if such "concepts are developed first from concrete activities and gradually abstracted over a fairly long period of time". Kalchman and Case (2003:15) also established in their research that it was "possible to introduce children to functions in primary and middle school", but at the same time admit that "significant limitations in children's understanding remained". Bakar and Tall (1992:13) noted that it is not possible for learners to " construct the abstract concept of function without experiencing examples of the function concept in action, and they cannot study examples of the function concept in action without developing prototype examples having built-in limitations that do not apply to the abstract concept". In this regard Confrey and Doerr (1996:163) mention the "critical role of tables, numeric calculations, and geometric investigations in the development of the function concept".

Dealing with patterns and ratio in a practical manner …

Kalchman and Case (2003:5) reported on work done by Case, Sandieson and Dennis (1986), Fischer and Bidell (1997), and Halford and Boulton-Lewis (1992) on the importance of designing material with a context with "some sort of analogical structure that will serve as a bridge between the schemes that are already available in isolation and the more elaborate and integrated structure", thus enhancing understanding. Knuth (2000:53) reiterates this point when referring to learners' often superficial understanding of the connections or relationships that exist between equations and graphs for instance, stating that "an important aspect of developing a robust understanding of the notion of function means not only knowing which representation is most appropriate for use in different contexts but also being able to move flexibly between representations in different translation directions". As such learners are to be given ample "opportunities to interact with, and to build connections between, graphical and algebraic representations" (Knuth, 2000:53).

The connectedness between different representations is thus deemed very important. According to Even (1998:105) the "connectedness between different representations develops insights into understandings of the essence as well as the many facets of a concept". Knuth (2000:53) suggests allowing learners to use several "representations in their solution methods", to "present different forms of equations", to "emphasise graphical representations whenever appropriate", to "pose tasks that require translation in the graph-to-equation direction, and to allow frequent "opportunities to share and discuss their different approaches and the advantages and disadvantages of each". Confrey and Doerr, (1996:162) also found in their research that the "rich diversity of multiple representations leads to more robust and flexible understanding of functions". Kleiner (1988 cited in Eisenberg, 1992:159) argues that the "connections between contexts be stressed, not simply illustrating a concept in context" and that "many function concepts should be introduced through visualizations".

Apart from particular views, approaches and intervention strategies proposed and applied by the mathematics educationists discussed above, there is also the important issue of when it is appropriate or apt to introduce learners to algebra. The NCTM Standards (2000) "propose that activities that will potentially nurture children's algebraic reasoning should start at the very first years of schooling" and so did numerous researchers such as Davis (1985), Bodanskii (1991), Vergnaud (1988), cited in Carraher, Schliemann and Brizuela (2000:2).

5.9 HOW TEXTBOOKS DEAL WITH THE FUNCTION CONCEPT

In this section I critique some textbooks with respect to how they deal with the function concept. I had been struggling with how to approach this for several months. I realised that I might have to develop certain categories, in consultation with fellow project facilitators and teachers, according to which mathematics texts would be critiqued. I also realised that it might be necessary to have to develop a table using criteria or categories based on questions such as the following–

1. How is the function concept being introduced in grades 7, 8 and 9?
2. How is the interplay between table / graph / formula dealt with?
3. Is there build-up or progression?

4. What contexts are used?
5. Are the contexts suitable / relevant?
5. What degree of realism is used?
6. How are different types of graphs (functions) being integrated as opposed to being compartmentalised?
7. What is the approach that relates to the dependent and independent variables and naming of the axes?
8. What types of exercises are used?

Apart from looking at a range of criteria, it is also interesting to compare current textbooks with older textbooks written before 1996 with respect to the function concept. The latter books are still very much in use in many schools, especially in communities where teachers find it difficult to adopt an OBE-approach to the teaching of mathematics. The analysis table is divided into three columns, with the criteria whereby the texts are critiqued appearing in the first. Column 2 contains information about books written before the implementation of OBE, and column 3 deals with texts written for an OBE approach to mathematics learning.

CRITERIA ACCORDING TO WHICH MATHEMATICS TEXTBOOKS FOR SENIOR PHASE ARE ANALYSED	**BOOKS WRITTEN PRIOR TO 1996**	**BOOKS PUBLISHED AFTER 1996**
Introduction – how is the function concept being introduced in grades 7, 8 and 9?	Much more formally done	More informally done without always stressing formal mathematics jargon
Interplay between table / graph / formula	Evident in problems that deal with data tables, formulae and graphs, but not linked to significant contexts	Greater emphasis on finding function formulae from context and number patterns; and making inferences related to (reality) context
Build-up or progression	Disjunct – first linear then quadratic etc. Introduced by means of tables (data with no contexts) then graphing – or starting with formula – then graphing then inferences	More subtle – different kinds of functions dealt with more or less at the same time

CRITERIA ACCORDING TO WHICH MATHEMATICS TEXTBOOKS FOR SENIOR PHASE ARE ANALYSED	**BOOKS WRITTEN PRIOR TO 1996**	**BOOKS PUBLISHED AFTER 1996**
Types of contexts used	Very seldom used, sometimes only a few contextual questions at the end of the chapter or section	Interesting and mostly relevant – as a rule most problems appear within a particular context
Realism: Are contexts realistic?	Mostly forced, distant from everyday life	Greater effort to make contexts more realistic, functional and current
Integration of different types of graphs compared to compartmentalisation	Separate and compartmentalised	Integration still not very evident
Aspects related to the dependent and independent variables and naming of the axes.	The use of x and y to name axes and in formula create the impression all problems should be explored and solved in terms of x and y	A greater tendency to solve problems in context, with the use of horizontal and vertical axes instead of x and y.
Type of exercises	Formal mathematics done for reinforcing recipes, laws and definitions	Geared towards understanding and concept development
Reflecting the RNCS(Curriculum) – stating of outcomes	No mention is made of outcomes or 'objectives' from the syllabus or curriculum. Except for some introductory comments related to the syllabus, there is no mention of outcomes or aims or objectives	A deliberate effort to link content with the curriculum, by starting with the outcomes, and assessment standards, offering examples and suggestions on how and when to assess
Investigation of numerical and geometrical patterns to establish relationships between variables	Neglected and not a priority	Much more visible. Pattern recognition and use thereof to establish function formulae are prioritised
Develop expression of rules governing patterns in algebraic language / symbols	Dealings with patterns not so prominent	Treated as important right through the section on functions

CRITERIA ACCORDING TO WHICH MATHEMATICS TEXTBOOKS FOR SENIOR PHASE ARE ANALYSED	**BOOKS WRITTEN PRIOR TO 1996**	**BOOKS PUBLISHED AFTER 1996**
Amount of reading in texts	Minimal, mostly mathematics jargon and formal mathematics language or symbols	By nature of the context used, much more reading involved, more skills needed to extract relevant information as opposed to facts and figures trivial to solving the problem
Thematic approach	Only themes in terms of formal mathematics	Context related themes prevalent
Underlying teaching philosophy evident	Behaviouristic; rules and definitions, emphasis on reinforcement / drilling exercises, memorising algorithms, etc.	Constructivist approach evident, concept development, contextualisation, learning as social enterprise, etc. drilling/practising with insight not necessarily seen as bad

Table 5.1 Textbook analysis

It is evident that some of the current textbooks and those prior to 1996 were written with different educational aims or outcomes in mind. Although some of the latest books appear to be more user-friendly and decorated with pictures and illustrations there is not much difference in how content is presented. Some of the textbooks scrutinised include the following:

1. Hart, D. and Kendall, J. 2005. *Kollig op Wiskunde*. Sandton: Heinemann.
2. Hunter, C. Smith, P. 2005. *All aboard Maths.Grade 7*. Sandton: Heinemann.
3. Ladewig, W. 2000. Potgieter, R. and Pretorius, J. *New Successful Mathematics Grade 7/8/9*. Cape Town: Oxford University Press.
4. Laridon, P. *et al*. 2004. *Classroom mathematics grade 7*. Sandton: Heinemann.

The change in teaching philosophy and methodology of teaching necessitated a different format as far as textbooks are concerned. However, current textbooks are not without flaws. To a great extent, many still compartmentalise the curriculum into sections. It is still difficult to find the well-balanced text that deals effectively with all aspects of the syllabus and that is learner friendly, yet challenging.

5.10 THE FUNCTION CONCEPT WITHIN THE CONTEXT OF THIS RESEARCH

During the 2nd and 3rd cycles of this action research learning material was implemented in the mathematics classrooms, by starting with grade 7 and expanding to grade 8 learners in 2005. In this section I mainly focus in on the nature of this material and the processes involved in the development and implementation stages.

The whole process of material development is underpinned by the RME stance of “guided reinvention and progressive mathematization” (elaborated upon under 5.5) according to Freudenthal (1973) and Gravemeijer (1994). Drijvers (2003:52), elaborates as follows:

> *According to the reinvention principle, students should be given the opportunity to experience a process similar to that by which a given mathematical topic was invented. Thus a route has to be designed that allows the students to develop ‘their own’ mathematics. … The point of departure for this process is the informal strategies that students come up with that gradually develop into more formalized methods.*

A concerted effort was made to ensure that the mathematics content to be mathematized in our modules was to a large extent kept “experientially real” (Gravemeijer, 1998:277). Consequently, we endeavoured to adhere to Freudenthal’s ideas (see 5.5) and to Gravemeijer’s (1998:278) suggestions of not only using “everyday situations” familiar to the learners, but also to expose them to “fantasy worlds” in which they have the scope to “immerse themselves”. Thereby allowing learners the opportunity to learn mathematics at their “own authority and through [their] own mental activities” (Gravemeijer, 1998:277), and to a large degree at their own pace. Learning mathematics thus also refers to actively doing mathematics essentially involving “solving everyday life problems” (Gravemeijer, 1994:91). It is however important to take note of what Van Etten and Smit (2005:5) have to say about the use of contexts when it comes to developing realistic mathematics material, namely that “a context is not simply a nice decoration used to illustrate mathematics. A context is [deliberately] chosen [in an attempt] to teach learners how to use mathematics [as applied to everyday experiences]”.

Implicit in this process is the crucial role of the teacher as facilitator to ensure that conceptualisation and the development of definitions and achievement of outcomes are “refined to a more formal format” (Van Etten and Smit, 2005:2). The assessment standards related to “Patterns, Functions and Algebra” (RNCS, 2002:63) are important here as we also had to keep in mind that it is expected of learners to eventually be able to construct mathematical models that represent, describe and provide solutions to problem situations, as quoted under 5.5.

As modelling plays such an important role in trying to make mathematics more realistic to learners, it would be appropriate to elaborate on what is entails. Drijvers (2003:54) aptly describes it as that which addresses a specific content, and as such:

> *[Modelling] refers to a meaningful problem situation that is experientially real for the student, and is a model of that situation. Then through working with the model, the model gradually acquires a more generic character and develops into a model for mathematical reasoning …"*

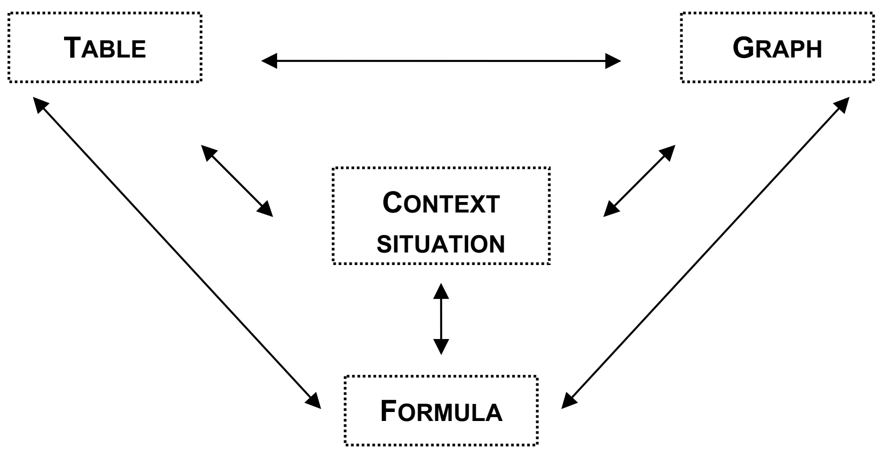
According to Drijvers (2003:54) the process of developing a model of a particular context to a model for mathematical reasoning develops through four levels, namely from *situational* to *referential* to *general* and ultimately arriving at *formal* (mathematics). We generally made use of these ideas in the development of our mathematics materials.

The project team realised that the format in which the study material was to be implemented and used by learners could play a significant role in the degree to which learners interact and identify with the mathematics content contained therein. After extensive deliberations is was decided to develop a series of modules that would cover all learning outcomes in the senior phase mathematics curriculum. This implies that the curriculum was divided into a number of smaller, more readily chewable bits (modules) and not as daunting or intimidating as a bulky textbook. The learners were also allowed to use the modules as workbooks. This was accomplished by writing the modules in such a way that learners would be able to do calculations, write comments and do drawings and constructions inside their *own modules*. This format would furthermore allow the teacher to perform his or her role as facilitator more optimally by substantially reducing the teachers' writing time on the writing board, as well as the time learners needed for taking down notes. This would consequently allow more time for constructive discussions, sharing of views, posing and answering orally communicated questions. Thus a higher degree of interaction with the material, peers and teacher would be practically possible. During observation sessions we would especially look for evidence whether this strategy of using modules would result in a shift from teacher-centredness to learner-centredness, and whether learners would increasingly take responsibility for their own learning.

Questioning plays an important role in the mathematics modules as a way of ascertaining or assessing learners' progress, as well as their understanding and concept development. As a rule we follow Bloom's revised taxonomy (discussed in chapters 3 and 4), especially with respect to the value of higher order questioning to stimulate learners cognitively and thereby enhance learning. The type of questions used can be seen in the examples below. A deliberate effort was made to avoid or minimise questions for which only one right answer exists. The rationale behind this is to facilitate discussion by affording learners the opportunity to share their viewpoints without fear of being wrong of giving answers that might be considered as incorrect.

The teacher's role in facilitating effective and constructive learning cannot be over-estimated. Teachers received in-service training and guidance highlighting their role as catalysts in the learning process by means of pre- and post-module implementation focus group sessions. During the sessions that preceded the lessons on a particular module, teachers were introduced to the material, focusing on the content, contexts, particular problems, time allocated to certain aspects, assessment tools and instruments, etc. At the post-lesson reflection sessions discussions revolved around aspects such as learners' understanding, speed at which learners progressed, problems related to reading, language and contexts, suggestions for changing or removing certain sections, particular learning moments connected to the content itself, and feedback from learners.

Different problems taken from some of the modules reflect the developers' efforts to translate real life problems into mathematical ones through the process of mathematization. Furthermore, a higher degree of flexibility is built into the material to increase learners' choices to permit them to start by using their informal knowledge and compelling them to progress toward using strategies that are more formal by nature. Tables, graphs and formulae as mathematical tools are applied to model a variety of context situations. In the questions or problem situations in the mathematics modules either the numerical, graphical or algebraic format is used as point of departure. The interrelationship between numerical information or data (table), graph and formula is depicted by the following diagram from Verhage et al (2000:37):

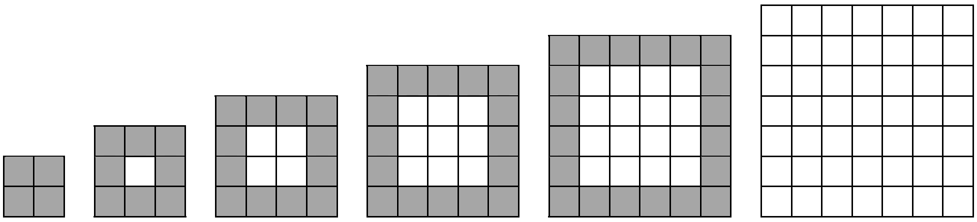


From Verhage et al (2000:37)

Figure 5.3 Table, graph and formula inter relationship

The following examples (taken from the module on functions and graphs) firstly deal with the numerical format as starting point to compel learners to use the context situations as point of departure to eventually progress to tables and graphs, allowing them to plot values, to study constant differences and emerging number patterns, to complete or fill in missing values, to construct appropriate formulae, to explore and solve relationships between variables algebraically, for instance (Verhage, 2000:38). The principal developer of project learning materials, in collaboration with the IMSTUS project leader and facilitators, was Bertus van Etten, our co-worker from Fontys University in the Netherlands.

2 Below appears a regular tile pattern:



a Colour in the pattern at position 7.

b Complete the following table:

Pattern number	2	3	4	5	6	7	8	9
Number of grey tiles								

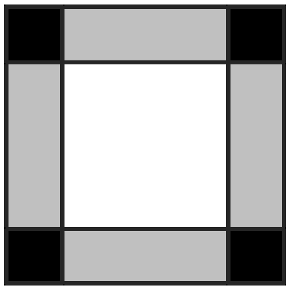
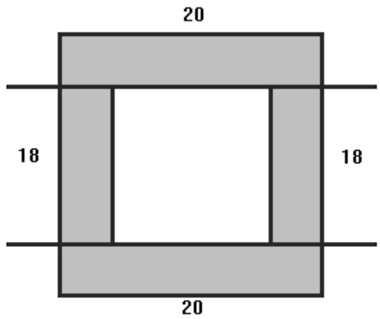
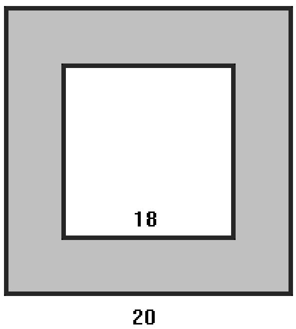
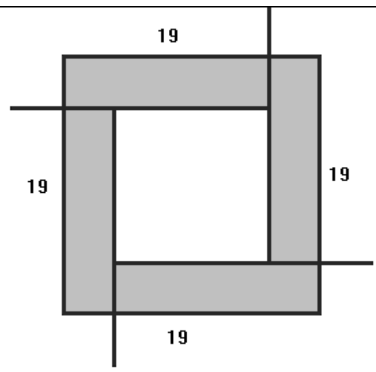
c How many grey tiles are there in pattern 20?

3 Different learners in a class obtained their solutions for question 2c in different ways. Look at the answers below:

Anton	$2 \times 20 + 2 \times 18$
Bart	$4 \times 20 - 4$
Christa	4×19
Dezi	$20 \times 20 - 18 \times 18$
Fuad	9 10 11 12 13 14 15 16 17 18 19 20 32 36 40 44 48 52 56 60 64 68 72 76
Gerrit	Pattern *5 contains 16* grey tiles. Each next pattern contains 4 grey tiles more. At 20 it is 15 times. Thus $16 + 4 \times 15$

a Say if you agree with the ways in which the learners arrived at their answers? Did you also get to your answer in one of these ways?

b Sometimes it is possible to see what strategy a learner used to get to his/her answer by looking at the sketch made by that learner. Look at the sketches below. Below each sketch, write down the name of the responsible learner.

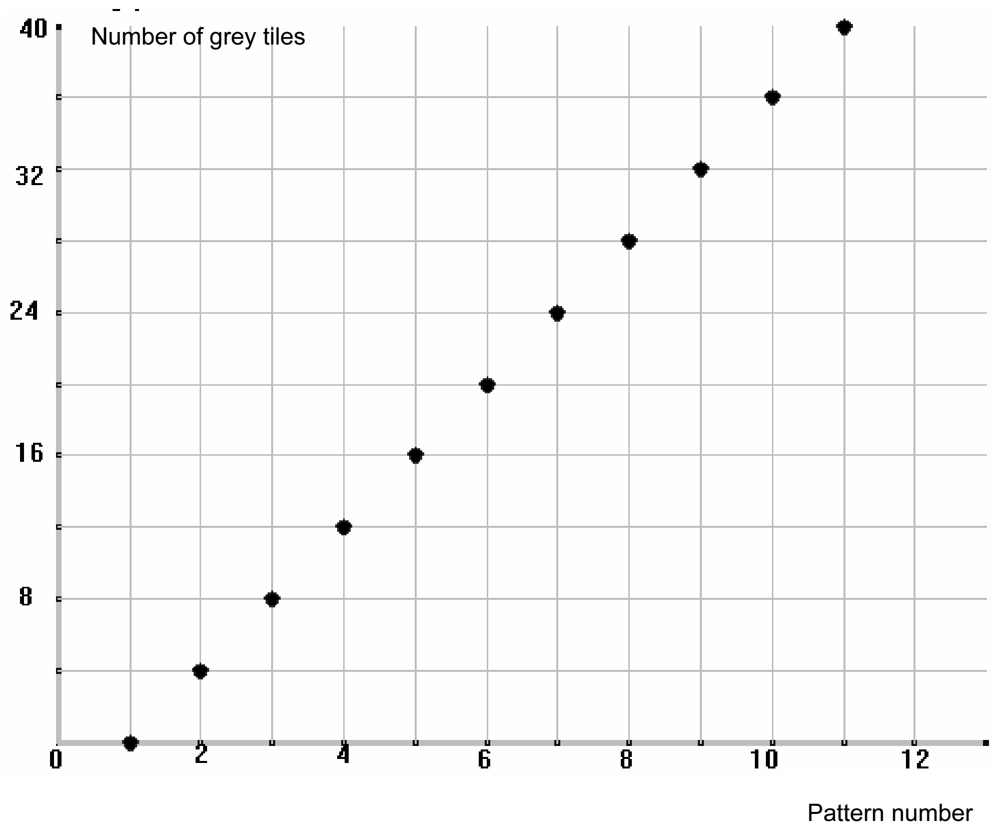
<table>
<tr><td>Four tiles are counted twice!
</td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

4 Let's look at question 2 again.

a How many white tiles are there in the pattern numbered 1000?

b How did you calculate it?

5 The information inside the table in question 2 also allows you to plot a graph. The pattern number appears on the horizontal axis and the number of grey tiles on the vertical axis (see next page).



a From the graph read which number of grey tiles belong to pattern number 11.

b Why is this graph in the form of a dotted line and not a continuous straight line?

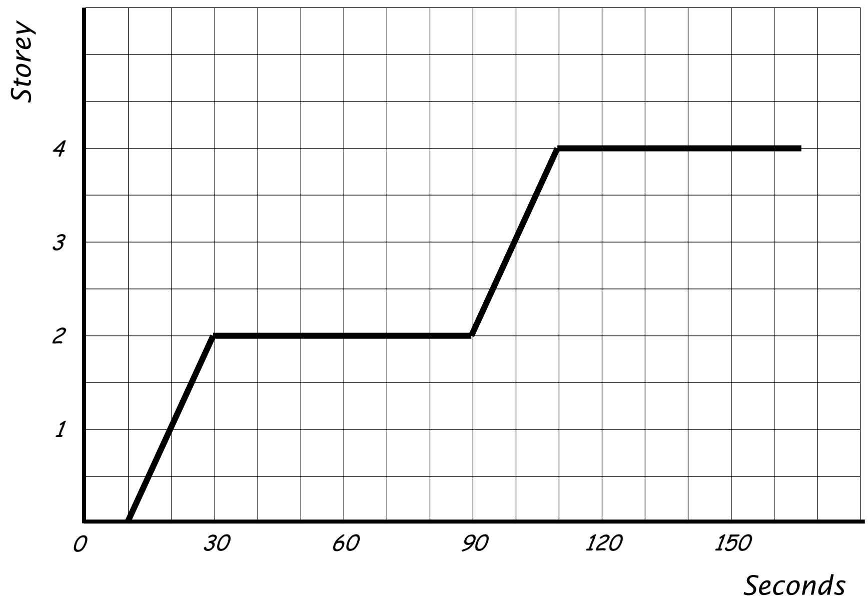
c One of the points on the graph does not appear in the table.
Does this point correspond to the pattern that is portrayed here? Draw the tile pattern that is applicable here.

In the following question the graphical is used as starting point. The aim is to ascertain whether learners have developed skills and possess the knowledge required to:

- correctly read information or values from a graph,
- make deductions and interpretations,
- discuss the ways in which the graph behaves,
- make inferences by focusing on aspects such as minimum, maximum, increase, decrease, constant,
- make statements with respect to the slope or gradient and rate of change, get exposure to more than one graph on the same system of axes,
- deal with intersections or intercepts, and
- develop equations or data tables using given graphs.

The graph below, also taken from the module on graphs and functions, represents the relationship between the position of a lift in a multi-storey building at any given time:

Graph of the position of a lift against time.



a How many storeys are described in the graph?

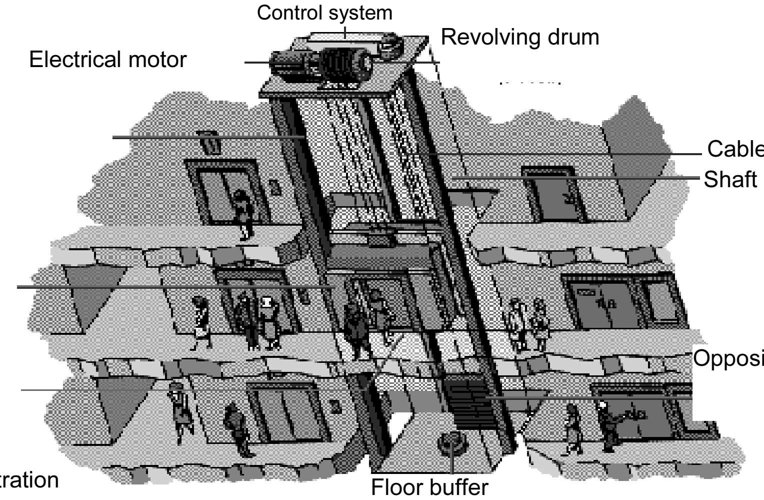
b How many seconds are described in the graph?

c On which storey is the lift after 60 seconds ?

d After how many seconds does the lift arrive at the fourth storey?

e How long does the lift stay on the second storey?

f How many seconds are needed to move up one storey?



Microsoft illustration

g Write a short story about the people who were inside the lift at the time as described by the graph above. Write down at what times people got out or into the lift.

The question that can be asked here is whether this type of context is appropriate for rural learners in remote areas far from city life. On the other hand, not to expose these learners to this kind of context would prevent them from broadening their experiences and horizons. With respect to the latter we thought it feasible to include a diagram of a lift to give those learners who have never been on one, a better understanding or basic idea of what it looks like. Some of the questions are fairly straightforward, but for many learners reading information from graphs accurately, or interpreting what happens or what is represented, remain problematic.

It should be evident that especially up to grade 8 mathematics terminology or jargon is avoided, and that the material encourages learners to think and develop mathematically in terms of the contexts that confront them. The following table, adapted from Van Etten and Smit (2005:4), illustrates the idea of communication "in the language of the context":

LANGUAGE OF THE CONTEXT TAKEN FROM VARIOUS PROBLEMS THAT APPEAR INSIDE THE LEARNER MODULES	MATHEMATICAL LANGUAGE
Number of storeys on vertical axis (refer to the problem above)	y-axis
Time (seconds) on horizontal axis (refer to the problem above)	x-axis
Kilometre against hour (as used in distance – time graphs)	Gradient
Deposit paid (for example where the cost of renting a car has to be calculated)	y-intercept
For the first 200 km the tariff car hiring company A is less than B. After 200 km A becomes more expensive.	Solving an inequality
At 200 km the cost of 2 car hiring companies with different cost structures are exactly the same.	Read the coordinate of a point of intersection from a graph or solve an equation.

Table 5.2 Communication "in the language of the context"

5.11 CONCLUSION

The above discussion was aimed at putting the function concept in perspective, not only as far as this study is concerned, but also with respect to its relevance in terms of the senior phase mathematics curriculum. Not only is it crucial to have an understanding of the outcomes addressed in the senior phase curriculum, but also have a clear understanding of what content and concepts learners have encountered prior to this phase.

Clearly this discussion was not intended to be an exhaustive discussion of all the various aspects of the function concept. It did not address all issues nor did it refer to the intricacies with respect to further education and training and beyond. What was important was to get some idea as to the experiences and findings of mathematics educationists that relate to learners' conceptualisation problems of the function concept and related mathematics. It was also to gain insight into the approaches advocated by various mathematics educationists aimed at facilitating learning and conceptualisation.

It was important to examine how the function concept is dealt with in respect of material development and research context and to put underlying strategies and methodologies into perspective.

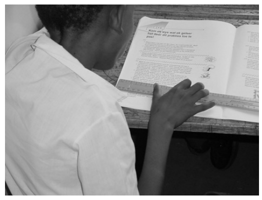
In the chapter to follow the most important aspects of my research done over the past three years are put into perspective. The cyclic process of action research over a period of three years (2003 to 2005) is divided into three cycles that incorporate assessing the situation, planning, intervention, assessing and reflection.

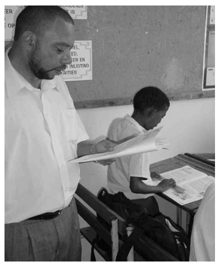
CHAPTER 6: INQUIRY AND INTERVENTION

A teacher's comments: "Quite often the teacher is a transmitter, sending out information which the student is expected to receive. I think that mathematics is much more than that. Mathematics is not just the science of learning the 'rules' and applying those rules to problems. Mathematics is much more dynamic, and there are many discoveries to be made not only by me, but my students." (Schatz Koehler and Prior, 1993:286)

6.1 INTRODUCTION

Confronting learners with text in the maths class…





As already mentioned in Chapter 1 and Chapter 4, my main concern was with analysing the state of communication inside the mathematics classroom in the senior phase as it occurs during formative assessment. This is directly linked to the title of this thesis, as it entails an analytical study of feedback that occurs during formative assessment. I was interested in the extent to which learning (which deals with conceptualization, making sense of, developing insight, through communicating by using mathematics language) was hampered or retarded by deficiencies in communication. This, however, cannot occur in isolation, but is dealt with in context.

This context implies, for instance, that any obstacle(s) to communication need to be addressed or countered. An obstacle could be a teachers' ability or inability to effectively facilitate small group work; teachers' (lack of) skills to steer or manipulate class discussion through effective questioning techniques; teachers' (lack of) awareness of how they listen to themselves and to their learners; teachers' ability or inability to change to a classroom structure that would facilitate discussion, and increase in learner participation; learners' impaired reading skills; teachers' limited mathematical content knowledge; teachers' ability or inability to devise and implement suitable learning materials that would limit writing on and copying from the writing board, enhance learning, allow more time for discussion, and facilitation, etc.

I realised as a result of observation of lessons and frequent interaction with teachers and learners that there were certain circumstances that hampered or interfered with dialogue and conversation and consequently also affected feedback in the mathematics classroom.

Circumstances in the classroom restricted the optimal use of mathematical language, learning and growth or progress of both learners and teachers. If mathematical knowledge or mathematical language was limited, it was obvious that in-depth discussions or rephrasing of questions or active, hermeunitical listening for certain clues was not possible most of the time. There were at least two ways of intervening or tackling the problem. One was for teachers to find a way to improve their own content knowledge and pedagogic skills. The other was for us as a research team to develop mathematics materials and apply teaching methodologies that to a large degree would extend the teachers' content knowledge and at the same time provide contexts to broaden opportunities for classroom discussion.

The use of feedback in the [process of formative] assessment of my research runs like a golden thread through the whole thesis. It was not only restricted to the mathematics classroom. It began with my conversations with the teachers and learners, and continued during lesson observations or analysis of questionnaires. It was also in evidence when I was assessing the impact of my intervention, while monitoring teachers' progress and implementation of new ideas and methodologies, and also assessing the effectiveness of recording my findings or observations, since these were considered to be learning opportunities (for both the teachers and myself) to ascertain what worked well and what did not. Simultaneously the structure of the classroom or classroom organisation and atmosphere were monitored and changes suggested, making the mathematics classrooms places that were more conducive to learning. It is essential to have a climate in which learners feel increasingly free to pose questions, raise opinions and share their points of view, that is, they are able to and encouraged to make constructive contributions towards the learning process. On the basis of these findings, strategies were changed or adapted before being re-implemented.

Once again feedback was used to assess the effectiveness or appropriateness of a particular intervention or action undertaken, etc. This was a recurring process. Although I eventually had to put a full-stop behind this PhD study, the cycle will recur again and again. I thus focus on a particular educational phenomenon inside the mathematics classroom, but simultaneously I am actively and analytically engaged inside my own PhD classroom in reflecting on, and critiquing my own endeavours related to what transpires inside the mathematics classroom. My reflection thus comprises the whole PhD exercise. At this point, however, the focus is not so much on the teacher or the learner, but rather on my own perceptions, findings and actions. This can be viewed as a form of self-critique, a critical re-look at the role of feedback and how it was used and how it evolved from 'start' to 'finish'. It also involves being conscious that the emotional (emotive) environment with respect to my trust relationship with teachers continually grew.

Although my research is characterised by three discernible cycles as indicated in Chapter 2 under 2.5.1, for practical reasons and because of the integrated nature of the research, it would be more appropriate to use the format set out below. The main aim is to refer to and discuss important instances to reflect on the state of affairs at a particular point in time, and to share instances of progress or change in the situation whenever it might occur.

> *It might be appropriate at this stage to point out that my efforts and discussions (especially in Chapters 6 and 7) are strictly geared towards improving teaching and learning of mathematics in the senior phase. As such findings and discussions that reflect shortcomings and limitations in teaching should be viewed in this light and not as an attack on teachers. I have made a deliberate effort not to be unduly harsh in my reporting, and to avoid negative personal comments. Where extracts of real conversations are used, teachers' real names have been omitted. A letter in the appendix indicates permission granted by teachers that their names may be used in this thesis.*

For reasons related to structure I have divided these cycles into different phases, starting with reflecting on what happened previously and assessing the situation as it was prior to starting the new cycle, which was followed by planning, action and observation. It needs to be said, however, that these phases run continuously through the academic school year and should rather be seen as smaller cycles within a larger annual cycle. The main reason for this is the fact the we as facilitators – once we observed an aspect that needed to be addressed or we felt compelled to provide guidance or intervene – took almost immediate action by reflecting with the teachers at their particular school after the lesson, and also at the fortnightly focus group sessions. This was then followed by observing the changes which the teachers made in their classrooms afterwards. This modus operandus is depicted by the following diagram, where the bigger cycle indicates the 2005 AR cycle consisting of a number of smaller AR intervention cycles.

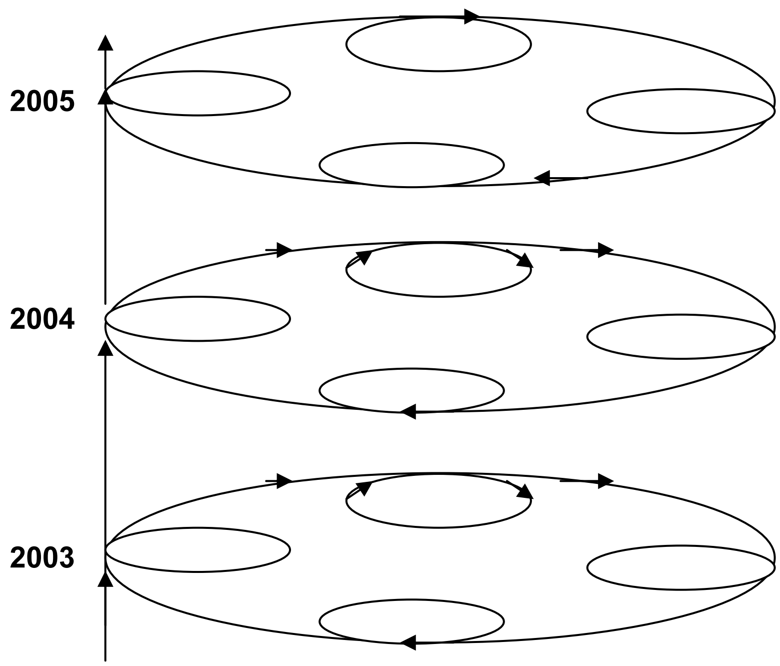


Figure 6.1 Intervention cycles

6.2 NEGOTIATION OF ACCESS TO SCHOOLS

Negotiating access (Tarr, 2005:457) or "getting in" (Terre Blanche and Kelly, 1999:134) or "to gain entrée to the field setting" (Touliatos and Compton, 1992:235) implies a process of requesting permission from those in charge, that is "persons who are empowered to grant or deny access to the setting" (Touliatos and Compton, 1992:235). These people are referred to as "gatekeepers" (Taylor, and Bogdan, 1997:33; Terre Blanche and Kelly, 1999:136) of an organisation or institution. Research could not be done in this particular setting without their permission. In this case permission had to be sought to work in the chosen schools in Circuit 6 of the West Coast Winelands EMDC.

My studies were performed as part of a larger project, The Brave Maths Mouse, (outlined in chapter 1). Initial negotiations to gain access (Tarr, 2005:457) between the schools and my institute directorate included meetings with all the important role players or gatekeepers (Taylor, and Bogdan, 1997:29), such as the directorate of the EMDC (West Coast Winelands), the principals of the chosen schools, as well as the mathematics teachers concerned. As facilitator and researcher I was an active participant in all discussions and negotiations. Each school had to sign a contract of consent and mutual co-operation, a copy of which is attached as an appendix. All the participant teachers signed a letter of consent detailing all aspects that centre on our interventions as research team. A copy of this consent letter also appears in the appendices as Appendix B.

I encountered very few of the problems mentioned by Taylor and Bogdan (1997:30) such as disassociation from the gatekeepers, or tension and conflict, or a sense of having to collaborate with departmental officials. The gatekeepers were provided with semester reports to keep them abreast of progress made.

6.3 STRUCTURING THIS CHAPTER

In the section that follows on this I briefly revisit some of the main themes contained in the first five chapters. The section contained under 6.5 essentially deals with the findings of my encounters with teachers: What I observed in the mathematics classrooms, and a discussion of the information I collected from all the focus group sessions. The focus thus is the pedagogic conditions as they existed then, teachers' perceived needs, the learning and classroom culture, teachers' concept of feedback and assesement, the way communication was structured, and the listening and questioning skills displayed by teachers. Right through this chapter ample use is made of images to visually portray what transpired though the course of the cycles.

In this chapter I give a chronological exposition of most of the inputs and outputs during the three years. These include workshops or training sessions, focus groups sessions, class visits, post lesson reflection, mathematics material (as modules) development and implementation, restructuring of the classroom dynamics, and restructuring of the way communication was organised. In chapter 7, I discuss the progress made, and report on the development with respect to changing the classroom structure, implementing and facilitating of cooperative learning by teachers. The extent to which teachers display their listening, questioning and feedback skills is also discussed.

6.4 MAIN IDEAS FROM THE PREVIOUS CHAPTERS

Chapter 6 and 7 should be read in conjunction with chapters 1 to 5. Chapter 1 introduces the problem of communication and its impact on formative assessment to facilitate learning, gives a rationale for this study, and shares perspectives on the nature of the problem as it occurs especially inside the mathematics classroom. Closely linked to this is the purpose of focusing on this aspect as research topic. The remainder of Chapter 1 is devoted to describing the context (region and population) within which the research occurs, as well a brief introduction to my role as facilitator.

In Chapter 2, I position my research ontologically, epistemologically and axiologically. Furthermore, I attempt to come to grips with action research as suitable research methodology by investigating the viewpoints of different experts in the field, and positioning it in terms of a suitable research paradigm. Consequently, I found the paradigm of praxis to be the most adequate epistemological structure to accommodate my action research. It allows me not only to reflect on practice, but also to take action geared towards improving the situation of the teachers within a framework of respect.

Chapter 3 deals with pertinent issues that impact closely on the underlying learning theories. Outcomes-based Education as teaching philosophy is explored, along with the meaning and role of formative assessment with respect to mathematics education. I attempt to show the interrelatedness of communication with assessment and learning inherent in OBE.

The concept of feedback as an integral part of communication is the focus of Chapter 4. This concept of feedback is central to this whole research and manifests itself throughout the whole dissertation through learner-learner, learner-teacher, teacher-teacher, and teacher-facilitator communicative interaction. Assessing teachers' understanding and applications of feedback as a pedagogic tool is an essential prerequisite before embarking on appropriate interventions to educate teachers and to remedy limitations or deficiencies that might exist in this regard.

In this dissertation, as previously pointed out, the "function" concept of curriculum content was used in this study of the influence of feedback. This concerns the way the use of feedback enhances learning, hampers or interferes with it. Chapter 5 thus deals with various pertinent issues as they relate to the concept of function. What is especially important here is how it is perceived in terms of realistic mathematics education and outcomes-based education, and the major conceptual problems learners experience in the view of experts in the mathematics education field and also my own as a result of my experiences during this study.

These main ideas contained in the previous chapters played a crucial role in helping me to understand what I encountered in practice, that is, what occurred inside the mathematics classroom, observing teachers' attitudes towards what they do and how they experienced change. It also informed my understanding of how teachers responded, not only inside their classrooms towards their learners, but also towards their peers and to me as facilitator. The ideas on action research covered in Chapter 2 played a major role in guiding me to assess, intervene, and reflect throughout this research.

6.5 ASSESSING THE STATE OF AFFAIRS

My concern during the course of 2002 and 2003 was with the state of feedback, and with its value in enhancing communication and interaction among peer learners and between the learners and the mathematics teachers as part of the formative assessment process. Upon establishing teachers' conceptions and skills with respect to feedback, and how they viewed and dealt with listening and questioning, I had to plan how to work with them and how to expose them to opportunities to address all the said issues. In order to do this an atmosphere had to be created that would enhance and increase the degree to which mathematics communication or discussion could take place inside the mathematics classroom. This meant that the teaching culture had to change, and specifically how the classroom was organised and managed. An important influence was Fullan's (2001:3) notion that teachers should be provided with opportunities to discuss what innovation is as well as the meaning of change. This could be done by building "professional learning communities that are good at sorting out the worthwhile from the non-worthwhile and [these] are sources of support and healing when ill-conceived or random change takes it toll".

It was important to determine which elements or factors were preventing this culture of dialogue and communication from coming to fruition. I considered it to be crucial to ascertain what teachers' feelings were, what they thought their needs were, what their opinions were regarding certain issues such as feedback, communication, listening, questioning and formative assessment.

6.5.1 What teachers said their needs were

The pertinent question to start (the project) off with was what the needs of the teachers with whom I am embarking on this new project were. Evidently we all have a limited sense of what our needs really are whether it might be social, emotional, political or educational. It is also possible that we might have needs that we are not aware of until some friend, colleague or facilitator points our attention to that which is amiss. At the outset of the project teachers shared their viewpoints with respect to what their needs are in respect of teaching mathematics in an OBE dispensation.

Since teachers at this stage had received little or no training in OBE related teaching strategies and methodologies I detected a general uneasiness and anxiety as to what was expected of them with respect to teaching, facilitating, allowing learners to work in small groups, formative assessment and recording of assessment results.

The following needs expressed by teachers gave credence to my initial hunches:

- Need for exposure to more effective teaching methods.
- Need to know how to convert from traditional methods to OBE-related methodologies.
- Need to know how to deal with bigger classes – 45 or more.
- Need for a framework for planning of mathematics, for example how to divide learning content appropriately into four terms (year planning).
- Need for assistance with applying teaching methods – to deal with mathematics in context, and how to get learners to participate more readily in the learning process.
- Need with help with organization and administration – practical lessons and demonstrations.
- Need to create a classroom atmosphere that increases learners' confidence levels.
- Need to find ways of effectively assessing learners' progress and performance.
- Need to find examples of assessment and rubrics.
- Need to know how to facilitate group work effectively.

It is also essential to look analytically at what was said by teachers during informal conversations whilst visiting their classrooms. At this point, I specifically want to have a closer look at the following conversation since it reveals interesting and generic needs of teachers in the project. All the teachers for instance acknowledge the fact that guidance was needed in this transition stage in 2002- 2003 to help them to change and adapt to outcomes-based education methodologies.

In the following dialogue (that occurred 22 August 2002 during first break after the morning session) – which is part of a post-lesson reflection – I allowed the teacher to control the direction of conversation. I believe it is an effective way of empowering the teacher, to find out where he comes from, where he finds himself at that specific moment, and to gather information as to where he might be going. My trust relationship with this teacher at this stage is much more advanced than with most other teachers in the project at this stage.

The converstation starts with Pedro expressing his opinion about the value of my visits to his classroom:

Teacher: I think it is important ... look we see each other about once every two weeks.

Stanley: Every two weeks, yes.

T: Now in these two weeks it is not possible – for argument sake - in 9 lessons we see each other only once. This lesson would serve as an opportunity to meet like this – I view it as a learning experience.

S: Whether you are on the right track or where you need to make changes.

T: I can measure or gauge where I am with the learners – to what extent I am making progress with respect to the learners, but who 'measures' me – what progress did I make? Do you understand what I 'm saying? I view these visits or observation sessions by you as a barometer against which I measure my skills or competency levels.

S: I'm a bit concerned about the kids – they seem to be a bit anxious, a bit inhibited – the fact that they could not come up with ideas to solve the problems during the lesson. Do you understand? Practical things – to indicate how they think...

Here he emphasises the need for my visits. The frequency of my visits he sees as a concern. He would like me to visit more often, but due to financial constraints and long distances between schools this is not possible. He acknowledges the fact that he needs someone to confirm, and to reassure him that he is indeed doing what is supposed to, whether it relates to content knowledge, depth of knowledge, quality of teaching, or pedagogic skills. He acknowledges the importance of getting feedback from someone, to be given peace of mind as to whether his feedback to the learners is apt, timeously, justified, or whether he adequately responds to the feedback received from the learners. He is thus concerned about the nature of and quality of formative assessment and how his communicative interaction enhances learning. He thus sees the value of reflecting with someone about what actually transpired in his classroom during a particular lesson. He is aware of the fact that he has certain shortcomings, but is clearly prepared to expose himself to outside 'interference' or intervention, he is open to suggestions, he is prepared to explore and clearly views this as a learning experience.

T: That is what I wanted to see – what were they going to do in that particular situation – whether they would move away from the normal idea of length times breadth. What do they do at home to solve similar problems? Cut the novilon in pieces at home? What do they do with the pieces that are left? What do they experience out there – how do they cut a plank or piece of wood – little things that they would have done at home. It seems to me the child views the school as something totally separate from his everyday life experiences. We must get the child to the point where he can apply that which he does at home also inside the school. Even more important is that he can apply that which is learned at school also at home - if we could only get to that point.

S: *You sit with two different 'cultures' – a school culture which is supposed to be a learning culture and with a home culture where the child is also supposed to learn. Somehow a gap exists that needs to be overcome. We need to bring these two closer together.*

In this instance, he sees the need to make learning content more relevant and realistic. What is learned at school needs to be useful out there. The child's experiences out there need to serve as basis on which the child can build further or develop more difficult concepts, and which can support the learning and understanding of new or related concepts inside the mathematics classroom. From what he says it is clear that what is learned in class is not supported in the home environment. The home in this community often does not serve as an extension that reinforces what is learned or conceptualised inside the classroom. This makes the work of the teacher extremely difficult, and the teacher experiences this as demoralising, since homework is either not done or incomplete, requests to bring 'equipment' from home is ignored, etc.

T: *I often talk to parents. They want to know how they can assist their children at home – the first thing they normally tell me is: the stuff that they say – remember Sir I do not have a writing board, then I tell them – you know if you want to help you do not have to do it the way we do it at school... make use of that which is at your disposal, that which is known to the child … let him count the plates on the table when the table is set for supper. Ask him to count the number of plates etc. you know it is most effective to ask the child... when he expects it the least … just him … how many plates do we have here? Coming to school means he is conscious of the fact that he comes here to learn. The unexpected question at home ... how many seats are there in the dining room …when he does not expect It ... this is when he has to make use of his mental faculties to think …*

Here there is an acknowledgement that the role of the parents especially in the disadvantaged communities is crucial. Many of the learners do not have parents, others are raised by single parents, and many parents were generally not really involved in the scholastic affairs of their children. This is due to many social factors such as alcohol abuse, economic factors, etc. Teachers actually need the support from parents to see that homework and other school work get done at home, that is, that a certain percentage of time after school is spent on their studies. This would serve to reinforce what was learnt in the classroom.

T: *The guy from IMSTUS will visit me today – so today and the previous day there are changes made, things are made in preparation to look good. If you* *came unannounced then one would get a better idea of what was actually going on. For example with respect to group work – do they use the group roles. Some of these aspects were dealt with in detail during the summer school workshops.*

This highlights the extent to which knowledge and skills modelled at the workshops are implemented in the classrooms. Some of these aspects were dealt with in depth during the summer school and at previous workshops. In the end, however, it all came down to the extent to which knowledge and skills modelled at these workshops were used by teachers. Some appeared reluctant or unsure about this. It seems the politics at school exerts a much stronger force on some of these teachers. One of the teachers actually acknowledges the fact that our workshops were excellent, but that she did not see her way open to use most of the ideas demonstrated.

An important admission by the teacher during this discussion is that "things" are done differently when the facilitator visits. Although I considered this situation to be artificial and acknowledged the restrictive nature of internal school politics on teachers' development, I realised that regular visits, involving observation, intervention through post lesson reflection might eventually lead to change as regards teaching methodology and teaching culture. It was, however, crucial to discuss with teachers the importance of experimenting with and implementing methodologies modelled at workshops or during demonstration lessons. Trying to impress the facilitator for one or two lessons, just to return to old ways afterwards was not very sensible.

S: Could you touch on this aspect at the next meeting – we just want to discuss it ... then you won't get this practice where things are polished up.

T: Yes, you would get a better perspective of what really happens. What is normal … I take it from myself … when you as educator have to prepare yourself for something – you have the specific idea in mind that you want to make things easier for yourself. If that guy comes I want to test myself and find out whether I can give him something better. The idea almost haunts you – as far as possible I am going to try to make a lot of things easier for myself … so if that guy comes to my class I might conjure up a better story (lesson) for him. But then we tend to forget that the learners do not respond as expected or as planned. They respond in a way they normally do as if there is chaos inside the class everyday (I am not sure what he means here.) and you then plan your lesson. During the lesson one realises – no, wait, wait, something is not right, because that which the teacher says, the learners do not respond to or do not do.

The advantages of unannounced classroom visits are touched on. He says that he in principle does not have a problem with this. He feels comfortable with unannounced visits. He maintains that this would help the facilitator (observer) to form a more realistic image of him as teacher. Although I do not want the teacher to put on an act but to approach his lesson in a way that enhances learning, this 'act' might become habit and thus a way of 'life'. That is it might help him to become more aware, more thorough, better prepared and more reflective. He admits that teaching is not about putting on a show for someone else. It is about learning, it is about making sure that learners understand. It is much more than just conjuring up and conveying a story to learners. Implicit in this is the role of feedback, the message received from learners, namely that they "do not respond or do not do", that the teacher has to do something different or remedy the situation.

What can possibly be deduced from this stance is the teacher's entrenched notions of structure and the need for learners to do as the teacher expected. The teacher seems to express a need to please whoever might be observing his lesson, instead of being flexible and pragmatic in order to address the needs of the learners, thereby accommodating them so as to enhance learning. In this regard as facilitator of change it is important to realise that change depends on the recognition that "educational change depends on what teachers think and do" (Inos and Quigley, 1995:1)

S: Unless you coach the learners?

T: Yes, if you coach the learner – for example if you know small group work is used regularly/frequently, the learners would respond accordingly …

S: I will show you all my diagrams – I forgot to make a sketch of the seating positions of your learners – can you help me to do it quickly?

T: Now?

S: Yes

T: The desks are arranged in such a way that learners can always face the writing board – because if an explanation is required we use the board on which to do it. Then we also have to see one another when they sit in groups. And the last thing is – the formation is very practical and allows for freedom of movement inside the classroom if I use three desks at a station.

He does not actually respond to my use of the word "coach" in a way that I hoped he would. "Coach" or train here (in a behaviouristic sense), as opposed to constructively getting learners to help construct their own knowledge, is meant to arouse a response. He rationalises why the learners' desks were situated the way they were. This teacher after a previous discussion on the function and role of small group work, and how it links to constructivism as underlying philosophy of outcomes-based education, had made a deliberate effort to restructure his classroom.

S: *If I sketch it like this (showing him a sketch of how the learners' desks are arranged) then it becomes easy to see how many learners were present during the lesson – that is if you want to know the totals. What was the lesson topic? Was it "Area"?.*

T: *Of irregular figures.*

S: *Determining the area. I still have to start marking your learners' tests.*

T: *People are still phoning me regarding small group work.*

S: *What do they say?*

T: *Asking for ideas to make it work*

S: *Who phoned you?*

T: *Another bloke – he was not at the workshop. I think the biggest problem that arises at the high schools is the fact that they do not have the time. Many of them say that they do not have time. Group work is an essential part of the learning outcomes – so somewhere you have to make provision. I think Shape and Space is ideal and very suitable when it comes to small group work.*

S: *Did you make him copies of the workshop handouts...*

T: *I have started – most of the work is based on grade 9 – I do not know whether I made copies of everything.*

S: *This morning in a grade 7 class in Riebeeck West we asked the learners to write in their own words what they were doing. The learners were doing algorithms with fractions. They had to multiply a proper (egte) fraction with a mixed (gemeng) fraction and had to explain accurately and in detail what they had to do to solve the problem........ Not one of the learners wrote the same thing – this is one of the learners with much detail – you will notice that she knows exactly what she is doing. Some of her descriptions, however, are vague.*

T: *Do you have to go through all of those (pointing to the stack of learners' efforts in my hand.*

S: *Yes, I want to go through it. I had it done especially to see how skilful they are at expressing themselves clearly and logically. Teacher concentrated on … without using a meaningful context, problems such as 0,8 divided by 20. I asked the learners what it meant, and they could not actually tell me. They did not have the concept that they actually had to cut up the 0,8 into twenty* *little small pieces or units. 0,8 divided by 20? Well, he or she might be able to read 0,8 divided by 20, but what does it mean. What is the use of using an example like this? It is without context – wouldn't it be better to say: "I have a plank/baton/log 0,8 metre in length and I need to divide it into 20 pieces. What is the size/magnitude of each small piece?*

Here the intention was to focus the teacher's attention on the importance of allowing learners to share their viewpoints and their approach to problem-solving. That is, he should use such opportunities of formative assessment to ascertain the level on which learners operate and the extent to which their language and communication skills are adequately developed to cope with subject matter and the way it is presented by the teacher. Instead he is much more interested in what I was going to do with learners' explanations. In order to enhance sense-making it is essential to use appropriate contexts to make mathematics more realistic and meaningful.

From the teacher's comments, and from my observations it is clear that he experimented with some of the ideas on cooperative learning that were modelled at the previous workshop, which was held during January 2003.

What is evident from similar discussions with teachers is their need for certainty. The lack of training and guidance in this phase of transition made them feel vulnerable and unsure. Consequently, they were looking for guidance and mentorship. Very often they highlighted those aspects of the work which riddled them with doubt or self-doubt, such as their understanding of formative assessment, how to find the appropriate assessment criteria when devising an assessment rubric, when and what to record, interpreting the curriculum, aspects related to the teaching practices they needed to change or adapt to, etc. Teachers were especially looking for support from the parents. They wanted parents at least to see that learners do the homework given to them. They realised, however that there is little or no cognitive stimulation in many homes.

6.5.2 What they consider to be their strong points

Teachers did not provide much detail at the outset about what their strong points were. In order to get a better idea of what they consider to be their strong points it was essential to observe lessons and to engage them in conversation. The following are some of the comments they wrote:

- I always try to achieve my outcomes with respect to the learners
- Love for the subject and patience with the learners
- Patience and subject knowledge

- Allowing learners to make an input
- The ability to give guidance in problem-based teaching
- Experience in the learning area and
- The ability to transmit knowledge (to learners who want to learn or those who are keen).

What this last statement really says – or what I read into it – is that this teacher is very much in the behaviouristic mode, possibly very good at her subject and has excellent content knowledge. What about those learners who are not keen? How do we deal with them? How do we organise, manage our classroom and learners to involve all learners? From what she says, is it fair to assume that there is not much two-way conversation taking place in her mathematics classroom? There could of course be questioning that occurs, directed mostly at the learners. Is it fair to assume that not much discussion and argumentation would be present inside her classroom? Transmitting knowledge seems to be very important to her. Most teachers I worked with at the time essentially viewed teaching in these terms. Does this imply that constructivist methodologies such as group work (cooperative learning) are avoided? Although the other teachers did not express the same view as this one it would be possible to detect in their teaching whether they held similar views.

What are their needs or problems in mathematics teaching that require immediate attention? Learning area content refers to the teachers' own subject knowledge. The same teacher discussed in the previous paragraph, reckoned that she had no problems except for "what exactly should be transmitted to the learners". She expressed the need for "new methods that would stimulate learners' thinking", and assistance in creating a "classroom atmosphere conducive to learning".

6.5.3 What teachers consider as the most significant changes in the past 4-5 years

The reason for probing teachers' perceptions with respect to how they experienced changes in education that occurred in recent years is essentially to gauge their thinking and knowledge patterns in terms of what they feel and their perspectives in general terms. This study occurred during a period of transition. Teachers' interpretation (Inos and Quigley, 1995:1) could shed light on how they experienced the new policy implementation and change – that is to what the degree they were comfortable with or resisted change. Information in this regard could be used to explain why the teachers in the project developed at different rates.

Teachers viewed the following issues as those which reflected the most change over the past 4 to 5 years (these views were presented in writing):

- There is a decreasing tendency in learners to explore and think for themselves. The manner in which things are done has changed significantly.
- Teaching methods
- Classroom atmosphere
- More emphasis is put on small group work – which creates opportunities for the stronger learners also to assist the slower ones. Teachers can provide assistance individual learners better
- Learners' participation during the learning process – it is less teacher centred
- There was a shift in emphasis from knowing to doing. Learners perform worse than under the previous system.
- Context-directed teaching
- Assessment and curriculum content.

The type of comments put forward by project teaches are quite general and could even be considered vague and superficial. Consider, for instance, a comment like "The manner in which things are done has changed". I can only imagine that it refers to certain aspects of methodology such as cooperative learning, formative assessment, etc. These few comments also provide insight into how teachers think about aspects of major concern. From these sketchy comments it is difficult to gauge what they really know. The first statement is quite interesting. From utterances such as this one one could assume that teachers realised the need for learners to have the opportunity to explore. Lesson observation would prove that such true exploration by learners very seldom occurred during this stage of the study.

6.5.4 Teachers' principal aims for 2002-2003

The ideas that teachers put forward as principal aims for 2002–2003 to a large extent resemble the needs expressed earlier. Some of the aims mentioned below, such as "to get 70 % of the learners to pass", and "to prepare learners thoroughly for the examination at the end of the year" indicate that many teachers have not made a change yet and are still very examination driven. The importance of formative assessment to ascertain learners' progress does not actually feature anywhere.

The following are some of the aims that teachers viewed as important should be priority:

- To investigate novel teaching methods
- To improve my teaching methods

- To develop a love for mathematics in learners and to empower all learners mathematically
- To get 70% of the learners to pass their grades; to make mathematics enjoyable for most of the learners and to stimulate them to think
- To prepare learners thoroughly for the examination at the end of the year
- To achieve all learning outcomes with the learners
- To improve reading in the mathematics class to acceptable levels
- To improve learners' basic skills in mathematics

These aims make it evident that the teachers realised and were able to identify crucial aspects that make teaching difficult. They knew, for instance, that reading is a major problem. Learners who cannot read would ultimately not be able to progress academically. They also realised that their pedagogic skills need to be improved. Another major concern for them was the learners' lack of basic mathematical knowledge. Interestingly they did not express a need to improve their own mathematical content knowledge.

6.5.5 Teachers' expectations of the facilitator

It is important for teachers to realise and constantly be aware of the limitations or constraints within which the facilitators operate. Facilitators had to be mindful of the constraint under which teachers have to work for that matter. Intervening factors including those that relate to financial constraints, the time and other constraints schools normally have, and curriculum guidelines and policies prevented us from working more intensively in the schools. Some elements exist over which we do not have or cannot exert much control as facilitators. These might include supportive and stimulating homes, an environment that shares and promotes the value of good teaching, adequate and nutritious diet, effective school management, the pressures peer groups exert on the individual learner, etc. At this stage of the study we were basically strangers, and it was critical to have insight into their fears and expectations as far as exposing themselves to me as facilitator was concerned.

The teachers at that time held the following expectations that relate to subject knowledge, teaching methodologies, teaching aims and objectives, planning and assessment. This links up with the discussion in 6.3.2. The teachers mentioned these when asked to identify the areas in which a positive contribution could be made:

- Assist with techniques that would help them achieve their envisaged goals (critical and learning outcomes).
- Give assistance to improve their mathematics teaching and administration, and to give input that would facilitate successful teaching.

- Provide critique that is constructive – “the facilitator should not hesitate to help or assist me whenever I am in need”.
- Give support and guidance with respect to the problem areas
- Help learners to understand the learning content by creating meaningful contexts.

Also in this case teachers were particularly vague. It was clear that they either did not have the skills to express their needs in detail or did not always realise what those needs were. Through classroom observation and one on one conversation I had to find out for instance what was meant by “to give assistance and guidance with respect to the problem areas”.

6.5.6 The way the classroom communication is structured.

After close observation during my earlier encounters with project teachers, Attie, Catherine and Pedro, it became clear to me that they generally acted as the authority (Hickman, 2002), more in an authoritative way than authoritarian; they generally talked the most; they initiated and dictated the direction and pace of the lesson and decided who might talk, when and for how long (Dillon, 1988). Seating arrangements were generally conventional with the desks facing the writing board, compelling learners to work individually and to have an opportunity to answer questions only when the teacher posed some, and then only some with their hands raised were allowed to respond aloud. Conventional ideas that relate to emphasising individual work as opposed to small group work and discussions were evident. Not much attention was given to the relationship between methodology and how the classroom (referring to desks or learners) was structured. Nor was it evident whether teachers were conscious of how seating arrangements related to the philosophies that underlie OBE.

During interviews teachers admitted that they never actually gave any thought to aspects such as communication and feedback as teaching tools (Hole, 1999; Kirmse, 2001; Sanchez, 2003) during their college training. This was also evident during classroom observation. They acknowledged that they were never actually trained in how to develop or employ strategies to enhance feedback and communication in the mathematics classroom. This interview was the first time that they were actually compelled to actively and consciously think about how they communicated or gave feedback during their lessons.

Across the board (referring here to the four teachers under discussion), not enough time was given for learners to think and respond to questions (Cazden, 1988); teachers’ knowledge of questioning (Brophy, 1997), the use of different types of questions to elicit learners’ responses or reasoning (Hickman, 2002) were limited or non-existent; teachers did not think adequately about questioning as mechanism to start or give direction to the lesson (Long, 1996; Dillon, 1988; Black & Harrison, 2001). The four teachers appeared to seldom realise the value of, or use questions to probe learners' thoughts or use higher order questioning (Curzon, 1985) to stimulate learners' thought processes. In both Catherine and Pedro's classes I experienced limited skills when it comes to rephrasing questions to prompt the learners to respond. Teachers still thought very much in terms of right and wrong answers, often ignoring the thinking and reasoning processes involved – that is how the learners arrived at their solution – whether right or wrong (Brophy, 1997; Davis, 1997; Mandel & Vontver, 2002). Pedro agreed that he put too much emphasis on 'right answers'.

The discussion, based on a grade 8 lesson observed as recently as August 2004, to follow shows that teachers generally encounter difficulty making a shift to a teaching approach that is more context-based. During this lesson I acted as non-participant observer, which means that there was no intervention from my side.

Starting off a lesson with mathematical symbols in simple equations proved to be counter-productive. The limitations with respect to the communicativce process were also exposed. This was an announced visit at a time when my relationship with this teacher already spanned two years. Furthermore, this occurred after several workshops during which outcomes-based methodologies and constructivist strategies were modelled. At this stage, we had already introduced the modular system in grade 7 to which the teacher was currently exposed. Bryan, however, did not seem to follow the same teaching methodology with the grade 8s that we advocated for the grade 7s.

The learners sat as follows – they faced one another, sitting on opposite sides of the table. During the lesson they do not actually converse as they had to focus on what the teacher did (and explained). Some of the learners (about 10) did respond when the teacher addressed them. Their responses, however, were very short – mostly one word. As such there were not discussions and opinion sharing in the true sense of the words. It was clear that the teacher knew his learners – he called them by their names. The classroom was quite big. They sat in 5 groups that differed in size. In front of the writing board there was a stage. Every time the teacher wanted to write something on the board he had to get onto the stage.

In the lesson given below, the teacher introduces equations, starting with $x+ 4 = 9$ (without context). The lesson more or less proceeds as follows:

> *Teacher: Do I know what the number is (pointing to x)*
>
> *Learner: It is 5, because 9 – 4 is 5.*

T: If I would say "a number increased by 4 is equal to 9" – does it make sense? Alton, does it make sense? Now say it in the same way as in the expression. Now what do I make this number (referring to x, used in place of the unknown value).

Learners (answer in a choir): An x.

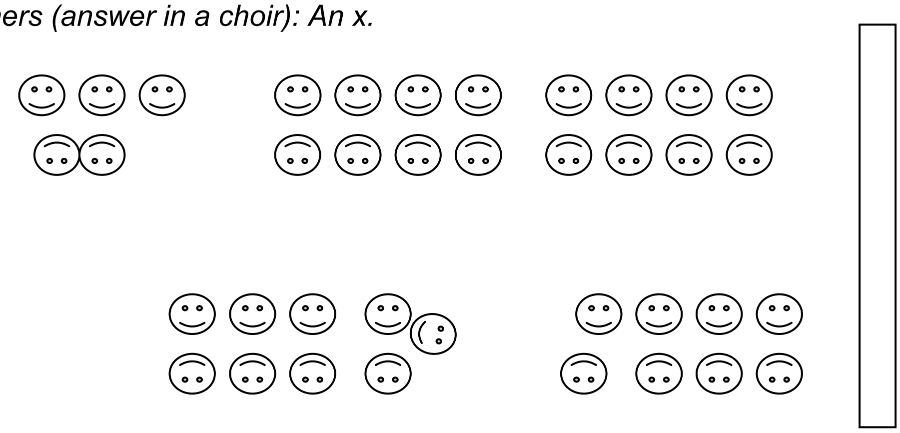


Figure 6.2 Seating arrangements

The teacher now distributes a blank piece of A4 paper. He then writes the following on the board: A certain number reduced by 10 is equal to 16.

T: What do we make this number? Is this number known? What do we do with numbers that are known to us? What operation do we use?

There is no response from the learners as they do not know to which question to reply.

T: Reduce means to ….?

L's in a choir: 'Reduce' means to 'subtract' [Verminder beteken om af te trek.].

On their blank pages some of the learners write the following:

L1: $x + 10 = 16$ L2: $10 + 6 = 16$ L3: $10 – 16 = 6$

L4: x $10 + 6 =$ L5: $X^6 + 10 =$

T: Remember it is a number minus 10. What is that number (referring to x).

L (Jonathan) $x – 10 =16$

$26 – 10 = 16$

$x = 16$

L (Quinton): $a – 10 =16$

$a = 16 + 10$

$a = 26$

L(Elton): $x – 10 = 16$

$x = 10 -16$

$x = 6$

T: *We talk of the left hand side and right hand side pointing to the opposite sides of the equation. He writes the following on the board:*

n – 10 = 16

n = 16 + 10

n = 26

T: *I have to take the 10 over to the right hand side – but now I add - this is the inverse calculation. Come let's see if I worked correctly. This means I first have to check whether the value of n is correct.*

One of the learners does it as follows

n – 10 = 16

n = 16 – 10

n = 6

The next problem is given. A certain number multiplied by 4 is equal to 20.

The learners' efforts:

1. *x + 4 = 20* *2.* *x – 4 = 20*

3. $x \times 4 = 20$, $x \quad 20 \times 4$, $x = 5$ *4.* $x = 4 = 20$, $x = 20 + 4$

5. $Q \times 4 = 20$, $Q = 20 \times 4$, $Q =$ *x = 20 + 4* *6.* $x \times 4 = 20$, $x = 20 \div 4$, $x = 5$

7. $x \times 4 = 20$, $x = \frac{20}{4}$, $x = 5$ *8.* $x \times 4 = 20$, $x = 4 + 20 = 24$

8. $x \times 4 = 20$, $x = 20 \times 4$, $= 5$ *9.* $x \times 4 = 20$, $x = 20 \times 4$, $x = 24$

T: *Test the answer of number (9): 5 x 4 = 20.*

Homework sum: The joint ages of 3 children in our family, is 32 years. I am twice as old as my sister, and my brother is 2 years older than I am. How old am I? [sister = *x*] The learners copy the problem from the writing board. The bell goes at this time.

6.5.6.1 The approach and introduction to this aspect of functions

Although the learners were supposed to have encountered number sentences such as $\boxed{\ldots} + 5 = 23$ (Nickson, 2000:112) in arithmetic in the Intermediate Phase, prior knowledge such as this cannot be taken for granted. As such this introduction may be described to a certain extent - as “abrupt and abstract” (Willoughby, 1997). It is obvious that learners struggle to make sense, and that the concept of the “relationship between variable magnitudes” (Sierpinska, 1988:572) has not been developed yet. In this context Crowley, Thomas, and Tall (1994:242) *[for example]* write that learners tend to “see x + 3 as a process and not a mental object – a process they cannot carry out because they do not know what x is. To be able to cope with such a symbol requires not only that it be given meaning, but the meaning should cope with it both as process … and also as an object which can be manipulated as it stands”.

The teacher’s approach should initially have been much more concrete as suggested by Willoughby (1997), and then only have moved gradually to the abstract. This approach does not enable learners to see the value or significance of what they are busy with since appropriate contexts with which learners can associate are missing. On the other hand, the difficulties learners experience could be ascribed to what Nickson (2000:110) describes “as a result of children making rather too direct a transfer of procedures used in an arithmetic context to an algebraic context without being adequately aware of the difference in the constraints that apply at the more abstract level”. Nickson (2000:113), referring to Lesh, Post and Behr (1987), writes that the meaning of equivalence of a symmetric and transitive relationship, … , is not necessarily part of children’s thinking when faced with simple number sentences …, even though it is equally applicable”.

It is clear that in terms of DeMarois and Tall’s (1999:257) analysis of the function concept most of these learners operate mostly at the pre-procedural layer and have not yet reached the procedural layer. They are thus far from the level of treating ideas as manipulable mental objects to which a process can be applied (DeMarois and Tall, (1999:258). In this lesson learners are exposed to elementary procepts such as those mentioned on page 159 (Chapter 5, 5.2). From the learners’ responses it is evident that their proceptual thinking skills are still very limited, as they do not yet regard symbols as mental objects and it reflects their inability to think about these concepts (DeMarois, 1996:2).

6.5.6.2 The kind of questions the teacher poses during the lesson

The teacher is clearly in control. He dictates and directs the learning process. Learners only respond (though often not) when prompted by the teacher’s questions. The learners themselves do not pose questions. Although they sit in groups, there is no real discussion taking place among themselves. One intuitively wonders if the flow of the conversation would be different if different types of questions would be posed. The list of questions that flows form the lesson are the following:

- Do I know what the number is (pointing to *x*).
- Alton, does it make sense?
- What do I make this number [*Wat maak ons die getal?*](Referring to x, used in place of the unknown value).
- Is this number known?
- What do we do with numbers that are known to us?
- What operation do we use?

The last four questions the teacher posed in quick succession without giving learners ample time or chance to respond, nor did learners know what question to respond to. From observation it clear that learners need more time to respond to the teacher's questions. The reason for this may reside in the fact that the teachers felt the need to proceed to other work, since there was a curriculum to cover. The questions are mostly of the type that limits learners to *yes* or *no* answers, also referred to as closed questions. The nature of the questioning strategies applied points toward the learning of certain algorithms. Consider, for instance, "I have to take the 10 over to the right hand side – but now I add - this is the inverse calculation." Furthermore, the incorrect ideas that were being transmitted are evident, since one can technically not move one number from the one side to the other side. Although the teacher's explanation in this case was aimed at facilitating understanding, his message was distorted as learners were not confronted with and do not understand what processes are really involved here. With respect to questions such as "What do I make this number?" and "What do we do with numbers that are known to us?" the learners do not appear to have a clue as to what the teacher really wants. Instead of asking "What do I make this number?", the teacher should aim at eliciting responses from the learners by rephrasing the question as "What value can *x* take on?" or "What value can we give or assign *x* to make the mathematical sentence true?" or "If we remove the *x,* what number can we write down in its place?", for instance.

Another important aspect that needs to be highlighted is the use of mathematics language without ascertaining whether learners understand the meaning of such expressions or terminology, such as "inverse" or even 'equation". With respect to formative assessment the learners' responses indicate that they did not understand them. There is a definite problem with translating the words of a problem into a meaningful number sentence. Unfortunately I do not know what transpired during the lesson that followed on this one, especially how he dealt with problems encountered by the learners.

6.5.7 Teachers' questioning techniques

What I found both interesting and alarming was teachers' ineffective way of dealing with questioning (as can be observed from 6.3.7). This was not only evident during classroom visits, they also admit the fact that they did not actually pay attention of the true value of questioning as pedagogic tool to facilitate conceptualisation (Harrop & Swinson, 2003) in particular and learning in general. There was no clear evidence of teachers' realisation of the crucial effect of classroom discourse, especially that of patterns of questioning (Hickman, 2002:1) on the mathematics content to be learned and the learning process.

At the start of the project I was looking for instances where or when teachers posed "questions that present[ed] interesting challenges and invite[d] friendly exchanges of views" (Brophy, 1997:378). I do not recall any instances where learners directly responded to peers' questions or comments. In all instances verbal interactions were teacher initiated. This created the impression that learners had to get permission to speak and had to wait to get their turn to speak, whilst teachers could speak at any time. It was obvious that not enough response time was allowed for learners to both understand and interpret questions posed to them (Hickman, 2002:4). Learners thus occupied a subordinate position in classroom discourse. Teachers generally wanted the learners to respond immediately to a question, instead of allowing them sufficient time in which to grapple with it. Another limitation was teachers' limited ability to rephrase questions when learners were stuck.

One crucial aspect that I was concentrating on was that of questioning (Dillon, 1988; Black & Harrison, 2001) at the beginning, during and towards the end of a lesson (Morgan, 1997). This refers to the nature of questioning and how questioning skills are applied to direct the lesson or to enhance learners' thoughts and facilitate learning. Through observation and face-to-face discussions it was clear that teachers generally did not pay much attention to the technical aspects of questioning nor did they recognise their value in eliciting responses that enhance conceptualisation.

6.5.8 Listening

How did teachers listen at this stage? At this phase of the study Attie, Catherine and Pedro's lessons were structured in such a way that learners could not freely take part in discussions. Learner responses were normally quite short, very often only 'yes' or 'no', in response to the type of questions posed by teachers. As such teacher did not have much to listen to. Feedback was mostly in the form of written exercises assessed by using a red pen, without elaborate comments from the teachers. It was evident that teachers did not have much to listen to, unless they were listening to themselves consciously. Communication was mostly one-directional – from the teacher to the learner (Carpenter &

Fennema, 1992; Seldin, 2000). Learners initially seemed to be hesitant and reluctant to say too much for fear of saying something wrong which might elicit negative comments from the teacher or being afraid of being mocked by peers (Cart, 2002; long, 1996; Bresset, Cheever, Townson & Turner, 2001)..

In terms of Davis (1997:359) it was clear to me that these teachers were to a large extent operating on the evaluative level of listening – at least this was my observation during the course of 2002 and 2003. They were listening for specific information – in the very narrow sense they were mostly listening for a particular answer. The method or problem-solving strategy was evidently negated as something being of lesser importance. The learners' responses were thus judged against the template of the teachers' own certainties (Breen, 2004:3). Not only were the teachers' judgements centred on right and wrong, but valid alternative methods or views were seldom or never considered.

It was my intention that after three years of intervention teachers would at least be operating on Davis's (1997) interpretive listening level, that is at least with the skill of assessing the subjective sense learners made (Maurer, 1994; Yates, 2002), by listening constructively and effectively interpreting where the learners were at a particular point in time, and how they felt with respect to the topic under discussion. Consequently, the classroom organisation and culture had to be changed to foster greater learner participation and ensure greater verbal interaction. How else would the teacher be able to formatively assess progress made, or assess the degree to which conceptualisation occurs, and furthermore what factors might interfere with the learning process. Assessment of learners' written responses (such as applying algorithms and calculations) was considered to be of overriding importance. From there the false notion that formative assessment implied assessing and recording all learners' work all of the time.

For these project teachers to be able to operate on the hermeneutic level of listening, I felt, would be easier to attain once their mathematics content knowledge was expanded. Better insight and understanding of their subject content and a broader knowledge of teaching methodologies would facilitate "negotiated and partipatory" interaction with learners and to come to a "joint understanding of each other's position" (Davis, 1997: 369). A better grip on content knowledge I believe would not only increasingly create a willingness among teachers "to interrogate the taken for granted and the prejudices that frame" their "perceptions and actions", but also the "attentiveness to the … contextual situations" of their "actions and interactions".

6.5.9 Cooperative learning and small group work

It was apparent that if communication inside the mathematics classroom were to be optimised, we definitely had to train teachers how to facilitate small group work Mason, 2000:344). Cooperative learning in small groups (Boston, 2002), one of the critical outcomes in the Senior Phase curriculum, was mostly non-existent. In some instances learners were sitting in small groups, but teachers were not actually trained or skilled to facilitate these groups effectively. To make matters worse, they had no idea as to why small group work had to be introduced or how it tied in with the constructivist theory underlying outcomes-based education (Spady, 1994).

Participant teachers, except for Bryan were not yet exposed small group work was concerned, and expressed reservations as to their effectiveness. They mentioned reasons such as the following as to why they thought it would not work: learners would copy each others work; the noise levels would be too high; they would discuss other things; etc. Most of the reasons were based on ignorance and to a large extent was based (as far as I could ascertain) on resistance to change.

As far as I could ascertain this criticism was based on a mixture of limited knowledge of cooperative learning, and a certain amount of fear that they would fail at successfully applying facilitation strategies. Another important factor that seemed to hamper the smooth transition to this mode of teaching was based on the perception that they would not be able to control the noise levels that would result from learner discussions. This they fear would reflect negatively on their perceived ability to control whatever was occurring inside their classrooms. The basic use of group work to enhance communication in the mathematics class by means of peer discussions (Alexander, 2002; Carr, Jonassen, Litzinger & Man, 1998) or explanations thus needed to be instilled and cultivated. It was crucial to get teachers to realise that through conversation with peers, all learners would ultimately benefit (Atherton, 2003; Mason, 2000), by thinking about mathematics as well as talking about it. The social aspect of learning mathematics thus needed to be emphasised (Atherton, 2003; Sfard, 1998).

6.5.10 Facilitation as opposed to teaching or lecturing

Some of the teachers hardly moved beyond the first row of desks. Interaction on a closer and intimate level between teacher and learners and between learner and learner was very limited. Facilitation would create more opportunities for formative assessment that was now restricted or absent since the teachers saw themselves mostly as transmitters of knowledge (Mason, 2000). This left very little room for discussion with learners (Breen, 2004:2). The teacher was in control and decided when to ask questions and who would be allowed to answer such questions.

Teachers still overwhelmingly spoke in terms of what they as teachers should do, or of the work in the curriculum they needed to cover with the learners – a teacher-centred approach. Instead of emphasising what the learners have done, what the learners can do, or what they still needed to learn or do, teachers instead focused on themselves –that is what they have done or covered. This implies that teaching was basically teacher-centred as opposed to a learner centred approach. The focus was thus much more on input rather than output (Nyland, 1991). The reason for this might be that teachers were under pressure to complete as much of the curriculum as possible, especially in the case of the grades 9s, who were due to write an external departmental examination at the end of the year.

The main flaw in the teacher-centred approach (Alexander, 2002) was that learners were viewed as homogeneous, and their diversity with respect to background knowledge, cognitive developmental levels, home environment and other factors were to a large extent ignored. Learner differentiation (with respect to cognitive ability, pedagogical gaps, progress, etc) did not seem to be priority. Since very little cooperative learning was taking place, it was more difficult to detect learners with learning problems, especially where classes were bigger than 30 learners in size. Also in this case teachers were under pressure with respect to the number of assessment pieces to be completed, learner portfolios, additional administration duties, dealing with large classes, etc.

6.5.11 Strategies to put learners at ease to get them to pose questions

Getting learners to the stage where they would feel comfortable to pose questions Black & Wiliam, 1998b; Boston, 2002) or ultimately respond to any question inside the mathematics classroom without hesitation or inhibition would not simply happen if the teacher one day says that learners are free to ask or answer questions whenever they please (Riddell, 1993;1). Conditions have to be created to make this possible. I believe the following aspects that I perceived to be lacking in most classrooms, needed to be considered and implemented to help create such favourable conditions.

Teachers should perceive mathematics as much more than merely a pen and paper subject. Elements and moments of enjoyment should be built into learning, thereby developing learner confidence. Learning does not have to be a formal and rigid exercise. Learning moments should be structured in such a way that all or most learners experience moments of success. Opportunities for learners need to be created and fostered to express their opinions, either to their peers or their teacher, (Brophy & Good, 1997:372-374). This could be done through cooperative learning, using familiar and relevant contexts to facilitate and enhance understanding and conceptualisation. Variety needs to be built into the mathematical activities ensuring that learners concentrate for longer periods at a time. It is crucial for the teachers to emphasise that their mathematics classrooms are secure environments where mistakes can be made without fear of retribution or of being reprimanded (Lowry, 2003). Doing everything (especially questioning) in terms of 'right' and 'wrong' should be avoided since this causes anxiety and inhibits learner responses (Bodin, 1993). Questions need to be posed by teachers that allow learners to express their own opinions (Jacobs & Lopez, 1993). It has been proven by researchers (Black & Harrison, 2001; Black & Wiliam, 1998b; Brophy, 1997; Dillon, 1988; Morgan, 1997) that an increase in the question response time would accommodate the slower learners, thereby allowing them longer periods of time to think about their responses.

The teacher's personality and attitude displayed inside the classroom are crucial. Somehow learners have the ability to detect (from body language and verbal comments) when the teacher do not hold them in high regard. Some of the teachers express negative comments and label learners, for example "Those 4 guys sitting in that corner (pointing to a specific group of learners) won't make it. You better start doing something about your work." This is meant as negative motivation, but at the same time learners get a sense of the teacher's low expectations.

6.5.12 Teachers' perceptions of formative assessment

It needs to be stated at the outset that my findings related to teachers' attitudes and understanding of formative assessment are in line with those of the Quality and Curriculum Authority (Neesom, 2000) of the United Kingdom. Teachers' limited conception of formative assessment is understandable since they are in the process of change. The training they received during the 2002-2003 period to guide them in the use and applications of formative assessment are at this stage still very limited and elementary. The teachers still regard summative assessment to be of overriding importance.

Through observation, post-lesson reflection and interviews it is evident that formative assessment is viewed as a burden, something additional to their daily practice (Neesom, 2000). A major issue is the fact that teachers were under the impression that formative assessment entails continuous assessment that needs to be recorded meticulously everyday. This according to them would mean endless loads of administrative and paper work. From regular conversation with teachers it seems that their morale at this time is at an all time low. It is thus obvious that at this stage they view formative assessment as something separate and not as an integral part of their teaching practice and essential to monitor learning and learners' progress.

It was apparent that teachers needed guidance and develop skills on a variety of aspects related to their learners' learning, on how to model quality and the effectiveness of the feedback given (Izard, 1993). Teachers as a rule never shared with learners what the learning outcomes were or what they hoped learners would achieve, and providing ample reasons as to why they were actually expected to know it. There is still a rush to complete a syllabus and as such stimulating learners to make contributions and expanding on such contributions were limited. Teachers were still very much in control and tasks that allowed learners to take initiative and work on their own and at their own pace was rarely evident.

Cooperative learning through small group work was not used, consequently there was no visible collaboration and discussion among learners. The value of peer learning and peer assessment appeared not to have been realised (Bright & Joyner, 1999; Wiliam, 2000) so it was not encouraged. Teachers' knowledge of the senior phase was to a large extent superficial, consequently they encountered difficulties finding or linking on to suitable criteria from the assessment standards to develop appropriate assessment instruments such as rubrics and checklists to appropriately assess learners' progress (Wiliam, 2000).

6.5.13 Teachers' content knowledge

Generally the teachers' mathematical knowledge was experienced as being limited. This means that during classroom observations I detected that certain information was shared, problems solved, or data represented graphically, that revealed limited knowledge on the part of the teacher. This directly impacts on the quality of classroom conversation. For classroom conversation to be meaningful and constructive, implies that the teachers have to possess a certain amount of content knowledge which would allow them to converse fluently and with authority. In reality, being fluent and skilful in the use of mathematical language, implies or presupposes a sound knowledge of mathematics and its applications.

One example that highlights this issue was teachers' inability, for example, to distinguish between discrete and continuous functions, or the example that appears on the introductory page in chapter one. Very often discrete functions were simply or wrongly indicated or represented by means of a continuous line or curve, instead of just consecutive points. It was evident that teachers had not actually come across this distinction before. In other cases teachers simply used and transmitted algorithms, for example with respect to calculating percentages without understanding the underlying principles (for example with respect to ratio or equivalence) involved. Consequently, we had to build in opportunities to expose teachers to content knowledge and problem solving strategies to boost discussions among teachers and learners.

6.5.14 Teachers' ability to reflect

Teachers' ability or inability to think about and reflect on their own teaching practice would allow me to gauge their stance and growth. From conversation with teachers and classroom observation, and also from their written comments it is clear that their ability with respect to self-analysis, self-reflection and self critique needed to be developed and nurtured (MacIsaac, 1996; Winter, 1989). I experienced their abilities in this regard to be very limited. I experienced Pedro as a teacher who was able at this stage to reflect much more freely about his experiences. Catherine often shared her frustrations and was very aware of how particular learners perform in her class. Attie and Bryan on the other hand needed more direct questioning to prompt them to share their experiences.

Ignoring this sensitive and delicate issue would prevent teachers from ascertaining their own limitations, their own growth, their ability to change, as well as ability to cope with such inevitable change. Fortnightly, focus group sessions would serve as effective catalyst to bring about essential growth and awareness in how teachers started to view themselves, and reflect on their teaching practice.

6.5.15 Teachers' perceptions of feedback

At the outset it was important to observe how teachers dealt with feedback, as well as what their perceptions were regarding feedback as concept, as it relates to didactics in general and to formative assessment in particular (Gunderman & Williamson, 2002).

An important factor in improving communication and interaction in the mathematics classroom is through the cycle of feedback (Bresset et al, 2001, Derby, 2003). This means mathematics teachers continually have to assess the quality and nature of their teaching, the extent to which the learners learn, and how their educational relationship with their learners facilitate learning (Brophy, 1997; Kirmse, 2001). The following extract from an interview I had with one of the teachers reveals some of the perceptions with respect to feedback. This interview basically contains all the views expressed by the other teachers during the interviews I had with them:

> *Stanley: I want to ask you a few questions, but please take note that in this case there are not really right or wrong answers. I just want your opinion … so do not be scared of saying what you feel, even if you might consider your answer not to be such a good 'answer'.*
>
> *Teacher: Yes … OK.*

S: Uhm … it basically deals with the concept "feedback". If I mention the word "feedback" what comes to mind? What does it mean to you? Feedback … Terugvoer?

T: For me it is uh … it is the answer given by a child in a short period of time or within the response time allowed by the teacher, …uh, but it can be verbal or written. It depends. If it is written you allow the child to work on it. Verbally means you expect the child to give feedback by talking to you.

S: OK … uhm… the uhm … is that all you want to say? Are there perhaps other aspects related to the concept that you want to mention? You basically view feedback as an answer?

T: Uhm … sometimes … it depends on the type of question or what you expext the child to give … for some types of feedback you have to allow much more time than in other cases.

S: Time for … time for the learner to answer?

T: To answer.

S: OK

T: Definitely. Time for the child to answer - yes. Uh… what else is there?

S: Think about it. You may mention other aspects that cross your mind.

T: Uhm

S: Uhm … what do you think is the role of feedback … in your teaching … when you teach?

T: It is very important … very important … in the sense that if there is no feedback forthcoming from the child exactly how will the teacher know what the child wanted to answer? There should be … I believe … how else would you know that the kids have it in their brains … the answers, but now … some kids do more easily, verbally … others do it more easily by writing it down and thus I believe you should try different ways to get children to give feedback. That which the child finds easier and that … uh … that which does not come so easy … and feedback needs to be developed. I believe many children are used to giving written feedback, but only certain children feel comfortable with giving verbal feedback.

S: OK. What do you think … about the role of questioning is with respect to feedback? How can you prompt or compel the learner … I do not want to use the word 'force' … to respond?

T: The type of question one poses … isn't that what it's about? Sometimes direct questions allow learners to come up with an answer immediately … with that kind of feedback you will not have problems, but some types of *questions require the child to think a lot before an answer can be given. I am not sure now … may be I'm not on the level that you ...*

S: *No no no … uhm … What type of questions? I do not know how you deal with questions … I would be able to get an idea once I observed some of your lessons.*

T: *Uhm*

S: *But your feeling about the type of questions that one can use … which questions do you consider to be effective … which questions are not? Do you think feedback … you have said previously … feedback is the answer that you get from the learner?*

T: *Uhm*

S: *So it occurs in a particular direction. You are given feedback from the learner?*

T: *Uhm*

S: *What about … from the other side?*

T: *From the side of the educator?*

S: *Yes … what do you think of the feedback that the learner receives from the educator?*

T: *I think it is important for the child to receive feedback from the educator since the child must get the educator's idea of the answer … not that the teacher has to think for the child because each person must get to an answer in his own way. Therefore it is important that we as educators also provide answers to the child … not an answer … an idea of how we arrived at the answer.*

S: *So so … I get the impression that the process of feedback overwhelmingly concerns question and aswer, question and answer?*

T: *Not totally … is it now verbally or written?*

S: *Yes, yes, yes?*

T: *At this stage yes … may be we do … engage with feedback in a different way to, but can't think now of different scenarios where I receive feedback.*

S: *Uhm … how long ago did you qualify as educator?*

T: *12 years ago* ***(this was said in 2002)***

S: *and of course there was also in-service training, and so forth.*

T: *in this time … yes … of teaching.*

S: *So do you think that the Department and NGO's such as us (IMSTUS) … during your training … prior to … as student or as in-service teacher, that emphasis was ever put on the role of feedback?*

T: *Uhm … never. I do not think so … they touched on questioning may be, but not specifically feedback … I don't think so … indirectly may be, but no emphasis was put on feedback.*

S: *OK. At a later stage I will revisit this issue at a workshop ... Uhm … I have another little question … it is actually a 'yes' or 'no' question, but … then I want you to give me a reason for your yes or no answer. Do you think there is a … uhm … a type of relationship between feedback and communication in the broader sense of the word?*

T: *Definitely. Because when a person communicates than you are busy … to give someone something in return. You do not actually communicate with yourself … you communicate with somebody else in most cases. So everywhere you communicate with somebody, you are also busy to tell that person something, and that which you tell a person, that person is going to evaluate … so … now that person can tell you something on the grounds of what you told him …I don't know whether …*

S: *Do you as speaker … as communicator … are you interested in what that person does with your message? Whether he understands?*

T: *the message that you give him?*

S: *Yes, yes ...*

T: *Yes sometimes it is important that that person … if you tell that person something … gives you something back in a manner that informs you that he …*

S: *Understands?*

T: *Uh … what you talked about … I believe so.*

S: *Yes, yes … but sometimes you use a word in the classroom that the learners supposedly know … if for instance mention the word string … one may think of the string of a racket … another may think of the string used to tie up a parcel, … a third may think of the string of a violin, and another of the string used for a top. … how would you ascertain … by means of feedback you should rephrase your question in such a way that allows you to ascertain whether all of them know of which string you are actually talking.*

T: *Yes I have experienced this.*

Not only this teacher but also the others thought of feedback in a narrow and limited sense, not realising the full extent of the power of this communication tool. Feedback is considered in this case to be merely an answer, either “right” or “wrong’. It was only later during the interview that the teacher acknowledges that feedback also deals with “an idea of how we arrive at the answer”. Another important aspect is that feedback - it is viewed by teachers mostly as something that comes from the learner – the teacher poses the question and the learner answers. It is thus viewed as a one-way process. It was only when I touched on feedback from the learners’ side that he mentions the importance thereof.

Feedback was furthermore hampered by the quality of questioning and the fact that the responses were seen in terms of right or wrong answers and not necessarily as sharing opinions or viewpoints. Teachers also admitted that they were never actually trained or their attention was never focused on the relevance of feedback with respect to learning and teaching. It was encouraging that the teachers appreciate the importance receiving feedback to inform them as to their progress.

Another crucial fact that came to the fore is teachers’ awareness of the fact that children are different (they differ from one another in respect of level of development, cognitively, socially and emotionally). This implies that different strategies would have to be employed to elicit learner responses. In this regard I could not detect appreciation for learner diversity in mathematics classes. I could not detect an appreciation in teachers for learner diversity in mathematics classrooms. The school setup and many associated pressures prevented teachers from really addressing problems in this regard. Teachers are generally not trained to detect or identify social or cognitive or emotional disorders in learners.

Furthermore, I perceived that teachers realised that it takes time for learners to get to the stage where they are be able to, and feel comfortable to give elaborate responses (feedback). Not only were the learners’ mathematical language skills limited, they also had to overcome inhibitions to share their views. It is for this reason that small group work was crucial. Individual learners would be afforded the opportunity to speak about mathematics, and interact more intimately with peers on an equal footing.

It was also clear that teachers’ knowledge about questioning as pedagogic tools was quite superficial.

These findings – also observed during lesson observation - reflected certain definite short-comings with respect to feedback, listening and questioning. In the first cycle a deliberate effort is made to intervene by means of running workshops, information sessions, and lesson observation to monitor implementation of ideas and demonstrated skills. Particular interventions are described under 6.5.

6.6 INTERVENTION: ADDRESSING THE ISSUES TO OPTIMALISE FEEDBACK

This part of the chapter is meant to be an exposé of the different inputs made throughout the three cycles. In order to address those problems mentioned previously, I realised that I would need to guide teachers continually to clear up confusion, anxiety and clarify whatever misconceptions they might attach to the effective implementation of formative assessment.

As stated before the aim was on improving the quality of formative assessment through developing and improving feedback (and consequently communication in general). From the outset it was evident that envisaged outcomes in this regard would not be achieved, unless conditions and structures were changed to focus on holistic development of the teachers concerned.

6.6.1 Cycle I (2003)

Classroom visits were initially (through the whole of 2002) geared towards formal lesson observation. Critique was kept to a minimum. The situation was very sensitive and I did to want to hurt the teachers' feelings, or antagonize them by unduly harsh comments or criticism. However, I also realized that an honest relationship (Kerwin, 2003; Fay, 1996) would be the best policy if I wanted to facilitate a difference or make a significant contribution towards the improvement of the participants' mathematics teaching practices. Although all teachers did not object to having me in their classes I could sense in some cases that the situation was tense and a bit forced since they did not have much of a choice but to cooperate. They were scared of being seen as unwilling to cooperate or were afraid of being exposed as a 'bad' teacher.

Towards the second semester of 2002 my relationship with the 4 teachers in the project had grown significantly. This implies that a trust relationship was established and teachers had become much more open to critique. In fact when I suggested to them that a more structured and formal assessment instrument would assist me to assess their lessons more meaningfully, all of them, except two teachers at one of the high schools who objected to this form of assessment, agreed. I needed to build in a higher degree of structure to help facilitate feedback to teachers. It would thus serve as a platform from where to launch or share my observational findings and offer suggestions for improvement. During this cycle it was possible to share ideas that could be deemed sensitive, mostly to individual teachers.

The lesson observation form (which was adapted from a form used at the Hampton University in Virginia in the United States of America, a copy of which appears in Chapter 7) reflected the following differential scale according to which teachers were rated: 5 (excellent), outstanding (4), good (3), fair (2), requires attention (1), NA (not applicable –

where a specific criterion was not considered or deemed important). Criteria according to which teachers were assessed included the following: outcomes for this lesson were made clear to learners; lesson was well planned and organised; presentation style was appropriate and effective; relevant examples, metaphors, analogies used to establish connections with learners' previous experience and learning; lesson time was well managed; critical thinking and analysis were modelled and encouraged; teaching techniques required most of the learners to be actively involved; respect for diverse opinions was communicated; a warm, accepting, open classroom atmosphere was evident; teacher interest in information was communicated; teacher interest in learners' learning was communicated; teacher mastery of learning area content was evident and thorough; appropriate and effective use was made of audio-visuals, computer or other technology to support presentation/lesson outcome; teacher easily related to learners; teacher responded appropriately to learner questions and comments; teacher integrated aspects from other areas within & outside of mathematics; teacher displayed sensitivity to learners' feelings; teacher demonstrated enthusiasm for teaching and learning; teacher discovered learner misconceptions and misunderstanding; learners attended to what was happening during the lesson; teacher moved around in class with ease, interacting with learners.

In retrospect I think that with respect to rating teachers' methodological skills I might have been too lenient. Some of the teachers commented in the following way when asked what they thought of being exposed to being assessed in this way:

Teacher 1: "During his class visits Stanley also expressed criticism. His critique was never negative, but rather constructive by nature. He assisted, and gave guidance where ever he could. His demonstration lesson on probability was interesting and the learners learned a lot from this. The workshops presented were meaningful."

Teacher 2: "Stanley's visits to my classroom were in no way interfering with my lessons. I could continue with my teaching in the usual way and could depend on him for assistance – information and guidance. Stanley explained the concept 'symmetry' to the learners. All, including myself learned stacks from the lesson he facilitated. He always showed understanding for the fact that I sometimes felt despondent because of the lack of cooperation from learners, and difficulties coping with all the expectations and demands that we as teachers are faced with."

Of the approximately 18 mathematics teachers in the Senior Phase, Brian, Pedro, Kaylene, Catherine, Ingrid, Godfrey and Attie were identified as potential participants in a teacher in-service development project called the Brave Maths Mouse. Prior to 2003, involvement with schools in the Winelands West Coast EMDC was done quite differently. Twelve high schools and primary schools were serviced, by fortnightly classroom visits to each teacher participant. Much more time was spent on the road travelling between schools. The time spent with a particular teacher was not always sufficient to make a real impact. Limited face-to-face contact made it difficult to hold meaningful in-depth discussions with all teachers.

The Intervention strategies used included the following: a summer school (a workshop that was run over four days from 08h00 to 16h00) dealing with a wide range of learning area content and pedagogic issues; a shorter winter workshop over two days; fortnightly school visits involving lesson observation and post-lesson reflection and discussion, co-teaching lessons with teachers; more emphasis on teacher development than on how learners learn; activities and skills modelled at workshop not actually experimented with or implemented in teachers' classrooms, facilitators spent many hours driving between schools; initially the facilitator-teacher relationship was more formal; a deliberate effort to work on and develop a closer educational relationship based on mutual trust and understanding; general complaint that learners had difficulty reading, especially with insight which hampered effective learning and retarded progress; and generally salient features that confronted project teachers and facilitators.

6.6.1.1 Workshops

During the course of 2003 a number of workshops were run to familiarise teachers with the different aspects related to OBE-related methodologies in an effort to model these to teachers. The main aim of which was to improve conditions and change classroom management thereby creating an atmosphere more conducive to small group discussions and verbal interactions between teacher and learners. It was thus aimed at enhancing mathematical conversation by making it more realistic, more relevant and more conversational. The following list contains some of the most important workshops, together with some of the aspects covered) that we ran:

- Workshop on formative assessment: What it is, what it means; strategies to assess formatively, exposing to different assessment tools and instruments; taking into consideration of assessment criteria and learning outcomes when assessing; when to assess for recording purposes; the role of peer- assessment and self-assessment as formative assessment strategies.
- Workshop on questioning: Types of questions, the importance of questioning in enhancing learning, international research findings on the role of questioning.

- Workshop on the "Newspaper inside the mathematics classroom": the focus was on the different mathematics to be found in the newspaper; using the newspaper in the mathematics class to facilitate reading and mathematical discussion.
- A workshop on global graphs: illustrating the use of contexts and emphasising the interrelationship between graph, table (patterns) and formulae; providing learners the opportunity to translate the graphs into stories explaining the shapes of different graphs.
- A workshop on cooperative learning and small group facilitation
- A two day workshop on getting learners to read, presented by an independent consultant
- A two-hour workshop on integration within mathematics (and across learning areas) was held during the summer school of January 2003.

These workshops were followed up by two-weekly, full day classroom visits to observe teachers' efforts to implement skills learned at the above workshops, and to assist them to effect successful application of knowledge.

6.6.1.2 Guidance through facilitation during classroom visits

Which initially started as an educational relationship (Perrone, 2003) eventually grew into a relationship characterised by support, sharing of ideas and needs, meeting frequently as friends at social-educational gatherings, sharing productive critique, which resulted in mutual learning (Denning, 1998) and growth. Apart from fortnightly focus group (Dreachlin, 1999; Kelly, 2001; Smith and Mander, 2002) sessions, the teachers also allow the facilitators into their classrooms to observe and critique their lessons.

Our roles varied from non-participant to participant observation which included co-teaching, modelling and co-facilitating lessons. Another important facet was to reflect on what transpired during lessons, informal discussion on issues of mutual interest that deal with learners' progress and achievement. Examples of such discussions are included in this chapter, as well as Chapter 1 and Chapter 7.

6.6.1.3 Changes to the classroom structure

In order to increase the amount of, and possibly also the quality of communication by creating more opportunities for discussion between teacher and learner, and learners with their peers, the classroom structure and classroom culture for that matter had to be changed. For this to be accomplished teachers needed to be assisted in facilitating cooperative learning, and in creating an atmosphere and culture conducive to discussion and constructivist learning.

Change in classroom for us did not only refer to the physical structure of the classroom – that is, the seating arrangement and the teacher's proximity to the learners, but also involved a change in teaching methodology (what the learners and teachers engage in) and a shift in assessing and monitoring learning. In this regard, Fullan maintains that schools "have to constantly process knowledge about what works and that teachers have to see themselves as scientists who continuously develop their intellectual and investigative effectiveness" (Sparks, 2003:4).He essentially refers here to a change in the cuture of teaching.

6.6.1.4 A greater degree of cooperative learning through small group work

It is interesting to note that teachers were given the instruction by the education authorities to make frequent use of small group work (Sfard, 1998; Atherton, 2003). They were, however, not sure as to the reason why, nor did they know how to go about it. Many teachers refused to let their learners sit in groups or let their learners work in small groups. Not only did they not know how to manage such a situation, but they were also scared of being reprimanded by the principal since many learners talking at the same time would increase noise levels.

The link between small group work and constructivism (Atherton, 2003; Carr et al., 1998; Matthews, 2000) as an underlying educational philosophy was not clear to teachers and had to be emphasised. Facilitating the learning process rather than transmission of facts had to become a central tenet. This was a radical shift for many teachers and for some it took quite a long time to adapt. Facilitating (Holden, 2002; costs and Kallick, 1993; Schuman, 2003) learning meant that the authoritative role changed to that of a facilitator-teacher who had to prepare differently, and who had to observe and monitor learners more closely. Instead of addressing the whole class once on a particular aspect of the work, the teacher would have to repeat this while intervening in the different small learner groups. Group rules would have to be devised and group roles assigned to the different learners within a particular group.

6.6.1.5 Creating an atmosphere conducive to conversation and interaction

A deliberate effort was made to create an atmosphere of reduced anxiety, to put learners at ease and to encourage them to take risks, to share what they think, to share their viewpoints, and to share their findings or solutions. During this process teachers were encouraged to instil the idea that not all issues can be judged in terms of right and wrong, that is by providing sound reasons, motivation or rationale for a particular stance, or opinion or problem-solving method. Endeavouring to know most if not all learners by name is important to create an atmosphere in which sharing of opinions can take place.

Important, however, is to get learners to pose questions – not only to the teacher only but especially to other learners as well. There thus should be a deliberate effort to encourage interaction among learners, instead of all individual learners addressing their comments to the teacher, or to one another through the teacher. “A teacher's excitement and curiosity can serve as powerful models for all students, whether silent or actively participating” (Corwin, Storeygard, Price, Smith, and Russell, 1995:4). This is especially possible through small group work. In this regard small group activities and tasks can be incorporated to build variation into the way learning occurs in the mathematics classroom.

A good strategy is for the teacher not to create the impression he knows everything but to demonstrate a certain degree of vulnerability. If the teacher admits that he is struggling to solve a particular problem, or that he has difficulty making sense of something, learners may feel less threatened if they make mistakes themselves. During the third cycle researchers and project participants – as described in Chapter 1 - really developed into a cohesive family of teachers, learners and facilitators, among whom teaching needs, frustrations, constructive critique and happy and intimate learning moments were, and still are shared. At the same time we cannot ignore the contributory role the West Coast Project, which preceded the Brave Maths Mouse Project, had played. During those two years teachers’ needs were thoroughly assessed, barriers were broken down, current Brave Maths Mouse teachers were identified, and sound educational relationships were to a large extent established.

It is important to remember this research forms part of a larger project of which the paramount focus is teacher development and empowerment. Although not always measurable it is a fact that participant teachers significantly changed and improved in a variety of ways. These would include attitudes towards their work, classroom organisation and management, teaching style, assessment skills, and communication. It is especially evident now that we are in a position to compare these teachers with what happens at the township schools in our new pilot project that started at the beginning of 2006. However, the members of the research team would be the first to admit that there is still room for improvement. The brief discussions under the heading “Activities” should give the reader a sense of the difficulties encountered and issues addressed during the course of an academic year. All the aspects addressed previously again received priority as we remained committed to developing teachers holistically by continuing to focus on teaching, learning and the learning material concurrently.

Throughout the project we remain very conscious of the intimate relationship between learning and teaching. Of the two, however, learning remains the most important, since even without a teacher learning is still possible, especially if the learning material allows for it. In this regard our modular system ensures that learners can each work at their own pace and more advanced activities are built in for the brighter learners to work on their own.

In the development and implementation of the modular system a high premium was placed on the role of peer- assessment and self-assessment. The modules allow ample opportunity for learners to reflect on what they had learnt, and to get a better understanding of their self-worth and abilities, and even more importantly, to remain active participants during the learning process. We considered it essential to first work through the activities with teachers to assist them in their approach and selection of the activities for optimal learning to take place. Using suitable material that lends itself to peer and self-assessment can serve to increase learners' confidence and to lessen their anxiety about aspects in which they experience difficulties.

A very important aspect of feedback and formative assessment is that of questioning. Consequently, we have given much consideration to the type, complexity, quantity and formulation of questions (in terms of Bloom's Revised Taxonomy) to facilitate or enhance optimal learning. Because of the nature of the modules teachers were allowed much more time to acquaint themselves with learners' progress. Although teacher conventionally initiates feedback, the learners can significantly contribute towards formative assessment by means of self-assessment. It is important that learners respond to questions (whether verbal or written) in order for the teacher to know what and how they think and reason, and how they interact with the mathematics content. In this regard the modular format and classroom structure, together with working in pairs and small groups (cooperative learning) definitely promoted and encouraged learner participation and response.

Observation and post-lesson reflection made it clear that project teachers' understanding of the Revised National Curriculum Statement (RNCS) was very limited or non-existent, because not much attention was paid to exactly what the assessment standards required them to do. Sharing of assessment standards were never or very seldom evident during observed lessons. Consequently, not being aware of what the assessment standards were, the learners did not have a clue as to the (intended) meaning or significance thereof. Thus, opportunity was rarely given to learners to think through and discuss the meaning with others. For these reasons all relevant assessment standards appeared on each of the front covers of the mathematics modules, compelling teachers to share their relevance and meaning with learners.

Another crucial aspect that required attention was the continual involvement in formative assessment with respect to peer- and self-assessment. Although peer and self-assessment frequently occurred in classrooms, it was not always evident whether teachers realised the potential it had in facilitating learning. These forms of assessment can help learners to reflect on their understanding and at the same time they serve as a vehicle to ensure their active participation in the assessment process.

In Cycle II most of the issues mentioned above were addressed. Change in this regard was essential to improve the qualitiy of learning for mathematics learners, as such we had to create "opportunities to reflect, learn, share the vision, and act in concert to implement lasting dynamic changes" (Inos and Quigley, 1995:1). They continue by saying that "Change processes that foster sustained professional development over a teacher's career and lead to student benefits and improved outcomes may be one of the most effective sources of revitalization and open to teachers". During Cycle II the modular mathematics material was be piloted with the grade 7s. This strategy closely ties in with Fullan's, notion (expressed during an interview with Dennis Sparks) that "we need professional learning communities in which teachers and leaders work together" with the emphasis on how and what learners learn, in such a way that the whole process is "infused with high quality curriculum materials and assessment information about … learning" (Sparks, 2003:1).

6.6.2 Cycle II (2004)

During this cycle a greater emphasis was placed on the social and mental aspects. This is in line with Fullan (1993) perception that educators' mental health and positive attitudes were crucial to ensure progress and success with respect to change. Arranging social functions once a term, formed an integral part of this cycle, additional to the usual forthnightly focus group sessions. These sessions were used to informally talk to teachers about a wide range of issues, such as more personal issues, work related issues such as responsibilities (educational, administrative), learner issues. Unknowingly, we compelled teachers to reflect more, discuss more, this seemed to have a therapeutic effect since during this cycle they have become much more positive, much more open and much more enthusiastic. This was based on Corwin, Storeygard, Price, Smith, and Russell's (1995:1) notion that "Mathematical knowledge develops through interactions and conversations between individuals and their community. It is an intensely social activity." This strategy greatly helped to break down any barriers that still existed and created the platform for a much more intimate working relationship between facilitator and teacher to more open and frank discussions. What follows gives a summary of most of the interventions for 2004:

Objectives 2004

The following are some of the most important objectives for this period. Facilitators endeavor to:

- establish and sharpen teaching skills in Outcomes Based Education principles;
- assist teachers in understanding their role in helping learners to develop their own constructs;
- assist teachers in actively performing their role in facilitating construct formation with respect to their learners
- assist learners to pro-actively participate and accept ownership of learning processes through effective facilitation;
- assist teachers in providing conditions that would allow learners to pro-actively participate and accept ownership of learning processes through effective facilitation;
- alert teachers and learners to those constructs that already exist;
- improve learners' conceptual understanding of Mathematics;
- encourage participative group work;
- find a balance between cooperative learning and working as an individual;
- expose and enhance problem solving strategies;
- improve a realistic approach in teaching and learning Mathematics (context-based); and
- develop critical thinking skills.
- expand teachers’ feedback, questioning and listening techniques;
- research and analyse learner performance by employing different teaching methods based on the use and application of activity-based content material; and
- create classroom conditions to promote verbal exchanges
- expand teachers’ feedback, questioning and listening techniques;
- research and analyse learner performance by employing different teaching methods based on the use and application of activity-based content material;
- develop appropriate assessment instruments and critique materials.

Nature of intervention sessions for 2004	• Focus group and brain-storming sessions involved reflecting on what was found and what transpired inside the mathematics classrooms. Mathematics modules were workshopped to ensure that teachers understood the content and were clear on what was expected of them. • Class visits by facilitators were geared towards monitoring the implementation of the project aims and objectives. These included how teachers used the modules, how they facilitated learning; and to observe learners' interaction with the project learning material. • Workshops and presentations. • Diagnostic tests. • Lesson reflection – what worked, and what went wrong. • Analysis and setting of an assessment instrument. • Focus group discussions. • Teachers share anecdotes and incidents. • Classroom observations and post lesson reflection. • Focus and discussion groups. • Classroom visits, lesson observation and lesson critique. • The use of handouts, including research articles. • Examining teacher facilitation strategies. • Observing communication patterns and teacher interaction with learners. • Reflection by teachers – writing down ideas based on experiences inside the classroom.

Actual outcomes for 2004

- Learners had taken ownership of the modules and enjoy Mathematics.
- Improved learner self-concepts and self-confidence were evident.
- Learners dealt with Mathematics in context and there was more time to discuss issues related to module content.
- Teachers spent much less time writing on the writing board, and learners spent less time copying from the writing board.
- Overall, there was more time for teacher-learner interaction and conversation. Also, learners talked more and teachers talked less.
- Improved reading (skills). Those learners with reading problems showed a keen interest in wanting to learn to read.
- There was willingness among weak learners to try and succeed.
- Teachers' enthusiasm was transferred to other areas in their schools, manifesting itself in computer lessons for colleagues; improved general school management, and participant teachers taking on leadership positions in Mathematics subject groups.
- Teachers' subject knowledge and assessment skills improved.
- Most teachers expressed interest in furthering their studies. Teachers showed increased levels of confidence, are more self-critical and self-reflecting.
- Improved listening, questioning, feedback and facilitation skills were evident from verbal exchanges with learners.
- The level of learning improved – learners showed greater enthusiasm; they tended to work ahead in their modules.
- Learners were more interested in Mathematics and increasingly enjoy the subject.
- Overall teachers were much more positive (evident in their body language and positive comments). They admitted that this approach to teaching had made them much more positive to teaching. They want to involve colleagues from other schools.

Assessment	• Ongoing assessment through various techniques were developed in conjunction with teachers, such as informal discussions; interviews and lesson observation; • Structured and verbal feedback from teachers during individual and group discussions and verbal feedback from learners were used to steer our intervention so as to address problems, address shortcomings. • Lesson observation • Structured interviews with teachers and with learners.

THE FOLLOWING IS A SUMMARY OF SOME OF THE MAIN TOPICS DISCUSSED DURING THESE SESSIONS

23 March 2004

Classroom visit: Willemsvallei PS

I also sat in at one of the grade 7 lessons on Percentages [as part of ratios (Module 3), page 16 – 10.50 grade 7.3].

A short introduction by Pedro is used to direct learners' thoughts towards the task at hand. Several learners had worked ahead. He does not actually praise them for doing so, but concentrates more on those learners that seem to be waiting for him to lead them instead of trying some of the problems on their own.

Teacher: This is the task … you better listen carefully … then I am going to give you a chance. First do a few sections … no, wait, let's start at the beginning. … [there is a long silence while the teacher is reading from a document on his table]. As you are sitting there, you have already been divided into groups … 24a and 24b are what I want you to work out … first solve a few problems. …. Read that shaded section first.

[The teacher asks one of the learners to read the introductory section on page 16]. They then read the outcomes on the front page. [I think this is one of the few times that I heard a teacher sharing the outcomes he wanted the learners to achieve in any particular lesson period]

Cowan is asked to read the problem 24 – Pedro notes that he said 90%. He comments on the fact that % means per cent – an international symbol recognised all over.

During this lesson Pedro, Bertus, and I facilitate different groups.

One aspect that is heartening is the fact that learners do not hesitate to ask questions, nor are they afraid to explain what they think is happening, or how *they understand a particular problem. It is evident that Pedro has made considerable progress in breaking down learner inhibitions.*

Lance's table looks like this. It is evident that he and the other members of the group did not have a clue. According to what Pedro said at the outset of the lesson, a lot of work on ratio's had been done prior to the lesson, but there seems to be still considerable confusion how to use ratio to determine the top values.

	90	80	70	60	50	45
	100	90	80	70	60	50

What is half of 90? No response from learners. One says 70. Someone else says 40. Eventually after prompting them to think again Y (girl) says 45. What is 80 out of 80 in terms of percentage? Some of the learners answered 80%

24 March 2004

An extract from a conversation with Pedro and Duncan (science teacher) – transcribed audio-recording

P: And the teacher is going to help me now! I always tell them [the learners] – do not let me get to your desk and for me to ask the question. I should not be the one who ask them what is going on here. They should ask me that question. For instance – Sir, I have done this what now? (Pedro asks this with passion and excitement). So they are aware of how I feel about this – so they need to tell me what problems they have – they have to share their needs. It is not difficult to accomplish this – you just have to do it regularly with the learners [prompt them to speak their mind].

S: So it is something that takes time.

P: I think so because during the beginning of the year they were not so keen to ask questions in class. They were a bit scared – that story of, "I want to ask a question, but I'm not so sure whether it would be the right question." So with time – as you create opportunities it becomes better. So it was not something that happened overnight – it takes time.

S: With reference to what you said during the lesson this morning: "You [referring to the learners] have done a lot of these examples [referring to the ratio tables on the writing board], but here was a lot of confusion this morning." They did not know what to do at all – (refer to the entry dated 23 March).

P: Yes, yes – not only them. It went just as bad with the other groups.

S: But is it the way the problem is stated / appears in the module? In the first column you have the ratio 90 is to 100, then the question mark with 45, then the empty blocks, with nothing in between.

P: I have talked to Bertus a long time ago. I mentioned the same thing to him, and he told me to record it. I think the learning program is too long.

S: The module?

P: That thing is hopelessly too long. And percentages used to be a learning programme on its own. Now it appears together with ratios.

S: Uhm.

P: I think it should be dealt with separately. That is my feeling. I think there should be a module on percentages only, because there a numerous stuff to do on percentages.

S: What is your view as far integration within a learning area is concerned? That you should not compartmentalise but to let the one aspect flow into the other?

P: [The first part of his answer I could not understand - he did not actually respond to my idea of learning area ingration, but he continues by saying the following] It is not worthwhile saying to learners that this is what a percentage is, work out this percentage, and the child has never heard of the concept. Somewhere there should be a lesson on percentage that ties in with the learner's prior knowledge. Then you can leave him to do calculations on his own.

S: So, what you are saying - that the concept percentage is not part of the child's frame of reference?

P: Exactly.

S: Now you have to try and make it part of the learner's knowledge?

P: That's right. It is almost like saving information on a computer – before there was nothing on it – so every time you need that information you retrieve it.

S: Some of the learners correctly said that 90 out of 100 was 90%.

P: Uhm

S: If you obtain 60 out of 80, what percentage is that of 80?

P: Oh, yes.

S: 80% some of them said.

D: The reason why they struggle with %, is because it is something new. So there is no prior knowledge, confusion and misconceptions with respect to percentage.

P: Exactly. That is why I say we have to have a module on percentage before we can pose questions such as these [referring to the ratio problems]. You should have to back or revisit the knowledge that is lacking.

25 March 2004

Focus group session: Last meeting of the 2004 Bertus visited with participant teachers. Transcribe audio-recording

15 April 2004

Focus group session: (Present: Marina, Stanley, Catherine, Attie, Bryan, Pedro)

Mooreesburg

Present: Marina (M), Stanley (S), Pedro (P), Attie (A), Catherine (C), Bryan (B)

An extract of the conversation:

P: I glanced at the syllabus … ant that which is done by the grade 7's, the grade 8s have also done – so they actually have a bit of an advantage.

M: Look, we do not want you guys to follow blindly what Bertus, Stanley and I suggest – we have to talk to one another all the time and ensure that the expectations of the WCED are met. The learners ultimately have to sit for the CTA. So we have to make sure that whatever we do is to the benefit of the learners - to make things better for them. Look it is not heaven yet – far from it – I want you to monitor whether you get the feeling that the material (modules) helps learners to learn and perform better – than when they had to copy stuff from the writing board. You see this was very time consuming.

(The teachers agreed with this statement.)

C: If they have to draw something – the time passes very quickly.

M: So we can honestly say that these modules work quite well. The learners do much more, since less time is wasted on trivial things.

B: Yes … definitely.

29 April 2004

Focus group session: (Present: Marina, Stanley, Catherine, Attie, Bryan, Pedro)

Main topic discussed – an approach to the teaching of ratio. Bertus set a test on ratio. This was discussed and workshopped.

13 May 2004

Focus group session: (Present: Marina, Stanley, Catherine, Attie, Bryan, Pedro, Kaylene)

Aspects related to the function concept were discussed. The use of realistic contexts to make it more meaningful was workshopped.

27 May 2004

Focus group session: (Present: Marina, Stanley, Catherine, Attie, Pedro)

Today Marina and I met with Catherine, Attie and Pedro at 6 Retief Street, Moorreesburg. We planned to do the analysis of the diagnostic task given to grade 8 and 9 learners earlier. The whole discussion turned out completely differently. Once they started talking about the positive results they experienced with the learner/study material there was no stopping them.

Catherine and Attie were visited by the curriculum advisor, Mr Thomas five days before. According to them he was quite impressed with the quality of their work, with the way learners interacted with the material, and generally with the quality of the materials used. He studied all facets of their work in great detail. He was also present at the forum meeting when Marina made a presentation about our involvement in the Brave Mouse Maths Project.

Attie told us that when he asked his class to use 10 minutes of the maths period to complete something to do with a different subject, his learners informed him that they did not think that it was a good idea since they would miss out on some of the maths they would do in that particular period. He reckoned that this was quite a positive sign and reflected the learners' increasing enthusiasm for maths.

The teachers also reflected in depth on the value of the two-weekly focus group discussions on their growth as maths teachers. From their discussions it was clear that:

- *Their skills and competencies increased;*
- *Their confidence grew tremendously;*
- *They did not feel threatened at all by negative constructive comments*
- *They were open to advice and critique*
- *They were more tolerant to learner questions and interjections*
- *They allowed more time for learner-teacher interaction.*
- *Learners increasingly develop freedom and become less inhibited to ask questions, express ideas, share findings, etc.*

The value of the grade 7 material was also discussed. The material facilitated learning, allowed more time for learners to interact with content, increased learner involvement, allowed the teacher to facilitate and observe learner involvement, and addressed learner questions.

The teachers told of numerous instances where other teachers expressed interest in the Bertus material. The project teachers felt that the two-weekly focus group sessions were very educational, enriching and worthwhile that it was *crucial to involve their colleagues at their particular schools as well. This was especially important to ensure continuity within the senior phase and to enhance communication.*

02 Junie 2004

School Visit: Laurie Hugo PS 10h00-13h00

I phoned Catherine early this morning – approximately 07h30 I phoned her to ask whether a classroom visit would be in order. Without hesitation she said that I would be welcome. I visited Attie's class during the 5th period, just after break. The 7c's were there and they worked on module 5. The problems on page 18 were dealt with. The learners sat in groups. Some discussed their findings, while others were still busy with calculations. The atmosphere was relaxed. The learners generally interacted very well with the material.

After about 15 minutes I went to sit at the table to get my digital camera ready to take a few snapsnots of the learners. Attie requested that I scutinise his June examination paper. From the paper it is evident that the questions and assessment style corresponded to the way he taught. Only now while I am writing my report do I remember that he wanted to give me a hard copy to check. After that he asked me to look through his teacher-portfolio, which looked very professional and which reflected his meticulous planning. This was the same portfolio that had already been scrutinised by the curriculum advisor. He also showed me the positive report from the curriculum advisor.

While Attie was facilitating, I had the opportunity to engage some of the learners in conversation. I observed that Carmen (one of the learners) answered 'yes' to all the self-assessment on page 19 of the module.

The following summarises the nature of the lesson:

A: What is the normal price?

Ls: R60.

A: How much would two such T-shirts cost?

Ls: R120.

A: Work out the discount of 25%. Complete the table. The discount is 25%. Now I'm done talking.

Based on a question posed by learners with reference to a particular question in the module, Attie said the following: People, you should be careful. If the article is under a R100, you pay the normal price. If you get 25% discount, how much of the original price do you have to pay.

Attie encourages learners and affirm learners' efforts: 'Alecia you are on the right track! Great! '

Attie says the following about percentage: Percentage is a fraction of which the denominator is 100. He then illustrates how a percentage can be calculated in the following way: 25/100 x 120 = 30%

At a later stage he observes what Alecia has done. Her table looks as follows:

Marked	10	20	80	100	120	140	160	180	200	300
paid	10	20	80	75	95	115	135			

It appears that the learner made precisely the mistakes Attie warned them against.

Focus group session at 14h30 at 6 Retief Street, Moorreesburg.

Improvement of teaching practices and self-critical attitudes.

10 Junie 2004

Moorreesburg focus group session

Present: Attie, Catherine, Kaylene, Pedro, Stanley

The main points of discussion focus on the value of diagnosis prior to starting with new work. We went about it as follows:

Teachers worked through a number of selected questions (from the activity sheets), for example 1; 3; 4; 9; 10; 19 to 26 or 28 to 33. (28 Minutes)

They then had to decide which group of learners they wanted to assess diagnostically. Grade 7, 8 or 9 (2 Minutes)

Workshop task to teachers:

Decide on a few questions (not more than 5 or 6) to include in your diagnostic assessment task. Use the RNCS document to find the assessment standards according to which you want to assess the learners. Check/verify that the questions you picked really address those particular standards. (30 Minutes)

Study Bloom's Taxonomy (Cognitive domain). Analyse each of the questions in your assessment task according to this and place each question on the appropriate level (30 Minutes)

General discussion (30 Minutes)

The teachers worked through the questions, determining the appropriate assessment standards and the cognitive elements contained by questions.

Learners were tending to think more – this was reflected by the type of questions that they posed and the verbal contributions that they made. 'Weaker' learners responded more than before, and seemed less scared. Catherine shares the information about a learner that under-performs, but who was able to correctly predict what would happen to the candle if it burns for a particular period of time.

The answer could be viewed as obvious but the fact that response was from this particular learner was quite significant. Pedro maintained that higher order questions initiate constructive conversation in the mathematics classroom. Learners gradually realised that problem-solving entails more than just a right or wrong answer. He also mentioned that he used a context in which the problem appears to encourage conversation. He mentioned the case that deals with tourists who spend on average R1000 a day. Where do they get the money? How is it possible that one person can spend so much money on one day? Learners who normally did not say much tend to part-take more readily. This was an effective way to get learners to work together better, and to encourage discussion and reasoning on issues of interest.

Teachers then discussed the pros and the cons of the material that we were currently piloting in their schools. Pedro expressed the opinion that some learners tended to be too 'group-oriented', meaning that they relied too much on the group. Learners should maintain their individuality by also working independently of the group. Some learners reacted like sponges who just want to absorb, without actually constructively contributing to the group. Pedro complained that it was difficult to control the learners' progress – while some, for example, were working on problem 6, others were already busy with number 11. Attie and Catherine suggested regular monitoring. Attie allowed slower learners to work on the writing board to ensure that they at least understood the few problems that they tackled. Catherine regularly evaluated particular problems done by learners at home. There was also the problem of learners who worked in pencil but then continually erased their work when the teacher wanted to check their work. This was problematic and implied that those learners were unsure or insecure.

The idea of using faster learners to assist their slower peers was discussed. Shortcomings in this regard are that the help given is not always effective since the faster learners only supply answers instead to discussing problem-solving strategies of how to arrive at the answer. Teachers do not always have the means to keep faster learners busy. The lack of writing space in the modules was also discussed. High printing costs prevented us from changing this.

5 July 2004

Focus group meeting

The role of reflection – keeping a diary.

Reflecting on the Ratio module.

Improvement of teaching practices and development of self-critical attitudes.

The power of positive feedback as part of assessment for learning.

19 July 2004

Focus group meeting

Formative Assessment: what it entails; the role of formative assessment; rubrics set according to assessment standards; short tests and activities

Improvement of teaching practices and development of self-critical attitudes.

The power of positive feedback as part of assessment for learning.

28 July 2004

Focus group meeting

1. *Reflection based on experiences with the previous module*

   What transpired?

   Problems experienced?

   Is anything vague or ambiguous?

   Learners' progress?

   How and what was assessed?

   Writing style/language difficulty?

   Volume of work contained in the module?

   To be used as part of the portfolio?

2. *Modules – planning and focus on the immediate future*

   The next module – critique.

3. *Bertus' next visit to South Africa*

4. *General: Research; diary, questionnaires*

29 July 2004

School visit: Laurie Hugo PS

A lesson on Interest and Percentages (Module) Grade 7c Thursday 29 July 2004; 11h00:

Attie (Teacher - A): What does inflation mean?

Learner (L): The value of money depreciates.

The following problem is given:

The percentage calculated on an amount is 0,292

A: Do we leave it like that or do we round it off to the nearst cent?

L: The 2 (referring to the thousandths) does not influence the 9 – it is smaller than '5'.

A: We can disregard the 2.

A: The price of the can of milk. Who has an answer. How did you go about it?

A: 8% is 8/100 times your answer.

A: How much is 8 x 6?

L: 48.

A: Does it mean that the article would be 8% more expensive?

No response from the learners. I think most of them were busy / engaged with the work and most probably did not hear the question.

The classroom appeared crowded. Learners sat permanently in groups. The teacher mostly facilitated. All learners appeared to be interacting with material and with one another – explaining, reading, trying to make sense of the content, or in conversation with the teacher. I detected a measure of spontaneity and interaction that were not that obvious two years ago. The class is a-buzz with activity. Learners were inquisitive, active, occupied and trying to make sense. Information sharing and explanation readily took place among peers.

One of the learners wrote 29c as the new price of a loaf of bread.

Attie stands at his desk and ask the whole class: Can one buy a loaf of bread for just 29c?

Choir of learners respond: No, Sir! Attie to the learner: At which shop did you go buy? You have to add 29c to the original amount to get the new price.

Attie to the whole class: You have to read the text and concentrate (with reference to the module they are busy with). It is impossible for a bread to be priced at 29c after inflation. It should be more expensive.

A: Inflation means that the article would be more expensive!

Attie has now moved to the group just behind the door. After having monitored what they have done, he directs the following question at a learner on the opposite side of the classroom: Little Farmer (her surname) what did you get for the new price of the can of condensed milk?

Anastasia Farmer answers: I got R8,27, Sir.

Attie: (to the group where stands): So you are right. He shows confidence in Anastasia's findings.

** Anastasia – the girl on the video-clip explaining how she arrived at the % increase in price of an article. Attie is satisfied that her explanation is sufficient.*

***14h30** : Focus group discussion*

Ingrid joined us today for the first time. She had come from Vredendal and accepted an appointment at Laurie Hugo PS. She was registered for an advanced teaching sertificate. She was teaching mathematics to one grade 8 class. She seemed to be open-minded and willing to improve herself.

P: Learners did not have textbooks last year. We covered fractions and rational numbers – we did the whole chapter as a whole. Do fractions only appear in little bits in the modules?

M: We also have to consider the relevance of stuff that we do? Why do we need to calculate one third plus two fifteenths, or 7/8 times 2/3? Where do we come across it in everyday life? What proof is there that manipulating fractions makes things easier for us? Learners must get the feel for ratio – do not compartmentalize; it is about developing number concept – insight into magnitude and value.

I: I have started at this school with only one grade 8 mathematics class. I think of the whole/global number concept. Mr Jones won R1000; R500 is for himself; R250 for his wife; R125 for each of his two children; learners are then asked to write these amounts as fractions of the whole amount, for example 250/1000; also to write values as ratios; with reference to 'making denominators the same'; learners must develop a sense of the ratio that exist between numbers and what it means.

P: He refers to a question paper from a neighbouring school that he finds disturbing. He specifically refers to the contexts used in one question that did not make sense: such as 2 ¾ pockets of potatoes. Contexts he says is much more than mere word sums. Context is not so much about words but about the relevance, appropriateness, and the sense that it makes. In the next *focus group session we will deal with setting question papers – question types and related technical aspects.*

Bertus will be coming on 23 August 2004. One Saterday should be used as a reflection Saturday. Marina suggested that part of the Saturday should be allocated to journal writing: "Think back over the past two years – and write in the diary".

S: I want to talk about aspects teachers should concentrate on, such as questioning, listening and feedback. Use 10 minutes for each reflection session daily or weekly.

Marina suggested 28 August 2004 as possible date. She emphasised that assessment should be a continual process.

Stanley emphasised the importance of the project file and teacher portfolio and the aspects that are deemed important.

Pedro reckoned that he was still struggling with questioning. He said that listening to learners took a lot of effort, especially in cases where he did not work through the problems prior to a lesson. In the case of calculating interest, he explained how carefully he had to listen to learners' explanations – in search of an answer because he as teacher was not sure of his own, and was trying to make sense. This was empowering to the learners – he depended on the learner to come up with an appropriate solution.

Marina requested that teachers should work through the new Further Education and Training (FET) syllabus in order to get an idea where learners were going and what the basic mathematics was that they had to know for the Senior Phase.

Ingrid maintained that the value and use of mathematics before 2005 were important, and that there were shifts in this regard

M: The feeling of empowerment – that knowing mathematics is to your benefit.

I: my own son is in grade 6 – the pattern in which things are done does not promote problem-solving.

M: do not be too doubtful about certain things because your mathematics knowledge is limited … be prepared to improve or better yourselves – have a vision for the future

12 August 2004

School Visits: Willemsvallei PS; Stawelklip PS

Lesson observation and post-lesson reflection

Pedro uses role play to make mathematics more meaningful and facilitate understanding.

19 August 2004

School Visit: Willemsvallei PS

Focus group meeting (Willemsvallei)

Function concept – difficulties learners experience with a range of concepts; the gap between social language and Mathematical language.

Confessions and anecdotes: teachers' stories.

Reflection: You and the teaching profession

- *Why did I decide to become a teacher?*
- *How do I see my future within the teaching profession?*
- *How did I feel two years ago?*
- *Compare it to how I feel today?*

Increase in work satisfaction

Lesson on equations

The next module

Module on symmetry

26 August 2004

School Visit: Laurie Hugo PS

Conversation with Marina about questioning as part of my studies.

It is not only the questions that are important, but also the way they are facilitated or managed. Asking higher order questions is only effective if the person who poses the question displays the ability to respond appropriately and timeously, and by compelling the learner through providing appropriate feedback. This facilitates learning, or is used to assess formatively whether learning has indeed taken place.

28 August 2004

Informal social gathering: All participants and their families (6 Retief Street Moorreesburg)

An extract from the group conversation:

We talked about the political past of our country and its effect on choosing a profession. Each teacher was asked why s/he chose teaching as a profession. They were very open, frank and honest. In broad terms teaching was not their first choice, but because of limited career choices and lack of career guidance they ended up in teaching. All of them expressed the view that they had come to learn to enjoy working with children, but they felt that the education system currently generated unbelievably high loads of frustration. Frustration was not only situated in the high demands coming from the WCED (by continually changing demands), but also in the ways schools were managed, and the fact that co-operation with other colleagues was often lacking.

This social gathering with educators and their families (spouses) formed closer ties, and strengthened the group relationship and collaborative spirit. It is clear from views expressed by teachers that although teaching was not their first choice they made peace with themselves and have adopted and are committed to teaching. This definitely indicates a change of heart since 2003, when most of them indicated that they were considering leaving teaching.

9 September 2004

Focus group meeting

- *Diagnostic tests with respect to patterns and functions set and discussed.*
- *Analysis and setting of an assessment instrument on the module on ratios. A final test was to be developed from teachers' contributions.*

The Brave Maths Mice were gathered to make history by writing down some ideas and reflecting on what happened in the past term.

Some positive comments from teachers:

The grade 7 boy who only brings his mathematics module to school, because he enjoys mathematics so much.

The boy who could never read, but who became so interested in mathematics, but who WANTS to learn to read now since he wants to do mathematics.

The module on lines of vision is very popular among learners.

We discuss problems encountered with number 4 and 6 related to the ratio tables.

The road ahead is discussed – what is to be done with respect to grades 8 and 9?

The mathematics curriculum advisor is pleased with the work that is produced by our project teachers. He mentions the need for grade 10 mathematics material.

Teachers need to budget as far as photo-copying is concerned.

The following aspects need special attention:

- *module 6 the last problem must get a picture of a skateboard*
- *Say which learning outcome is addressed there*
- *The elephant icons – do they work?*
- *5 forms of assessment*
- *2005: themes and holidays such as women's day celebration, etc.*
- *Casio pocket calculator training?*
- *Dutch students that will do their practical training in our project schools.*
- *Blocks / cubes and mathematics games*

Present: Bertus (Be), Bryan (Br), Catherine (C), Ingrid (I), Pedro (P), Stanley (S)

The teachers wrote down ideas on what the focus group sessions mean to them:

Br: The nature and format of the mathematics material of the mathematics modules seem to develop a need in learners to want to learn to read. Learner 1 has been tested psychologically and teachers were told to find ways to keep him busy in class. At this stage he can already read certain lines in his modules. The nature of the modules develops an urge in learners to want to read. Learner 2 also experiences learning problems ... and shows improvement. Learners can write and draw inside their modules. The learners want to write inside their modules. Working with both a notebook and textbook tend to be cumbersome.

C: the learners were especially enthusiastic about the module on lines of vision.

Problems are encountered with respect to ratio tables.

The grade 9s will most probably do better than the grade 7s. In cases where compound interest had to be calculated, learners generally struggled.

Calculations involving % by means of ratio tables – learners are under the impression that the open blocks need to be filled in - the open blocks create confusion. In cases where % has to be calculated with the calculator, learners just press the % key and enter the number or value – they thus do not really know what it entails and how the % is arrived at.

Marina replies that the ratio table is merely to asssit the learner to better understand ratios. The question in itself does not have value if the feedback is not appropriate.

The amount of accolades in the form of positive feedback received from learners and teachers really exceed our expectations by far.

Pedro: What it means to gather regularly?!!

For me as educator:

- *Improved planning of work / and forms of assessment*
- *More self-confidence*
- *More content knowledge gained*
- *Standardization of tests and examinations – 5 forms of assessment*
- *Feeling of belonging*
- *Subject advisor - transformation*

For the school:

- *Better/improved vision*
- *Can assist peer educators better / involve*
- *Liasing with other schools*
- *Future coordination of : 1. olimpiad, 2. presenting certain classes/lessons, 3. getting learner to advance to one point.*

Catherine: Value of regular discussions:

- *improved work relationships with colleagues*
- *greater understanding and insight into general problems*
- *support (give and receive)*
- *Sharing of ideas*
- *Enjoy the pleasant atmosphere – formation of support group and forging friendships.*
- *Learn from peers*
- *Becoming more open and less inhibited – speak / express opinions*
- *More self-confidence*
- *Has grown with respect to developing positive attitude*

Marina as facilitator and teacher -mentor:

- *It is motivating*
- *Learn to know and understand the school situation better*
- *Think and reflect on phenomena that we usally take for granted*
- *Make new friends*
- *Learn about occurances in my country that I was ignorant of (days of apartheid)*
- *Develop a better understanding of team work.*
- *Develop new ideas about what can be done differently.*
- *Feedback on the modules in use thus far – what can be changed or improved.*

Bryan: Value of workshops

- *Sharing of ideas.*
- *Addressing problems in mathematics education.*
- *Learners much more enthusiastic.*
- *Become more creative with respect to compiling activities*
- *I'm not alone in the struggle*
- *Learners - read*

Ingrid: The value of coming together regularly: So far I have only attended two sessions – this is the second (the social excluded). My experiences so far:

- *I experienced mathematics in a more humane way – started to see the 'human factor' within the subject.*
- *Experienced that people have different intelligence levels, but that this should not necessarily have a limiting factor.*
- *I was extremely glad to experience that people could so openly and frankly talk about the subject in terms of problems, future plans, visions, etc without pretenses – I liked it very much. I believe teachers have to break free. No risk, no pain. Nothing ventured, nothing gained.*

28 Oktober 2004

Focus group session

Present: Bryan, Catherine, Attie, Marina, Stanley

Apologies: Ingrid; Pedro and Kaylene (parent evening)

Discussion points:

1. *What incident (that occurred inside your classroom) do you want to share (on paper) – positive as well as negative:*

B: *The Robben Island materials learners find very interesting. Learners are proud of the fact that they are able to complete the graphs on their own. The mirror in module learners found to be stimulating. Calculating percentages to complete the pie graph was a bit problematic for them – some did not know what to do exactly..*

C: *A learner of 18 years old who is a more time (MT) very much enjoyed working on module 9. He managed to work completely on his own – surprisingly he completed most of it at home – virtually everything was correct (Remember he has a reading problem). Modules that get lost is currently a problem – a few learners do not care, lack of neatness, and the tendency not to do homework are some of the negatives.*

A: *Learners busy with exercise, doing numbers 1; 2; and 3. Learner (L) approaches me where I was sitting at the table.*

L: Sir, may I also do 8; 9 and 10?

A: But you first have to do 5, 6, and 7 before proceeding to number 8.

L: I have already done it. It was easy.

A: Would you asssit group A (working slower) with numbers 5; 6 and 7

This learner has now progressed far with module 10 because she is enthusiastic and also likes to work at home. She prefers doing mathematics rather than watching television. We need to get contributions from Catherine and Pedro.

2. *CTA Common Task of Assessment) – reflection to be held at Cape Peninsula University of Technology (Mowbray Campus)*

   Bryan would possibly accompany Stanley to this event.

3. *Madeleine's short assessment on module 10. All Teachers have already started on this module, but since they are still in the beginning stages, the*

diagnostic test can still be administered. It is distributed at the meeting and learners will write it 1 November 2004.

4. *Questionnaire for learners: Teachers read through the questionnaire and comment on it. They are of the opinion that it should be an interesting exercise. We also talk about the procedures to follow when administering the questionnaire. Teachers should not lead learners, or influence them with respect to making choices. Teachers would be expected to facilitate the process to ensure that reading and interpretation problems are kept to a minimum.*
5. *Modus operandi, work schedule and work program for 2005. We will concentrate on these issues on our workshop scheduled for 9 and 10 December 2004.*
6. *Progress with the 2004 modules. It seems that the grade 7's might at least get to module 12.*
7. *Further dates and gatherings for the rest of 2004.*
8. *Keeping-learners-in-school activities for November 2004. This aspect will be revisited on 4 November 2004.*

4 November 2004

School visit and Focus group session: (Present: Marina, Stanley, Catherine, Attie, Bryan, Madeleine)

Marina and I visited Laurie Hugo and Willemsvallei - the principals were quite willing to pay R10 per learner for the modules per year. This reflected a healthy attitude. We hoped to build this expense into the school budgets for next year, and to look for local sponsorships.

Attie set his first test on the COMPUTER and it looks good.

We looked around for suitable accommodation for the Dutch students who would be doing their teaching practical at the beginning of 2005.

25 November 2004

Present: Marina, Stanley, Catherine, Attie, Pedro; Kaylene

Venue: 6 Retief Street Moorreesburg

The workshop programme is discussed.

9 and 10 December 2004

(Whole day workshop + end of year function) – Participants were joined later the afternoon by their families (schools have already closed for the summer holidays)

Reflection and discussion of accomplishments and struggles occur in Chapter 7 under 7.3. The most important findings are shared as well as critical issues that need to be developed or addressed further. Whilst cycle II still mainly focuses on the re-organising and restructuring the classroom to facilitate interaction, and implementation of learner materials, cycle III is further geared towards the holistic growth of the teacher as facilitator of knowledge by developing questioning, listening and verbal interaction with learners.

6.6.3 Cycle III (2005)

The activities undertaken in 2005 were aimed at improving the teachers holistically and ultimately enhance learning further. This would imply addressing issues such as planning, verbal questioning skills, responding to learners' needs and questions by providing appropriate feedback. This implies improving formative assessment strategies by responding appropriately and timeously to inform their teaching methodologies.

Another important aspect was the extension of the piloting of study material to grade 8 learners in an effort to develop a more intimate relationship between learner and learning material and to increasingly allow more time for the teacher to monitor and facilitate learning. Through the course of the cycle new grade 8 modules were discussed with the teachers. We reflected on how learners experienced those already used. At the same time the input and suggestions from grade 7 were used to make appropriate changes to the modules used during 2004.

The following sums up all the activities in respect of Grade 7 & 8 learners in Mathematics and their teachers undertaken in circuit 6 during this period of 2005. Some specific learning incidents and intervention moments are discussed in more detail to share and highlight problems encountered, and progress observed.

Actual outcomes	• Teachers are more self-critical and self-reflecting. • Improved listening, questioning, feedback and facilitation skills. • Improved teaching and learning. • Learners tend to be more interested in Maths and increasingly enjoy the subject. Even weaker learners perform better in tests and other forms of assessment. • Teachers admit that this approach to teaching has made them much more positive to teaching. They express the need to involve colleagues at their respective schools. • Growth (verbal comments, body language, attitudes) in confidence, less inhibited to be self-critical.

Envisaged Outcomes	• Develop and reinforce teaching skills in Outcomes Based Education principles; • Assist teachers in understanding their supportive role in helping learners to develop their own constructs; • Assist learners to participate pro-actively and accept ownership of learning processes; • Get teachers to allow ample opportunities for learners to explore and find solutions on their own; • Alert teachers and learners to those constructs that already exist; • Improve learners' conceptual understanding of Mathematics; • Encourage participative group work; • Expose and enhance problem solving strategies; • Improve a realistic approach in teaching and learning Mathematics (context-based); • Develop critical thinking skills. Establish and sharpen teaching skills in OBE principles.
Nature of sessions	• Focus and discussion groups; • Classroom visits by facilitators to monitor the effectiveness of the implementation of the project. • Post lesson reflections • Informal talks / discussions
Assessment	• Ongoing through various techniques, developed in collaboration with teachers. • Lesson observation and recording • Structured and oral feedback from teachers during individual and group discussions and oral feedback from learners. • Written feedback from learners and teachers.
Focus group session 3 February	Orientation, planning and assessment: Devising assessment instruments such as tests & tutorials; teacher preparation; selecting learning material; classroom conversion; learner support; the process of learning; classroom management; communication.
F G session 17 Febr	Correct mathematics and didactics: Use of the correct language to prevent the formation of misconceptions - commas do not shift; values are not carried over; 0's do not appear or disappear, etc.

Focus group session 3 March	Constructing a lesson: Examples and non-examples; what kinds of questions to pose; when to pose particular questions; planning of questions prior to lessons. Not interrupting learners while they are working in groups. Barriers to learning – how to address them. Integration of learning material: how do teachers approach ratio in Geography and Economics.
Focus group session 17 March	Small group work – how to approach module 13. Focusing on the aspects that underlie social constructivism such as group work; what group rules to develop and group roles to assign to learners; how group work is linked to the methodology and outcomes to be achieved.
F G session 7 April	Negative numbers and algebraic language (jargon): Making sense by assigning meaning to algebraic concepts
F G session 16 April	Review: What have we accomplished thus far and what aspects still require attention; how do we maintain high levels of motivation? How to improve and adapt.
F G session 21 April	How to approach Module 14: Questioning – different types and levels of questioning; conversion – converting one measurement unit to another. Assessing the content of modules 4 and 5 – improvements for 2006.
Focus group session 12 May	Making use of the overhead projector when dealing with coordinate systems and plotting points and drawing graphs. The proper use of pie diagrams, histograms and bar graphs. How to get learners to perform or achieve optimally – avoiding negative comments and body language.
Focus group session 26 May	Dealing with functions: The interrelatedness of tables, formulae and graphical representations. In-depth discussion of how to assess module 5 in general and more specifically. Planning: example of a lesson plan. General: practical issues e.g. the lack of pens and pencils in classrooms.

Focus group session 9 June	Computer lesson: Using the drawing toolbar to enhance and optimize worksheets for the learners; using the properties of tables to make worksheets, business cards and to draw up assessment grids. With two teachers we explored using MS Excel for school and personal purposes. A group of 6 teachers practised standard formatting skills in MS Word. (e.g. typing an "exam"-paper).
Focus group session 21 June	Discussion of tests for modules 7 and 15. This led to discussion of the "alternative" memo we used for modules 4 and 5. Module 17 on rounding and accuracy was discussed in depth. Nuances which are often not addressed in class but which are essential for forming of concepts were highlighted.
Focus group session 21 July	How far are we? Strategies should be implemented to enhance basic skills like using a compass and protractor. Ways in which reading skills are being addressed in the Mathematics classroom. Discussion on how we really get to know how learners think. Discussion of textbooks that can be used as enrichment or enhancement to the modules.
F G session 4 Aug	Research in the classroom. Discussion of interviews Stanley held with learners with regard to the co-ordinate system. Planning and evaluation of progress with modules.
Focus group session 18 Aug	The dependence of learners on the teacher was addressed and discussed. Organization and management in the classroom should be optimized - all learners should be busy with mathematics all the time in the Mathematics class. Ideas on how to facilitate this were discussed. Strategies were discussed to solve the time-consuming problem of eraser and pencil borrowing in class. This posed a real threat to learning productivity. Discussion on outcomes at beginning of modules acting as guideline and framework for reflection of learners at end of each module.

School visit 01 Sept	School visit: Laurie Hugo PS Godfrey, 8E, Exponents: Whole class teaching, but all learners were involved. He was the director, always in control, but the learners played along merrily. He did not mind that I guided a learner towards the solution and he also expressed his appreciation for her contribution. From all the scribbled notes in his module it was evident that he was well prepared. Catherine, 7E, Symmetry: Learners appeared to be difficult – they had no tracing paper and were not in the mood for work. The teacher was upset about the state of affairs. I took one of the learners outside and confronted him about his attitude. I also became involved with a group of unwilling boys. Eventually they participated. A large number of learners were constructively busy. She explained patiently while facilitating. The class had to stay after school and complete the exercise.

School visit 08 Sept

Visit to Pedro and Kaylene at Willemsvallei PS

Pedro (Grade 9.1): He was busy talking to the class expressing his displeasure and venting his frustrations at their attitude and their lack of seriousness as far their schoolwork is concerned.

Kaylene (Grade 8.4): One of the most important observations here was the fact that learners were not listening effectively when the teacher spoke. It is, however, possible that the way in which the following statement was expressed led to confusion or misinterpretation.

Five multiplied by itself twice. Instead of saying 5 multiplied by 5 meaning 5 x 5 or 5^2

For most of the learners it means 5 x 2.

24 multiplied by itself four times – instead of saying 24 times 24 times 24 times 24."

Grade 8.1: Introduction to the module on powers (exponents)

The learning outcomes on the front of the module are discussed through questioning and answering. Learners are first given the opportunity to read through the envisaged outcomes.

What do we have to know, and what should we be able to do after completion of this module? Learners are then given the opportunity to identify words that they do not know the meaning of. One of the learners is asked to make a list on the writing board. The list includes:

- grondtal (base)
- exponent
- priemgetal (prime number)
- Factor
- notasie (notation)

Some of the learners give the following meanings to :

- Grondtal / base – 'n lae getal / a number low in value
- Eksponent / exponent – om iets te doen / to do something
- Faktor / factor – iets / getal wat baie belangrik is / something / a number that is very important
- Notasie / notation – om iets te maak / to make something

School visit 15 Sept 2005

School visit: Willemsvallei PS

Workshop with teachers

Kaylene has to fax the proposed changes to module 11. She wants to use the test on rounding off numbers that we developed. Catherine mentions that she does not use all the instruments that we set as tests – some she uses as tasks and homework activities. The ultimate responsibility lies with the teacher as to how s/he wants to use the assessment instruments, that means to decide for yourself what is effective or useful and what is not. Marina point out the importance to differentiating when working through a module – in this regard the little elephants on the right hand side of the pages should be taken into account. Group work should be alternated with small group work, working in pairs and working individually. It remains important that learners do not lose their individuality. Give clear instructions to learners, such as: Now everyone works on activity 3 alone. When working in pairs the learners have a greater chance of making a verbal contribution.

Post-module reflection by the learners is important and we need to allow time for this to be done. Marina: Do you feel it is worthwhile just to reflect or to take stock before going on with a module or proceeding to the next?

Kaylene: The comments by learners get a bit much – I allow them to do it during the reading period. Learners must not only say yes or no – they have to motivate and substantiate. Say if you struggle and what you are struggling with …

Catherine is of the opinion that comments should be stapled to the module.

Marina: Each teacher should find ways in making his\her life bearable and do things more effectively.

Pedro: Look at the format again and streamline – positive comments and learning barriers.

Catherine: Positive comments should refer mostly to positive changes in behaviour, school visits by parents.

Module 23 will possibly have to stand over till grade 9. Many learners can plot graphs but have difficulties interpreting them.

The theorem of Pythagoras needs to be dealt with next.

7/8 October 2005 Brave Maths Mouse

Weekend Workshop 7/8 October 2005: The following teachers and facilitators attended the workshop:

Bertus, Marina, Stanley, Bryan, Catherine, Attie, Godfrey, Ingrid, Bryan, George, Eddie, Alecia, Pedro, Kayleen

Refer to the workshop roster for time allocated for each of the topics presented or discussed.

Issues discussed included the following:

1 Teachers had to check whether the outcomes that appear on front pages of the modules corresponded with the assessment standards as stated in the RNCS.

2. A session on chance and probability

3. A session on planning (year plan, work schedule, lesson planning)

4. Using the newspaper to develop relevant mathematics activities

5. Early Sunday morning was used to discuss general educational issues with George and Eddie.

6. Learners' sense of ratio seems not to be at a level where they can adequately interact with the ratio tables. Learners generally experience problems to complete ratio tables. Their sense of equivalence is 'impaired'. It is important / crucial to first deal with fractions before learners are confronted with the ratio tables. Link the tables to real experience, for example where water is mixed with cool drink syrup.

Cool drink	1	2	20	?	Price	1	2	60
water	3	6	60	?	total	5	10	300

7. Teacher comments:

a) Activities on probability were very interesting. Just to know / see what the chances are of winning the lotto. Learners can appreciate this. Devising projects – it is beneficial to share ideas and to apply concepts. By comparing the assessment standards to the learning outcomes we were able to identify shortcomings in the modules. The sessions were taxing – especially taking into consideration the time of the year. Enjoyed it tremendously. We need more time for planning.

b) Is was a very good weekend to share thoughts and ideas. Good presentations. Interesting challenges posed to us

	c) The weekend ... the weekend was very well planned ... and facilitated. Thank you very much Bertus for your input. I can't wait to start working with the grade 9's. Marina: Thanks for your hospitality and for seeing to all the meals. Stanley ... you are more than a facilitator ... thanks for your friendship. Respect is earned and you have earned it.
School visit 25 Oct	School visit to Pedro at Willemsvallei: Grades 7.1; 7.2; 7.3 Sat in on three lessons on Measurement. Learners were requested to measure objects. Learners experienced problems measuring in the appropriate units. They experienced difficulties converting from one measurement unit to another. If used diagnostically the teacher should sense that misconceptions exist. *Kaylene (Grade 8.2 and 8.3): Learners busy with module on similarity. They use the two knots in an elastic band to enlarge the sketch of a bird. Interesting. Initially the learners struggle to get it right.*
School visit Thursday 3 Nov	School visit: Bertus and Stanley visit Laurie Hugo PS in the morning: discussions with Attie, Catherine, Ingrid and Godfrey. Workshop: Present : Attie, Catherine, Stanley, Marina, Pedro Issues discussed: • Progress schedules of the grade 7's and 8's for 2003/2004/2005 • Modules to start off with for the grade7s, 8s and 9s • Students to visit us from the Netherlands • Visiting businesses to find finances for the modules for 2007.
Friday 20 Jan 2006	The 4 students arrived from the Netherlands for the practice teaching period of 3 months. We fetched them at Cape Town International and took them to Moorreesburg where they will be stationed.
Monday 23 Jan 2006	Stanley took the Dutch students to the project schools to introduce them to the principals and mathematics teachers.

School visit 26 Jan 2006	Stanley and Bertus visited Laurie Hugo PS and Willemsvallei PS and had the first workshop for 2006. School visit: Kaylene assisted by Nicole (grade 8's) were busy with number patterns. Some learners were still struggling with basic concepts such as 'area'. They struggled to identify the common factor.
School visit 02 Feb 2006	Stanley and Bertus visit Willemsvallei PS Kaylene's classes were still busy with the module on patterns. They were working at a satisfactory pace. Learners constructed a paper container with a capacity of 500 ml. A practical application where learners had to go outside to complete the activity. Pedro (Grade 7s). Learners were busy with module 1 on measurement, constructions and geometrical patterns. Pedro mentioned the benefits of this module to learners: helps new grade 7s to adapt more easily, how to work in groups, how to work independently. The pace at which they work was faster than the previous year, it served as a good introduction to the year; it kept learners constructively busy.
School visit 09 Feb 2006	Stanley and Bertus visit Laurie Hugo PS Attie (Grade 7s) revised a test that learners wrote. He had an interesting way of going about it. Ultimately all learners had a clear idea of where they made mistakes. Ingrid (Grade 8) dealt with the introduction to statistics where learners had to devise a questionnaire to gather information from their peers. Learners did not understand some of the jargon / concepts being used. Catherine (grade 9s): Her learners were busy working on applications related to the theorem of Pythagoras. Generally learners were progressing well.
School visit 16 Feb 2006	Bertus visits Willemsvallei PS Pedro: Statistics. The use of surveys and questionnaires to gather data Kaylene: Functions plotting and interpreting graphs

As can be seen from the chronological exposé of events a wide range of issues were addressed through lesson reflection, interviews, informal discussions and focus group sessions. Some of the aspects discussed relate to improvement of teaching practices, the power of positive feedback, effective assessment, experiences with, and critique of the modular materials, formative assessment related issues, small group work, questioning, etc. Outcomes of the discussions, and achievements, issues that need to be revisited, what worked and what did not are elaborated upon in chapter 7.

6.7 SUMMARY OF THE MOST IMPORTANT FINDINGS

This chapter should provide the reader with ample information to form an impression of the type of activities and intervention strategies that were used over the three cycles.

The position of teachers, their fears, their needs, their views on issues such as feedback, how they see themselves, and their expectations are clearly highlighted.

The frequent interaction between teachers and facilitators in different settings and situations (classroom visits, interviews, post-lesson reflection, focus group sessions, workshops, social functions) should be evident, and consequently a positive educational and social relationship resulted that allowed teachers to grow holistically (cognitively, emotionally, socially, pedagogically, self-critically, and with respect to mathematics content) as will become clear in Chapter 7. Chapter 7 – together with Chapter 6 - consequently contains my reflections and findings that explore my relationship with teachers, moments of frustration, moments of learning, and moments of accomplishment. Although much had been accomplished, there is room for improvement.

A few of the most important findings made at the outset of the study that steered this research include the following:

- Teachers encountered difficulties making the transition or shift from conventional (behaviouristic) teaching methodologies to OBE (involving a more learner-centred approach with greater emphasis on knowledge construction)
- Teachers' perceptions, knowledge and use of feedback were limited
- Teachers viewed formative assessment as extra work and not integral to their teaching practice
- Teachers' knowledge (of the value and as tool to stimulate and assess) of formative assessment was limited
- Communication patterns were rigidly structured in a way that allowed teachers to do most of the talking, and allowing learners limited opportunity to participate verbally.
- Classroom organization and management did not allow greater learner contributions or sharing of ideas from learners
- Teachers' knowledge and skills with respect to cooperative learning, using small group work were limited or non-existent

- Time allowed for learners to respond was generally less than 5 seconds
- Teachers did not consciously think about the value of different types of questions (open questions, higher order questions, etc) prior to lessons.

All of these aspects mentioned above were addressed during the course of the three research cycles. The extent to which teachers have improved is the focus of Chapter 7.

CHAPTER 7: MY REFLECTIONS AND FINDINGS

When the purpose is to develop understanding, strategies or awareness, then the classroom must become a place where meanings are created, problem-solving approaches are shared and values are debated. This necessitates a different kind of classroom environment, in which discussion and negotiation predominate. (Swan, 2000:155)

7.1 INTRODUCTION





At different stages during the study I reflected on what was accomplished, to what extent teachers have become more skilful, and knowledgeable as mathematics teachers in their use of feedback to assess formatively more effectively. These reflections are explicitly focused on the state of communication inside the mathematics classroom, and intimately linked to the action research (qualitative) techniques discussed under 2.3 in Chapter 2. As such the continual use of the research journal (including field and observation notes), focus group discussions, video and audio recordings, and interviews was aimed at ensuring a greater degree of validity through triangulation.

Apart from dealing with my experiences with teachers and what transpired inside classrooms I also reflected on what outcomes were achieved, what should be changed and how it should be changed. It is important for the reader to remain mindful of the fact that these reflections were written at different stages of the project and I have attempted not to make changes, apart from grammatical and other technical changes. Discussions are usually written in the present tense to give a greater sense of immediacy to the event as it was occurring then. The process of reflection enabled me to follow my growth as facilitator, and the issues dealt with at different stages of the project.

This chapter thus in essence reflects all the findings throughout the three cycles. It needs to be reiterated that I have made a deliberate effort not to be unduly critical or harsh on teachers, although I might not always have succeeded. The teachers have been remarkably open to critique and displayed a willingness to improve their practices and empower themselves professionally.

7.2 REFLECTION THAT OCCURRED DURING AND AFTER CYCLE I

After a term of classroom observation in March 2002 I reported as follows: Teachers generally teach and they seem to have done a fair amount of preparation. Documents such as lesson plans, and activities are evident. As far as classroom conversation is concerned I think it could be labelled as a form of monologue rather than dialogue. It is one-directional – from the teacher to the learner (Curzon, 1986; Davis, 1997; Nickols, 2000). For most of the period all the teachers transmit knowledge, model algorithms, while learners have to copy from the writing board, and imitate strategies explained by the teacher. This can be ascribed to the pressure exerted on teachers to cover as much of the prescribed syllabus as possible. As such no or very little time is given to learners to explore on their own to interact with one another.

Learner responses are minimal, and they tend to respond “yes” or “no” in chorus. This type of whole class response creates the false impression that everybody understands, or that everyone is fully aware of what is happening. Learners are not sharing their ideas, engaging in discussion or asking questions (including asking for clarification). Many learners very often lose the teachers’ train of thought or do not understand what teachers try to explain. This is happening in all of the classes. Teaching is directed towards the whole class, and the whole class is communicated with as if they are a homogeneous group on the same level of cognitive, social and emotional development, with the same prior knowledge and experiences.

Hand-outs (activities) are used which are essentially copies from textbooks. The impression that I formed is that for teachers, working with activities as handouts constitutes outcomes-based education or a significant part of it. Teachers are not clear as to what outcomes-based education entails and have no real knowledge of the underlying philosophy of constructivism as opposed to behaviourism (Atherton, 2003:1). I can see no sign in what they do that they actually understand the ins and outs of OBE. The shift or transition has not been made and consequently the teacher still does most of the talking, decides when to ask questions, and who will be targeted. Since the classroom conversation is mostly one-directional, the teachers do very little or no listening. In other words, opportunities are not created to listen to their learners (Carpenter and Fennema, 1992; Cart, 2000; Davis, 1994;

Erven, 2003; Long, 1996). It is also doubtful whether teachers are always listening to themselves (refer to the introduction of Chapter 1). Consequently this skill is completely under-developed (Davis, 1996).

For the observer it seems as if the teachers generally do not have a strategy in place to gauge what the conceptual problems of many of the learners are, or how to identify, or to remedy such problems. Teachers are faced with many problems that they do not really have much control over. For instance, their input to have learners condoned or kept back is frequently ignored. Many learners are mentally challenged and teachers are not trained to recognise or identify different psychological problems that might exist within a particular class.

At this stage have activities been encountered or observed in which learners actively engage with equipment or apparatus geared towards self-exploration and constructing their own knowledge since the process is teacher driven and controlled. There is no radical change in lesson presentation or approach thus far. It appears at this stage that mathematics is viewed as abstract and exclusively as a ‘pen and paper’ subject.

How do teachers structure their classrooms and how do they approach their work? Two of the teachers teach in a more conventional way (through whole class instruction), while the other two made use of small group teaching. Learners in groups discuss the problems trying to make sense of it. They also try to find solutions through problem-solving strategies. Most learners do not actively participate in the discussions. It is clear that learners are not yet used to work in this manner.

In all classes where group work is used, except for Bryan and Pedro, activities do not seem very well planned. Rules for group work have not been established and discussed with learners. Particular roles and rotation of such roles are not discussed with or assigned to the different learners within a particular group (Atherton, 2003; Car et *al.*, 1998). There is no real time management. It is not just enough to tell learners to talk or discuss. Discussion and dialogue should be linked to particular relevant tasks and questions (Kirmse, 2001).

Teachers often make use of peer assessment which can be a very effective way of re-capping certain aspects (Black and Harrison, 2001; Bright and Joyner, 1999; Kulm, 1994) of the work and to reinforce previously not well understood concepts or algorithms. In classes where peer assessment is used, such as in Pedro and Attie’s classes, and where teachers want learners to apply specific guidelines, problem-solving strategies and answers, teachers, however, do not effectively control and monitor that such guidelines, etc. are indeed assessed as they should. Often learners are not sure what to do, but are too inhibited to ask for clarification. Large classes of learners, understandably makes monitoring of this process enormously difficult.

Learners' cognitive abilities in many cases seem to be quite limited. This observation is in line with information shared by teachers (during post lesson reflection and at focus group sessions) that numerous learners are passed on to the next grade as they are only allowed to hold a child back for one year. With all the administration burdens, such as recording of intervention incidences linked to keeping a learner back, most teachers just promote them to the next level. In many cases, when teachers decide to keep learners in a particular grade, curriculum advisors simply override such decisions.

In certain small groups, in Bryan, Pedro and Catherine's classes, (observed during classroom visits) learners are seemingly busy working, but they are actually busy with trivialities such as drawing frames around the edges of the pages on which activities are to be done, writing down the date, copying the questions from the exercise either from the text or the writing board. They actually never get down to attempting or doing the activity. Teacher facilitation, except in the case of Bryan, is not really in place to ensure that learners stay focused on the task at hand. Learners tend to respond as a choir which creates the impression that all of them know exactly what is expected of them. They generally do not ask questions for clarification (Davis, 1997; Dillon, 1988; Hickman, 2002), nor does the teacher request them to reflect on how and what they understand with respect to the task or assignment. Learners generally do not ask questions. Communication is mostly one-way – from the teacher to the learners (Cazden, 1988; Davis, 1997; Hickman, 2002). Higher order questions posed to learners are minimal. This can only change if the lesson is structured in a way that would made higher order questioning possible.

Limitations with respect to communication in general and questioning in particular are revealed by the following short extracts from classroom interaction between teacher and learners as recorded by Bertus (one of our project facilitators):

Extract 1:

Teacher: *Who has a question?*

Learners: *[No response.]*

Teacher: *Is it clear?*

Learners: *[In a choir] Yes, sir.*

Teacher: *Who wants to ask a question?*

Extract 2:

Teacher: *What type of scale do we have here?*

Learners: *[No response.]*

Teacher: *[Without allowing adequate response time] It is a ratio scale.*

Extract 3:

Teacher: *What is here on the board [pointing to a + 1 = 3]* *2a + 3*

Learners: *Breadth.* *a + 1*

Teacher : *[Immediate response] No, an equation.*

Verbal interchanges between learners and the teacher are mostly very short. Questions posed by teachers are very often vague and do not really prompt or elicit responses from learners. Dealing with ‘wrong’ answers seems to be problematic and teachers’ skills to use wrong answers as incidents for learning needs to be developed (Bodin, 1993:133; Confrey, 1991:122; Wiliam, 2000:22). Furthermore, teachers’ questions do not generally lead to expanding of ideas or to direct the progression of the lesson.

Planning is sketchy or fragmented and compartmentalised, and often no planning is visible. For example, all technical aspects related to fractions would be dealt without meaningful contexts and percentages would be done totally separately, without realising the interrelatedness or possibilities for integrating aspects such as ratio or equivalence. It seems that most teachers need assistance to plan in more detail as to what they want to accomplish and how they want to go about it. Except for two cases, I have thus far not come across lesson planning reflecting real introspection.

On the positive side it needs to be said that teachers show an awareness and realisation of the shortcomings that exist with respect to planning. They maintain that the in-service training they have undergone is insufficient, that they need guidance and are willing to accept input in this regard.

Are all teachers really busy with outcomes-based education? This question can possibly be answered when the following statements are analysed, based on lesson observation, and post-lesson reflection.

- Most teachers do not differentiate clearly between learners with varying abilities or knowledge (Black and Wiliam, 1998b; Wiliam, 2000).
- The assessment criteria are not shared with learners prior to an assessment activity – whether it is a test or task. As such assessment is not transparent as it is supposed to be (Frederiksen and White, 1997; Spady, 1994; Wiliam, 2000).
- Learning outcomes are generally not shared with learners prior to a lesson or series of lessons (Frederiksen and White, 1997; Wiliam, 2000).
- Assessment rubrics (based on the assessment standards) are not appropriately applied to acquire deeper insight into learners’ skills, knowledge or to ascertain or identify misconceptions, etc. (Wiliam, 2000).

- Small group work is not applied nor is it facilitated effectively. This can possibly be ascribed to a lack of training.
- Teaching is overwhelmingly geared toward the whole class as one big group.
- Written /typed activities as handouts appear to be the norm as far as outcomes-based education in mathematics is concerned.

After a semester of project work I reflect in the following way: Reflecting on what transpired during the past six months (December 2003) is not an easy task. Intuitively and instinctively it compels me to pose the following questions: Have I accomplished what I set out to do? Have I achieved the required outcomes? Have I succeeded in accomplishing what was expected of me as facilitator? Have I adequately assisted and guided 'my' mathematics teachers in growing didactically? Have I empowered them to become increasingly confident and equipped to deal with the diverse aspects of outcomes-based education? Is there evidence of progress with respect to classroom communication? And ultimately have I adhered to the proposal criteria as stipulated in the initial proposal presented to the funders of the project?

All of what is said in this reflection should be viewed within the context of the shortcomings associated with the manner in which OBE was implemented at schools. Teachers were not really thoroughly trained in the nitty-gritty of OBE, and expert support from the WCED (Western Cape Education Department), based on my experience, is almost non-existent. Constant and effective monitoring is absent. There is no consistency (pedagogically) as far as what happens in different classrooms at the same school, or at different schools in different communities. Other factors hampering and adversely affecting, or achieving the envisaged outcomes are mentioned below.

The following are the outcomes that I wanted to achieve within the context of OBE and the West Coast Project with Senior Phase (Grades 7 to 9) mathematics teachers. Some of the objective outcomes became increasingly clear and meaningful as I tried to figure out and came to grips with my role (and true function) as facilitator.

- To make teachers realise that mathematics is much more than a 'pen-and-paper' learning area (emphasising the need for: changing to a different style of teaching; increasingly accommodating all learners and to optimise learning, preparing lessons differently; making lessons a more practical endeavour; preparing simple yet effective apparatus for learners to use; co-teaching functions and related concepts aspects in the mathematics curriculum

- To get teachers to adhere to OBE principles such as group work, getting learners to increasingly construct there own knowledge, and take charge of their own learning
- To get teachers to use effective formative assessment strategies
- To get teachers to talk less, and learners more
- To use newspapers to teach mathematics to enhance reading and communication
- To bring main social events like world cup cricket to the classroom
- To take learners outside of the classroom to teach mathematics
- To teach mathematics in context – using a more realistic approach
- To increasingly (as a team of teachers) integrate learning outcomes as well as *different learning areas*
- To share resources such as activities, assessment sheets and learning programmes
- To increasingly communicate with mathematics teachers on the same staff

The dynamism of facilitating (as discussed under 1.5.1 in Chapter 1), and my ever-changing role as facilitator (Denning, 1998; Godnough, 2003; Perrone, 2003; Zuber-Skerritt, 1991) are elaborated upon here. I was never actually trained in the specifics of facilitating, namely in the explicit detail of how to go about it, what to expect, what not to do, what to do initially, what to do afterwards, etc. Consequently, I continually had to adapt and change, and had to be flexible to address the varied needs of the different teachers and to adhere to the outcomes set out in the project proposal. My training as an adult educator and post-graduate studies in adult education served as a solid foundation on which to build.

Periodically materials on facilitation shared by my mathematics coordinator and co-facilitators were studied, internalised and implemented to improve my role as facilitator. For the initial four to six months in 2002 discussions with teachers revolved around the issues of OBE, namely as to what were expected of participant teachers, non-participant classroom observations, post-lesson reflections with teachers, monitoring teachers' implementation of methodologies and content materials discussed and 'work-shopped' in the summer schools (four-day workshops in OBE-related issues during the last week of the December holidays). As my relationships with teachers became stronger towards the latter part of 2002, non-participant observation changed to participant observation (Perrone, 2003; Denning, 1998; Godnough, 2003). This means that I increasingly became more involved in the mathematics lessons and intervened at different stages either to clear confusion or assisted with facilitation.

Critique became more open, structured and candid. Learning programmes, and lesson activities of teachers were shared with others. This implies that most teachers allowed me to intervene during teaching sessions by re-phrasing questions differently, by making comments on particular issues, by asking additional questions to learners for clarification, and making suggestions during post-lesson reflection. An additional dimension was added, when, with permission of the majority of teachers, some of their lessons were audio- and video-recorded for analysis and reflection (as discussed under 2.3.5 and 2.3.6 in Chapter 2).

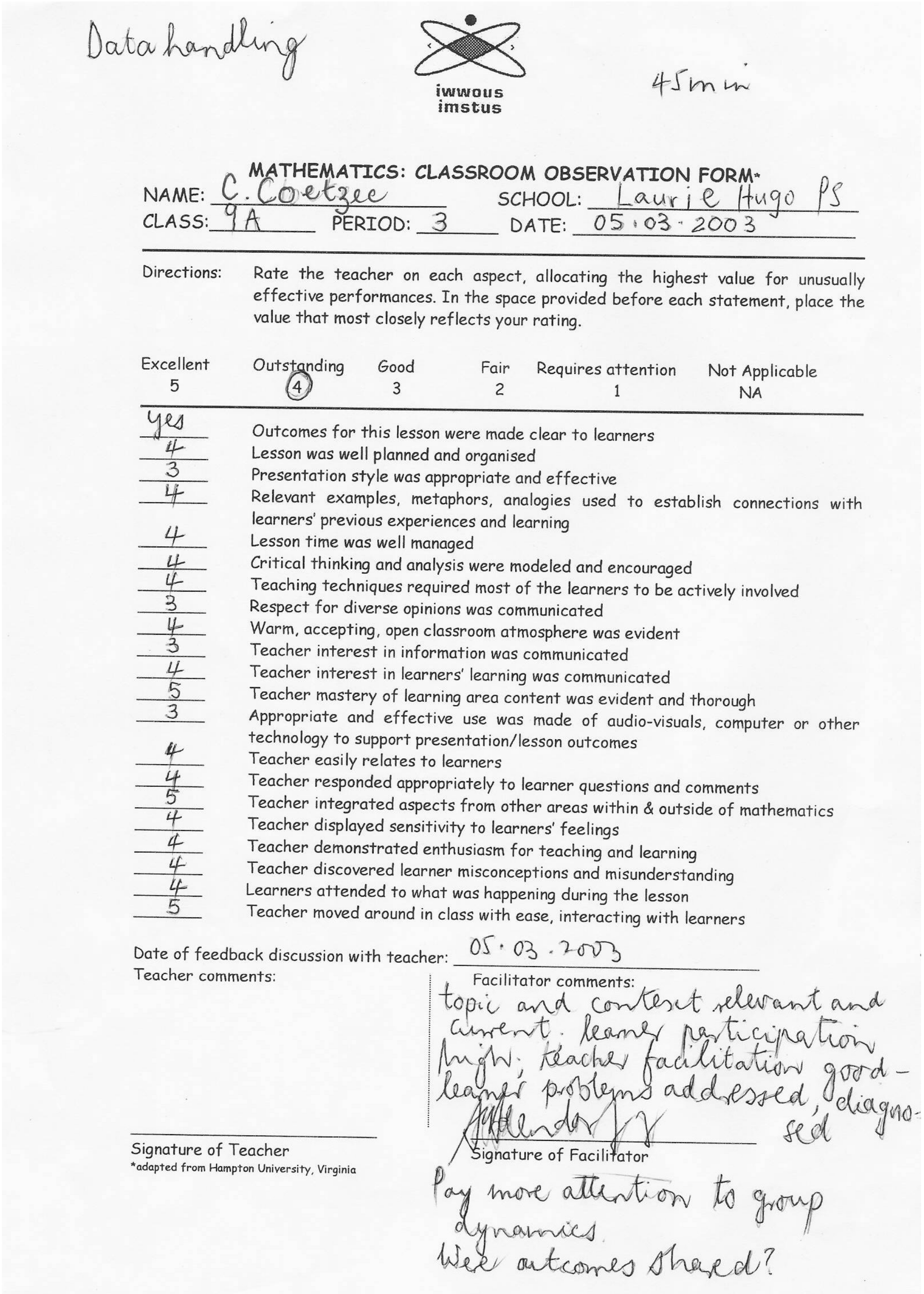
Yet another dimension was added to my role as facilitator (Burns, 1995; Perrone, 2003; Denning, 1998; Laird, 1985) when I became more involved in teaching and co-teaching to demonstrate how teaching and learning can be adapted and facilitated to make it much more creative, more interactive and more fun. One of my important achievements was to make teachers aware of how, with minimum effort, simple everyday household items can be used as tools to optimise learning by incorporating practical elements and by means of learner participation and activity.

At this stage my (perceived) limited accomplishment, or achievement (or success) when it comes to certain individual teachers is not easy to gauge. Did I fail in my duty, or did these teachers lack the vision to internalise what we as Imstus wanted to achieve? For ethical reasons teachers other than Attie, Bryan, Catherine, Godfrey, Ingrid, Kaylene, and Pedro, the real name of the other teachers are avoided.

KK (High School 1) admits her enthusiasm about her educational and fruitful experiences at the Imstus workshops, but claims that she is too inhibited to explore and employ OBE methodologies such as group work. Consequently, I never have the opportunity to observe how she dealt with many OBE-related issues. Her colleague TT (HS1) is never really part of the project. In her case she is always providing a recipe that the learners have to follow meticulously. To me it is clear that the abilities of the learners are underestimated. It is my impression that the two of them never actually give their views on project issues. In this case I think internal school teaching policies weigh much heavier than adhering to project goals. It is quite evident that they are overloaded with work. Having to teach two different learning areas in grade twelve is not easy. KK is looking for ready-made materials to use in class, not having the luxury of time to develop her own, she claims. These two teachers have many years of teaching experience between them, but everything they do is geared towards the matriculation examinations. It seems – from discussions and sentiments expressed – that in this case the teacher feels disempowered by the school politics at their school, consequently she often feels inhibited and reluctant to experiment with new ideas. She admits that excellent ideas and skills are developed at our workshops. However, once back at school she does not see her way clear to even rearranging learners' seating positions for small group work.

The teachers at HS2 (II and BB) request that they be left alone to continue in the way they were used to. Workshops and other information sessions are attended irregularly. I cannot detect any growth or willingness to change through observation. Much blame is put on the attitudes and quality of learners that they have to teach. I expect some of the teaching strategies demonstrated and experienced at our workshops to materialise in their classrooms. It never happens? I have always questioned some teachers' power to simply ignore official educational policy? Isn't OBE law? HH said she would contact me. However, I think she was glad to see me go?

To make classroom observation meaningful and constructive I had to structure these sessions by using an observation sheet. This formed part of my initial effort to ascertain the general qualities and skills of the project teachers. All aspects of the observation schedule were discussed with the project teachers on an individual basis. The process of assigning codes to teachers would give them first-hand experience of the feelings and emotions involved when assessing learner performances and achievement, and to sensitise them in this regard. This was a confidential matter between facilitator and teachers.



Data handling

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MATHEMATICS: CLASSROOM OBSERVATION FORM*

NAME: C. Coetzee SCHOOL: Laurie Hugo PS

CLASS: 9A PERIOD: 3 DATE: 05.03.2003

Directions: Rate the teacher on each aspect, allocating the highest value for unusually effective performances. In the space provided before each statement, place the value that most closely reflects your rating.

Excellent	Outstanding	Good	Fair	Requires attention	Not Applicable
5	4	3	2	1	NA

Rating	Aspect
yes	Outcomes for this lesson were made clear to learners
4	Lesson was well planned and organised
3	Presentation style was appropriate and effective
4	Relevant examples, metaphors, analogies used to establish connections with learners' previous experiences and learning
4	Lesson time was well managed
4	Critical thinking and analysis were modeled and encouraged
4	Teaching techniques required most of the learners to be actively involved
3	Respect for diverse opinions was communicated
4	Warm, accepting, open classroom atmosphere was evident
3	Teacher interest in information was communicated
4	Teacher interest in learners' learning was communicated
5	Teacher mastery of learning area content was evident and thorough
3	Appropriate and effective use was made of audio-visuals, computer or other technology to support presentation/lesson outcomes
4	Teacher easily relates to learners
4	Teacher responded appropriately to learner questions and comments
5	Teacher integrated aspects from other areas within & outside of mathematics
4	Teacher displayed sensitivity to learners' feelings
4	Teacher demonstrated enthusiasm for teaching and learning
4	Teacher discovered learner misconceptions and misunderstanding
4	Learners attended to what was happening during the lesson
5	Teacher moved around in class with ease, interacting with learners

Date of feedback discussion with teacher: 05.03.2003

Teacher comments:

Facilitator comments: topic and context relevant and current. learner participation high; teacher facilitation good - learner problems addressed, diagnosed

Signature of Teacher

Signature of Facilitator

*adapted from Hampton University, Virginia

Pay more attention to group dynamics. Were outcomes shared?

Figure 7.1 Teacer assessment instrument

Another important aim was to get teachers to reflect increasingly on their teaching practice, and to become increasingly critical of themselves. In a sense the use of this observation schedule was also a way of ascertaining to what degree teachers were prepared to be exposed to scrutiny. The teachers at HS3 (MM and NN) did not appreciate the form. This was the only school where teachers objected to the use of such a formal written observation sheet. They simply did not like the idea of their lessons being critiqued in this way. My impression was that they had not seen the need to grow as teachers. I also got the impression that they were quite content to be left alone. It might be that they had different reasons for their decision not to take part any further. Did I see them apply OBE principles in their classrooms? Hardly!

RR (HS4) has a pleasant personality. We developed a sound educational relationship. She purposefully endeavours to implement Imstus workshop suggestions in her classrooms. She is always appreciative of any positive critique. As a result of her positive attitude I enjoyed observing her classes. Her mathematical knowledge is sound. She is open to suggestions and new influences. She has grown as a teacher. Effective learning and assessment occur inside her classes. Mathematics in context, however, needs to be employed more readily by her – especially when dealing with content such as the linear function, for instance. She has acquired skills to apply formative assessment appropriately.

EE (PS1) teaches under difficult circumstances. The political atmosphere at the school hampers optimal learning. Apart from this, the learners, especially the grade 9s, appear to have enormous pedagogical backlogs, and appear to be environmentally deprived. EE and I co-taught a few lessons together. We encountered learners to be extremely inhibited and un-cooperative. Most learners were unable to communicate adequately, shying away from expressing their views, and incapable of responding to, what we thought were simple straightforward questions. Both he and I realised that some of these problems could only be adequately addressed by outside intervention and expertise. EE is skilful, hardworking, willing to learn and open to suggestions. Unfortunately, he did not attend most of our workshops and other information sessions.

WW (PS2) is a dedicated teacher. He is open to suggestions, and willing to improve himself as educator. He normally is well prepared and conducts his lessons well. Learners are allowed to increasingly take charge of their learning. More learner discussion should be prompted. More practical elements need to be built into his lessons. WW's two colleagues, DD and FF have the potential to develop into model teachers. They basically still control all classroom activities allowing only minimum contributions from learners. I suggest to them that learners be allowed to become more actively involved, by talking less, thus allowing learners more freedom of sharing their own ideas and experiences.

Compared to the other teachers involved in the project PP (PS3) seems to possess more advanced skills to communicate his ideas about his own teaching practice most effectively. He has the ability to self-reflect and self-critique his own efforts constructively. Furthermore, he does not hesitate to admit that he could be more effective in certain instances. He constantly and readily admits when he has learned something new. He has the gift to get most of his learners to participate, involving them in sharing their ideas and allowing them to challenge him. He has shown significant growth. QQ, his colleague, was away from school for the greater part of 2002. As a result she missed out on many school visits and network sessions. She still needs to further develop OBE strategies such as group work and mathematics in context. She displays a positive attitude and is keen to improve and hone her teaching skills.

OO (HS5) is a teacher with great potential. He still has to grow didactically speaking. Generally, the learners seem to be difficult to handle. With lessons structured differently – by involving all in hands-on activities I had noticed that they become much more manageable. UU appears to be highly critical of what we want to accomplish and unwilling to commit himself. I obviously don't have the authority nor the will to try to compel him to adhere to project guidelines. I have never observed him employing OBE teaching strategies. I support his matrics' preparation by giving lessons on Monday afternoons CC always has sound ideas to incorporate information found in newspapers into his planning. The kids are ill-disciplined and noisy and it takes a lot of effort on his side to stay on track. HS5 experiences major disciplinary problems – many learners are uncooperative and ill-disciplined.

YY (PS4) appears to be a bit insecure. His insecurity seems to be related to the fact that he was compelled to teach grade 7 and 8 mathematics for the first time this year. His insecurity also stems from the fact that he is not actually a trained mathematics teacher. He is also in charge of the Natural Sciences. Although this is his 2nd year in the Science part of the project, he only became involved in the mathematics in 2003. His OBE didactical skills need to be developed further.

It is evident that BB (PS5) is in another league as teacher. His approach is much more hands-on and practical, getting the learners to engage much more intimately and excitingly with the learning area content. It is apparent that many of the learners are slow learners, but he succeeds in engaging the learners effectively by employing appropriate strategies. He does not hesitate to take his learners outside of the classroom in order to build variety into his presentations.

It is evident from regular conversations with XX (PS6) that he is a well-balanced educator. His classes are fairly large and not that easy to manage. I find that he still talks too much. He needs to involve the learners more.

AA (PS7) has only attended about 2 cluster meetings (regional meetings that cluster schools and organised by the local EMDC) in the past 18 months. This, however, has not hampered his growth as mathematics teacher. He is open to suggestions and shows a keenness to learn and try out new things. Consequently, he reflects more growth then some of our regulars combined. ZZ (PS7) is a hard worker. However, the indiscipline of her learners appears to dampen her spirit. She readily implements suggestions and employs materials and activities from other teachers shared with her. VV, the deputy principal at PS7, is on the quiet side. This makes it difficult to gauge exactly how he feels about issues discussed. I spend less time with him then with the other two. He is an experienced teacher. The few lessons I observed were interesting and practical, but I felt that learners should take more charge of class activities and discussions.

The following criteria or descriptors were used to describe the teachers' abilities, skills and professional growth:

Level 4: High level of growth and development achieved: acted as co-presenters at Imstus or Amesa workshops; regularly implemented project material; implemented group work effectively; aptly and effectively implemented newspapers as learning materials; frequently takes learners out of the classroom for mathematics related activities; allows learners to construct models in class; allow learners to dominate discussions through effective questioning; learners show evidence of skilfully participating within groups; attended all or most of the workshops and cluster meetings; frequently uses tools/object to make mathematics practical and enjoyable and different; liberally uses materials and ideas offered by the facilitator; adhere closely to project guidelines; shows the skills to develop effective assessment grids; test papers reflect OBE teaching strategies; Teaches in context overwhelmingly

Level 3: Level of growth achieved, considerable: can improve further; regularly implemented project material; group work skills require honing; allows learners to become involved in discussions through questioning; attended most of the workshops and cluster meetings; mostly work with printed activity worksheets; uses materials and ideas offered by the facilitator; adhere more or less to project guidelines; increasingly teaches in contexts;

Level 2: OBE skills need to be developed further: Learners are mostly listeners; teacher dominates; inhibitions to employ OBE methodologies; No, little or ineffective group work; Project guidelines generally need to be taken into consideration more seriously; some display effort to improve;

Level 1: No teachers were placed on this level, since all have some teaching skills and are qualified teachers.

My teacher ratings in terms of teachers' OBE growth:

TEACHER PROGRESS AND GROWTH TOWARDS OBE			
LEVEL 4	LEVEL 3	LEVEL 2	LEVEL 1
Teachers (grades taught)	Teachers (grades taught)	Teachers (grades taught)	Teachers (grades taught)
	AA(7)*		
	PP (7, 9)		
	BB (7, 8, 9)		
	RR (8, 9)		
	VV (8)	KK (8, 9)	
	EE (8, 9)	DD (7)	
	XX (7, 8, 9)	TT (8, 9)	
	YY (7, 8)	QQ (8)	
	ZZ (9)	UU (8)	
	MM (8, 9)	FF (7)	
	CC (9)		
	OO (8, 9)		
	12	6	

Table 7.1 Teacher progress and growth towards OBE

Although AA, PP, BB and RR cannot be placed in column 4 as yet they have achieved some of the criteria that resort under level 4. They, however, need to develop various other skills related to questioning, facilitating small group work, listening, and directing learner discussions. This implies that they still have to grow significantly before they can be placed on level 4.

One of the most important conclusions reached during cycle I is related to change. It became evident that teachers cannot be forced or coerced into change if they do not want to change or if they are not ready, even when new policies require them to. This corresponds to Inos and Quigley's (1995:1) statement that educational change is intimately related to teachers' thoughts, perceptions and actions. Fullan, cited in Inos and Quigley (1995:1) agrees that for change to occur, teachers' "... mental health and attitudes ... are crucial to success".

Generally, at the outset, teachers appeared unwilling to expose themselves, and seemed scared to venture into unchartered territory. They were not sure of what was expected of them in the new curriculum. Since it became too expensive to work with so many teachers in 2003, we had to identify, based on our observations and interactions, at least 6 to 8 teachers who would be prepared to empower themselves, expose themselves to intervention and collaboration. Four of these teachers are described in Chapter One, and it is their progress that I describe throughout this dissertation. These teachers were the ones who were willing to expose themselves to our interventions throughout.

Another very important finding was that the classroom structure and management had to be changed to create opportunities for more constructive verbal interaction and communication. Learners needed to talk about mathematics (more). Listening levels of teachers needed to be developed or increased, and questioning strategies had to be improved. Learners appeared to have reading problems generally. Through observation it became evident that learners' reading abilities needed to be addressed or developed. These are the very issues that had to be addressed in cycle II. Modular mathematics materials for grade 7 were developed during the course of the cycle to pilot during 2004, with grade 8 materials to be implemented during the course of the following year.

7.3 REFLECTION: CYCLE 2 (2004)

In 2004 money was a bit tighter and school visits were reduced to one visit every three weeks per teacher, together with focus group sessions of the same frequency. We pilot the grade 7 mathematics modules. Teacher participants grew by one; Attie expressing willingness to participate in the project. Ingrid joined the study during the third quarter of 2004. The project was now much more structured pedagogically and teachers had the opportunity to improve much more in this regard. The introduction of learner modules appeared to have a definite impact on learner enthusiasm as reported by teachers and observed by facilitators. Learners were now much closer involved. Indications were that the module system seemed to facilitate learning. Stories and revelations of weaker learners' improved performance were frequently shared at focus groups sessions.

Discussions and critique has become more open and frank. Teachers attend focus group sessions much more regularly, because they have started to view it as a mechanism to vent frustrations, discuss mutual problems, discuss progress with respect to the modules, analyse and critique module content, and develop assessment tools. Generally they learn to talk about what they are doing inside their classrooms – something that did not happen before. They now unconsciously make use of the opportunity to reflect on their classroom practice and at the same time developed their skill to communicate their experiences.

By December 2004 my relationship with the teachers in our participant schools at Laurie Hugo PS, Stawelklip PS and Willemsvallei PS spanned three years. In essence the progress of 2004 can be ascribed to the quality and intensity attained and maintained in this collaborative venture during the course of the year. I want to elaborate on what I consider to be contributory factors that impact positively on progress, and which facilitated growth and change in teachers and learners.

The development and implementation of learning modules for grade 7s resulted in the following ripple effects, listed below. Learners had taken ownership of the modules and its contents – this is evident from questionnaires and conversations with teachers and learners, and observation. Improved learner self-concepts could be seen in their enthusiasm about working in groups and on their own. Not only was there a greater learner enjoyment of mathematics in evidence, but learners definitely talked more in class, not only with their peers but also to the teacher. The teachers talked less. I (and other facilitators in the research team) detected an increase in the number of questions posed by learners during lessons compared to previous years. This could possibly be ascribed to the fact that learners dealt with mathematics in context and more realistic situations, and from their improved reading (skills).

We encountered longer periods of verbal engagement or exchanges inside the classroom as can be seen from the following example of class talk recorded by Bertus in the first term of 2004. The limitations reflected by this transcribed conversation are obvious, but we made a deliberate start for verbal exchanges to occur, between teacher and learner, and learner and learner.

The class talk deals with the graph that represents the relationship between the position of a lift in a multi-storey building at any given time, as discussed in Chapter 5 (under 5.10):

Teacher:	What do we have on the horizontal axis?
Learner:	[No learner response.]
Teacher:	On the horizontal axis. [The teacher repeats.]
Learner 1:	Seconds.
Teacher:	We all have seen a lift?
Learners:	Yes. [The learners answer in a choir.]
Teacher:	What happens when you go inside a lift?
Learner 2:	You press a button.
Teacher:	What is the function of that button? Why do you press it?

Learner 3:	To go up to another floor.
Teacher:	There is a drawing on page 10 (module 5). What is it about?
Learner 4:	No response
Learner 5:	It is the inside of a building
Teacher:	On the graph there is a line. What is the function of that line
Learner 6:	[No response.]
Learner 7:	[No response.]
Teacher:	Why do we have that line?
Learner 4:	[No response.]
Teacher:	It indicates the movement of the lift!
Teacher:	What is on the horizontal axis next to zero?
Learner:	30.
Teacher:	Next to zero?
Learners:	[In a choir] 10, 20, 30, …
Teacher:	And on the vertical axis?
Learners:	[In a choir] 1, 2, 3, 4, …
Teacher:	That is the layout of the graph.
Teacher:	Read exercise 4a.

a How many storeys are described in the graph? [Whole class read]

Teacher:	How many?
Learner:	4.
Teacher:	Read exercise 4b.

b How many seconds are described in the graph?

Teacher:	What is the answer?
Learners:	150 seconds.
Teacher:	All agree?
Learners:	[In a choir.] Yes.

c On which storey does the lift come to rest after 60 seconds?

Teacher: What does the graph tell you about time and distance?

Learner: [No response.]

Teacher: No idea.?

Learner: [No response.]

Teacher: Between storeys the lift travels in seconds, not in minutes, hours or days - in seconds.

Learner: [No response.]

Teacher: When the lift is in rest, the lift is not moving. Look at the graph carefully.

Learners: [No response.]

Teacher: On which storey does the lift come to rest after 60 seconds?

Learners: [No response.]

Teacher: Our line started from the ground floor. After 30 seconds the lift is on the second storey. If the lift is moving, the line is also not moving.

Teacher: But what about the seconds – do they stay the same?

Learners: [In a choir.] No.

Teacher: The seconds tick on.

The amount of interaction should be closely related to the nature of the material. The degree of interaction is much higher than is the case when there is not context. It would even be more beneficial to the learners if they were given the chance to first discuss or share their impressions with one another - especially with respect to the latter part of this dialogue. The material allows more time for such exchanges since writing and copying from the writing board is reduced substantially. Apart from the reason already mentioned, that is allowing the learners to have small group discussions prior to engaging the whole class, several other reasons could be forwarded as why there are so many "no response" from learners: not enough response time allowed, learner inhibitions, learner uncertainty, lack of understanding, etc.

In the latter part of the conversation where learners are unable to respond, the teacher is compelled to "openly revise" his "mathematical thinking" (Corwin, *et al.*, 1995:3). As such the teacher provides a model by expressing his "evolving ideas while working" (Corwin, *et al.*, 1995:3) on the problem. They continue by saying that learners "learn some of the *forms* of mathematics through taking part in classroom mathematics conversations. In the process of talking, students internalize these conversations as models for both thinking and problem solving. The process of talking about ideas may be as important as the ideas themselves".

Not only is considerably less time spent on copying notes from the writing board, but teachers also spend much less time writing on the writing board. More time is thus created for learners to discuss issues related to module content, there is more time created for teacher-learner interaction and conversation, as well as more time for questioning, reflection and feedback. There is more time for teacher facilitation as learners became increasingly willing and less inhibited with respect to sharing their own views or opinions. I detect a high degree of eagerness in weaker learners to try and succeed. The teachers' enthusiasm is transferred to other areas inside their schools, manifesting itself by assisting in computer lessons for fellow teachers in their schools, improved general school management, and participant teachers taking on leadership positions in the mathematics subject groups.

Most of the teachers express an interest in furthering their studies. Those learners with reading problems show a keen interest in wanting to learn to read. Teachers' subject knowledge as well as assessment skills improves.

The following strategies contributed greatly to the significant progress that teachers made during the course of this year:

- Working with small groups of teachers to allow for more depth and intensive intervention,
- Improved facilitation techniques (promoting understanding, trust, working with and portraying an interest in the teacher as a whole person (Fay, 1996),
- Thorough knowledge of our participant teachers with respect to
    1. needs
    2. teaching conditions
    3. knowledge and skills,
- Formation of strong and intimate educational relationships,
- Fortnightly class visits and lesson observation combined with post lesson observation reflection,
- Fortnightly focus group (Kelly, 2001; Nairne, 2000; Smith and Mander, 2002) sessions (a type of support group forum characterised by frank discussions and situational analyses),

- Quarterly informal sessions or social gatherings to bond (Covey, 1989; Kervin, 2003),
- Co-teaching and modelling certain OBE techniques,
- Regular telephonic conversation to check on teachers' well-being and progress (Loughran, 1997).

The teachers in this project at this stage appear to be more positive than ever before. The moaning and groaning of two years ago has made way for enthusiasm, eagerness and greater willingness to expose and improve themselves not only didactically, but holistically. Constant growth in the relationships among facilitators, researchers and teachers is evident, as are teachers' increased levels of confidence and their improved abilities. By now most teachers in the project have successfully made the transition to outcomes-based education; they have developed skills to facilitate small group learning more effectively; learner interactivity and talk time increased substantially. Learners, exposed to our interactive materials and teachers' positive attitudes, generally show an eagerness that tells us that we are on the right track.

One teacher who joined this project for the first time at the start of the third quarter 2004 claims that she, already during her first session with us, experienced Mathematics on "'n meer menslike manier" (*in a more humane way*). This idea ties in neatly with our philosophy of realistic Mathematics and teaching in context, allowing learners to make sense of and identify with themes from everyday life. This humanness should be viewed as an umbrella concept to also cover concepts such as support, honesty, constructive criticism, a sense of belonging and learning (Fay, 1996).

This humanness is also increasingly evident in classrooms where learners are allowed and encouraged to pose questions, prompted to say how they feel and given the scope to differ from teachers on the methods used to reach a solution.

I attribute the dramatic growth in teachers' professional development to a combination of factors such *as classroom visits, lesson modelling, workshops* and ultimately *the implementation of learning material in an overwhelmingly facilitation style.* All of this occurred within an Outcomes Based Education (OBE) paradigm. We are most encouraged that *more teachers ask to join this project.*

The Department of Education's curriculum advisors were impressed with teachers' improvement in *planning, facilitation and other teaching skills,* not to mention the anecdotes of *learner enthusiasm and improved performance in assessment tasks.* Despite adverse conditions such as large classes, lack of communication among teachers on the same staff, learners' reading problems and the multitude of other teacher commitments, there is progress.

Our relationship with the teachers in participant schools now spanned three years. In this time we had moved from a big West Coast project to a much smaller, more focused and intensive project. We had changed from a huge, clumsy, unwieldy elephant to a small but very dynamic Brave Maths Mouse (Project).

There were still obvious pedagogic and communicative short-comings and areas that needed to be developed further. Teachers' listening skills remained limited and ways had to be found to address this. Broadening of teachers' content knowledge seemed to be a pre-requisite if their listening skills were to improve. Their ability to rephrase questions to elicit and enhance learner responses also needed improvement and practice (Black and Wiliam, 1998b). The response time allowed for learners on teachers' questions remained problematic. Teachers generally still did not think constructively about the type and sequence of their verbal questions to steer their lessons (Brophy and Good, 1997). This was clear during most lessons observed. During discussions teachers admitted that they needed to specifically focus on this aspect of their teaching.

The formulation of verbal questions could still improve considerably. Another aspect that links on to this and that needed to be revisited was teachers' knowledge and use of different types of questions (closed, open, etc) and the impact of higher order questions (Brophy and Good, 1997; Riddell, 1993) to formatively assess (Black and Wiliam, 1998b; Lowery, 2003) and facilitate learning. Learner self-assessment and peer assessment were used too infrequently. Teachers needed to realise the important role of this strategy as part of formative assessment (Kulm, 1994; Stepanek, Jarrett and Peixotto, 1997). The frequency at which learners posed questions was still alarmingly low. We would have to pay particular attention to creating conditions in classrooms that provided opportunities and facilitate questions from learners to teachers (Confrey, 1991; Dillon, 1988; Hickman, 2002).

7.3.1 Assessing teachers' experiences generally

The following is a summary of teachers' individual perspectives of how they viewed themselves after two years of intervention. Their responses are based on the question posed at a focus group session held on 19 August 2004: in what respects do you feel differently compared to two years ago?

TWO YEARS AGO	TODAY 19 AUGUST 2004
Feeling scared (to speak my mind or to do things Dissatisfied with my work and position	More self-confidence. Knowledge and skills broadened. Greater responsibility; more learner-centred. Work satisfaction: I have become permanent; staff support increased substantially; access to further studies (IMSTUS). Moderation keeps you on your toes.
With respect to the many changes and commotion –felt very negative – I wondered whether I was in the right profession.	IMSTUS + NEW curriculum = challenge with respect to teaching. Feel positive to empower learners with mathematics (struggle subject) – try to present it in a different way – do everyday maths, eg interest on savings account – hire purchase, etc. Work satisfaction increases. I want to offer extra classes, start a maths club for learners and parents
Frustrated – circumstances and conditions uncertain – move between the learning areas. Not motivated.	Conditions at work improved; better equipped for disciplinary difficulties the learners and I enjoy the work. Work satisfaction: more support and more motivated parents; no money / functions. More positive
Negative attitude towards the curriculum and administrative tasks. Frustrations with respect to co-operation. Educators generally negative.	More stability; less frustration; more co-operation; attitudinal changes evident in some teachers. Work satisfaction increases: manage to get learners to think more independently; try to get parents to become more involved.
Not very enthusiastic; a novice – OBE new – more work Frustrated – had to work on my own mostly / been evaluated.	Very enthusiastic; much more matured, and more positive. Empowered, more self-confidence. Work satisfaction: I need to be more positive; more time should be allowed for planning; need to become more involved with learners; must be motivated; approach to the curriculum must be positive.

7.4 REFLECTION: CYCLE 3 (2005)

I detect a definite shift in relationships, that is, towards that of friends that share an intimate interest in teaching and learning of mathematics. Godfrey, one of the teachers at Laurie Hugo Primary School has become more involved in the project as one of the team of teachers. More sponsorship money becomes available, and we continue with school visits and lesson observation, the frequency of which is increased to one day per week. Fortnightly focus group sessions continue. The growth patterns in teachers are evident - they talk more freely about their shortcomings and needs; they have learned to reflect by consciously thinking and sharing what transpired during a lesson, and identify what went well, and what could be done differently. The pilot study has been expanded to include grade 8 learners, and teachers are committed to spending more time with one another and with Marina and Stanley as facilitators.

On 25 August 2005 I wrote the following: The pertinent question that I need to address here is the following: Am I making headway with respect to achieving our envisaged outcomes for 2005? In an effort to answer this question, I will report briefly on what has been achieved as far as the outcomes are concerned and to what degree it contributed to the quality of communication now prevalent in the classrooms that I frequent. This will be followed by a detailed discussion of crucial aspects - both positive and negative - that impact on the successes and achievements.

From my regular interaction and communication sessions with project teachers it is evident that they generally have significantly progressed on the road towards becoming more well-rounded, and more skilful teachers, increasingly able to understand and interpret learning content, and to facilitate learning. At this stage learning materials (modules) based on the large parts of the senior phase curriculum for both grades 7 and 8 have been completed. Feedback from teachers concerning learners' increased participation and anecdotes of positive learning moments provide ample evidence that teachers increasingly succeed in motivating and assisting learners to pro-actively participate in and accept ownership of their own learning. During classroom observation discussions and focus group sessions I observe that teachers have become adapt at applying certain crucial outcomes-based methodologies and implementing content knowledge, allowing learners to build their own knowledge constructs, exposing them to problem-solving strategies, etc. The balance between group work and individual work is essential. Teachers need to get the balance right. It is important for the learners to be able to work in a group to develop social skills, share knowledge and ideas, but at the same time the individual in the final analysis also has to take responsibility for her or his own learning.

Some of the grade 8 teachers are initially not comfortable with using the modules in their classes during this phase of the project. This can possibly be ascribed to the fact that using the modules in class meant that they needed to change their teaching styles, by facilitating more as opposed to transmitting facts. The material content and format differed from that of previous years (as pointed out in Chapter 5). However, by means of face-to-face inspirational talks and didactical guidance in the classroom teachers generally make satisfactory progress over the past six months.

I am concerned that generally teachers are not yet able to engage all learners most of the time. In this regard I made a deliberate effort to help teachers to be alert and adopt greater awareness of what happens or transpires in all groups or in the whole class at a particular instance. Classroom management is thus closely linked to the type of tasks learners engage in, as well as the quality of monitoring and facilitation by the teacher to direct or steer the learning process. I acknowledge that the act of keeping all learners constructively busy is adversely affected by large classes, the fact that some learners progress faster than others, that some learners suffer impaired concentration, etc.

Another issue that was addressed at several of our focus group sessions relates to the unsatisfactory management of learners' stationery. Too many learners are without pencils, pens, erasers and other equipment. This retards the learning process. It effectively means that those learners without equipment are idle and not effectively participating in classroom activities. It consequently also creates disciplinary problems. Strategies to counter this were discussed in detail and at great length, and it was eventually agreed upon that teachers needed to tackle this problem jointly as a team, and severally as classroom managers.

The use of mathematics material in modular format is experienced as very effective. There are currently very good textbooks on the market geared towards outcomes-based mathematics education. With this in mind project teachers are asked what they would prefer: "A good textbook or the research modules that we piloted during the study" They are adamant that they preferred the modules for the following reasons:

The teachers acknowledge the fact that textbooks currently found on the market can be quite useful, they however, prefer to use textbooks supplementary to the IMSTUS modules. Textbooks are thus mainly used to find different ideas for tasks, assignments, tutorials etc. According to the teachers a significant difference and positive aspect is that learners can work inside the module, it becomes their module, resulting in a much more intimate 'relationship' between learner and module (and its mathematics content). Mathematics textbooks cannot be used in this manner – the textbook always remains something extra, something external and separate to their notebooks. The module thus meaningfully and significantly merges notebook and textbook. They lose their erasers or pencils, but so far not a single module was lost. Teachers consider this to be quite remarkable, and we assume that this is indicative of the bond learners might have with THEIR modules.

The way in which the modules have been written – its format (refer to Chapter 5 and the addendum to see extracts from different modules) – provides the kind of structure that teachers want. It makes planning easier since outcomes and assessment criteria form an integral part of how material is structured – it provides continuity (a continuous line). The appropriate outcomes appear on the front page of each module. At particular phases inside the modules learners have to reflect on what outcomes were achieved.

No more time is lost through copying teachers' notes from the writing board. Also teachers have become less dependent on the writing board, and are allowed to facilitate the learning process more effectively. I feel that there might be something psychologically positive or beneficial with respect to the module format.

Because of this approach to OBE, namely that of realistic and contextual mathematics, teachers are convinced that learners feel compelled to read more – in fact the text is in their faces – the text confronts them – that is, they are thus compelled to read if they are to make sense of the mathematics. Here I am, read me! Some of the teachers claim that they detect improvement in some of the learners' reading skills, especially in weaker learners, and an overall increase in reading speed. Learners also tend to display a greater degree of enthusiasm than was previously observed. There is a stronger tendency to want to know what the text wants to say or convey. Learners are less inclined to copy from one another than was the case previously. Here we can definitely talk of integration of mathematics and language (that is in terms of reading, comprehension, spelling, etc).

Teachers are adamant that they definitely share the outcomes at the outset of a new module or lesson or series of lessons. Also during post lesson reflections learners have to determine which outcomes were achieved and which were not, what they enjoyed, what went well, and which section of the work were problematic.

The outcomes above are related to what we as facilitators observed inside the classrooms, in our conversations with learners and issues raised by teachers during our focus group sessions in the course of this 2005 cycle. It was obvious that learners spent much less time copying content from the writing board or from textbooks handed out and collected at the end of each class. Instead they had more time on their hands to interact with the material, by reading and making sense, more time to interact and share ideas with peers. Simultaneously the teacher could devote a greater percentage of time to facilitating and monitoring learners' needs, answer their questions and enter into meaningful discussions with them. It also allows the teacher to remain more conscious of what was happening in all the groups at one particular moment.

A summary of the most important findings and outcomes achieved are listed below:

- The idea of their *own* Mathematics modules in which they can work and draw has generally proved very motivating for the learners.
- Teachers focus less on neatness and correctness and concentrated more on the essential building of mathematical constructs; they ask more meaningful questions than in previous years and encourage group work.
- Teachers and learners are more positive about learning experiences, because of more success moments and less time spent on disciplinary matters.
- Teachers address learners' lack of reading skills by allowing learners to read the questions aloud as a group or individually, and then explaining the meaning of words.
- The material stimulates creative thought in teachers, enabling them to develop their own context-based examples.
- Teachers find assessment easier, as the material encouraged formative assessment. Assessment is increasingly seen as a way of identifying the special needs of each learner on his/her road of progress and using it for optimal learning;
- Learners are generally more confident and involved in their own learning process by actively participating in discussions, asking questions, helping their peers, working on their own without waiting for the teacher to spur them on and implementing a reflective way of self-assessment. Teachers increasingly create the circumstances or conditions that make this possible.
- Incidences and anecdotes shared with teachers indicate that there is an increased awareness and involvement of parents in their children's learning processes.
- The project team have developed a better understanding of critical success factors necessary to ensure sustainability for the years to come.

It must be noted that all of the above outcomes are relative to previous years or cycles and do NOT imply that we have "arrived" yet! Many hours of interaction, learning, reflection and change of behaviour are still needed to further enhance learning and teaching skills.

It is evident that project teachers are increasingly confident and share their own opinions and experiences with other teachers during cluster meetings of the WCED. It seems that the role of our regular focus group sessions is a very valuable way of developing teachers' ability to continually reflect on their own situations and teaching practices and share their insights with teachers outside of the project.

The following are crucial / critical issues that still need dedicated attention:

- Content knowledge of teachers is still inadequate. Consequently they experience difficulty explaining and facilitating learning in all aspects of the curriculum of the senior phase;
- Knowledge and understanding of implications of the curriculum of the FET phase for the Senior Phase need to be further developed.
- General classroom management linked to general management in the schools – learning (teaching) time is wasted in many ways and instances.
- Skills to productively engage learners optimally during the full lesson time need to be developed.
- Lessons must be less impulsive and should be more structured. It should be evident that the teacher did plan and think them through.
- Mathematical confidence in learners and teachers needs to be developed further.
- Teachers should be guided into showing greater willingness to become more open to learning and to allow facilitators to address their needs.
- Teachers and learners will have to increase their working pace. Learners' low levels of reading skills and consequent struggle to make sense, interpret and understand generally retard the learning process.
- The idea of homework must be instilled. Learners in the project schools generally do not do homework on a regular basis.
- Social issues outside the classrooms should in one way or the other be addressed to provide support to what teachers want to achieve inside the classroom.

Past experiences have helped us to realize that greater success can be accomplished by focusing simultaneously on all three aspects of the learning process: the educator, the learner and learning material. It is quite clear that educators not only need to improve their academic knowledge and familiarity with policy documents, but also develop didactical skills and their confidence and motivational levels to implement the present challenging curriculum. As such we focus on teaching methodology, assessment techniques, material development, attitude, classroom management, effective communication and questioning strategies, work schedules, lesson plans, the development of teacher and learner portfolios and other relevant issues.

Our successes are manifold and we strongly feel that the positive results can be attributed to our multi-varied project strategies and work ethics. In our dealings with project teachers we endeavour to maintain a healthy balance by not only focussing on the cognitive, but also on the social and psychological dimensions. This has proved to be very effective in addressing the needs of our project teachers through building up sound inter-personal relationships. On the other hand, however, it is important to state that we have had the luxury of working with enthusiastic teachers who really want to improve their knowledge and skills. They are open to critique and prepared to expose themselves to our intervention strategies. Respect is emphasised throughout. We have also come to realise the importance of an honest and open approach to pertinent teaching issues.

A number of learners have been interviewed to ascertain learners' conceptualization with respect to certain crucial aspects that deal with the development of the function concept. Simultaneously, we want to observe learners' development with regard to their communicative skills, which include the way they express themselves orally and use mathematical jargon, and get a sense of their logic and reasoning abilities.

From the interviews it is evident that the grade 9s are generally more advanced than the grade 7s and are able to articulate their ideas more successfully. The hesitation, inhibitions and anxiety that learners generally display during the interviews might be the reasons for learners' inability to express themselves adequately. Although the interviewer could sense that some learners (interviewees) know exactly what is going on, they are still unable to communicate freely and aptly by using the appropriate mathematics jargon.

On 04 August 2005 during a visit to Willemsvallei PS I have informal interviews with grade 7 and grade 9 learners, respectively, to ascertain their progress and understanding on the module dealing with coordinates and points on a system of axes. The interviews specifically refer to the following diagram:

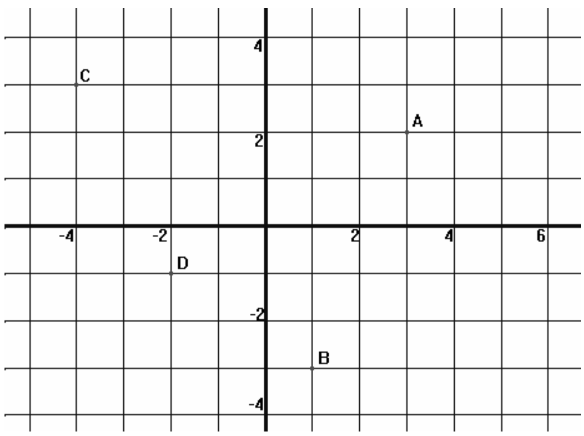


Figure 7.2 System of axis

Karin (grade 7.2)

The learners are busy with negative numbers, and coordinates. I am sitting next to Karin in the front row. The learners sit in pairs facing the writing board. She is in the process of plotting points in order to form the figure below.

S: What do you need in order to plot a point E on the system of axes?

K: She takes a long time to respond, then says, "Where to place the point?" (only now I realise that my question was actually ambiguous.)

S: I pose the question again, and rephrase it as follows: What do you need to determine or indicate where the point should be on the Cartesian plane

K: A ruler and a protractor.

Nazeem (grade 7.2)

S: What do you need to know in order to put/plot a point E on the system of axes?

N: Where I have to place it? He does not go further than this.

I then decided to address the question at the whole class. One of the learners shouts "numbers", another says "coordinates". In order to see how grade 9 fare with similar content, I also interviewed some grade 9s (referring to the sketch below):

Ferzaderick (grade 9)

S: Plot point Q

F: After a short period of consideration he responds by saying: How do I know which number the Q is? Is it only -2 or …

S: So what do you need to know?

F: Coordinates.

S: How many coordinates?

F: Two

S: Which two?

F: Any two on the system of axes.

S: In terms of which axes?

F: First the x-axis, than the y-axis. (Meaning the horizontal axis, first and then the vertical.)

S: What do the coordinates tell you?

F: *It tells me where to plot / place the point – where the two lines cross each other. For example*

X: -4 (go up); Y: +5 (go across – indicating to the left)

S: *There is a word I'm looking for – it means where the point lies.*

F *(He thinks)*

S: *It starts with a "p".*

F: *Position.*

It is interesting that this learner speaks in terms the x- and y-axes in stead of referring to it as the horizontal or vertical axes. He seems to know exactly what goes on in this instance. His ability to communicate mathematical ideas or subject terminology still lets him down at crucial moments, as for example when he says "How do I know what number the Q is"? Instead of asking, "How do I know where point Q lies?" or "What is the position of Q? or "What are the coordinates indicating / determining the position of point Q?". His immediate response to the first question indicates that he is aware of the fact that coordinates are used to plot the point somewhere on the system of axes. During one of our focus group sessions subsequent to a series of lesson observations, one of the teachers is of the opinion that the learner's first response reflects some inhibition, a certain degree of caution, preventing him from assertively saying that two coordinates are required to describe the position of a point accurately. Similarly, his response to the question: "What do the coordinates tell you?" is indicative of his understanding. However, his inability to use appropriate terminology is still evident.

It is evident that feedback from the teacher, in terms of the use of mathematical terms (such as coordinates, vertical axis, horizontal axis, etc), often serve as a "powerful model" (Corwin, et al, 1995:4) for learners. They further maintain that not only do learners "find the words that fit he ideas they, themselves, are expressing, but they will hear and gradually internalize (Cazden, 1988) words that highlight salient mathematical features they may not have noted fro themselves (Corwin, et al, 1995:4). In this manner for instance they will construct the concept "horizontal axis" and then learn the "conventional term that fits it", namely "x-axis".

Elaine (grade 9)

She is friendly and confident. I ask her where she stays. "On a farm near Voorberg (a large prison complex just outside of Porterville)", she replies. It is a wheat and cattle farm, not a fruit-growing farm.

S: Plot point Q for me. Would you do that? This I ask while pointing to the system of axes on page 6 of the module that deals with negative number and coordinates.

E: Yes (I cannot establish whether she is uncertain as to what to do)

S: Now do it.

E: She takes the pencil looks at the system of axes on page 6 of the module. She makes a dot at (-6; 1).

S: How do you know it is there?

E: I just decided to put it there.

S: But why there? Why not there or there? (I point to different positions on the Cartesian plane.)

E: It would be better if I place it inside an acute angle (points to the second quadrant)

S: I am not sure what she means by this. She is not able to explain what she means by this.

S: You cannot simply plot any point. What do you require? To be able plot the point where it should be? What do you need?

E: Coordinates (she says without hesitation).

S: How many coordinates do you need to indicate or plot a point?

E: Two

S: Which two?

E: X-axis and Y-axis

S: Which coordinate is placed first?

E: She hesitates for a moment. Then she says: "y-axis". She corrects herself by saying "x-axis" (May be she could read from the expression on my face that her answer was incorrect.)

S: You mean the x-coordinate is put first?

E: She nods affirmatively.

S: Suppose the point I wanted you to plot was indicated by Q(-4;4). Show me where you would plot it?

E: She indicates it correctly without struggle.

It is difficult to ascertain why she plotted the point where she did. She never asked me what coordinates to use. She might have been afraid to ask me. Her correct response to the last request shows that she knows what is required to plot a point on a Cartesian plane. It is possible that her ability to question or to be critical and assertive is not yet optimally developed within the classroom context. It is however possible that she would have responded differently to her peers or her teacher. Her mathematical language to indicate accurately what she tries to say should be developed further. The teachers should use learners' willingness to be engaged in conversation to mentally stimulate them, thereby enhancing learning.

This was an exercise in ascertaining learners' progress, and getting insight into their thinking processes. In this regard we still have a long way to go in getting learners to comfortably communicate their understanding and thinking in mathematics. In this regard it is also important to keep in mind that "when teachers are trying to improve the quality of classroom interactions, it is important for them to be aware of students' confidence level, attributional style, and perception of mathematics. If these aspects are not considered, even the most perfectly phrased question … may not elicit a thoughtful student response (Koehler and Prior, 1992:288)

7.5 ASSESSING TEACHERS' GROWTH IN USING FEEDBACK (EFFECTIVELY)

7.5.1 Assessment in general

All of the aspects that appear in the questionnaire were dealt with during workshops at a summer school in January 2002/3. Over the three years teachers' progress with respect of using feedback to assess learners formatively, was evaluated twice by means of a questionnaire, namely 29 April 2004 and then again on 08 October 2005 (Appendix F). Validation of the questionnaire occurred through input from co-researchers and experts in the Curriculum Studies Department at Stellenbosch.

The same questionnaire was used each time and only slight changes were made to remove ambiguities. It stands to reason that my involvement in this regard was ongoing and involved concentrating on feedback techniques or criteria as spelled out in the literature on feedback (Bonwell and Eison, 1999) during lesson observation. The reason for using a questionnaire was basically to ascertain whether discrepancies of differences existed between my perceptions and observational findings and those of the project teachers involved in the study. It should thus be viewed as an effort to triangulate (Borgia and Schuler, 1996; DuFon, 2002; McKernan, 1991) findings in this regard. After having stated each of the teachers' responses to particular questions, my viewpoint is shared in cursive print.

The first number of questions deal with feedback in general terms as it relates to their personal disposition of sending messages to, and receiving messages from the learners. Teachers strongly feel that they clearly own their messages by using personal pronouns such as “I” and My”. *My findings correspond to this view.* They are, however less emphatic about whether their messages are in fact complete, unambiguous or specific, and whether they indeed make it clear to learners to which word, idea or equation they are reacting. *There is still room for improvement in this regard. This is an aspect that needs to be revisited continually.* Teachers agree that their verbal and non-verbal messages to learners are mostly congruent. *In a certain sense they do what they preach.* To the question as to whether they often ask learners for feedback (as clarification) about how their messages are received by the learners, teachers are uncertain. *This was the case with both of the evaluations. Asking learners for clarification happens very rarely. Teachers seem to be apathetic of the blank stares of learners or the meaningless ‘yes’- responses that are sometimes forthcoming from learners.*

Teachers agree that they make a concerted effort to ensure that their messages are appropriate to learners by fitting it to their frame of reference. *Teachers have become increasingly aware of the importance of this as more emphasis is put on whether learners are in fact learning as opposed to teaching. We have come to an agreement that teaching outside of learners’ frame of reference is futile, therefore the emphasis is on meaningful contexts and a more realistic approach to the teaching of mathematics*. Most teachers tend to agree that they describe their feelings by name, action or figure of speech. *In this regard they more often say how they feel by expressing satisfaction or dissatisfaction. Often expressions of satisfaction such as “I then told you to…” or “I’m not happy with …” can be heard.* Teachers do not entirely agree that they verbally describe or acknowledge learners’ responses, behaviour or methods that lead to a particular feedback for instance by saying: “You said that …” or “Do I understand that you are saying …”. *According to my observations this kind of acknowledgement happens much more frequently now than in 2003 or 2004.* Teachers replied in the affirmative more strongly during the second evaluation to the statement as to whether they verbally describe learners’ responses without evaluating or interpreting it. *I detect that most teachers in fact evaluate and interpret learners’ responses based on their own preconceived expectations. This is not necessarily a bad thing provided that an open mind is kept to give credit to the learner’s response on merit.*

The following question also relates to the emotive responses by teachers, but in this case it is phrased differently: Assessing the same aspect in a different way is sometimes done to probe respondent uncertainties. *Interestingly in this case teachers strongly agree that the feedback that they give reveals their real feelings about a learner’s response in the form of surprise, approval, expressions of agreement, disagreement or disappointment. It needs to be said that teachers have become much more positive in their approach to teaching. They deal much better with their frustrations and are less inclined to giving negative feedback in* *the form of insults or attacking learners personally. This leads directly to an atmosphere much more conducive to discussion and sharing of ideas. Teachers generally agree that over the past two years learners in grades 8 and 9 have grown to become more responsive.* In one of my reports dated 23 March 2004 (after a visit to Willemsvallei PS) I wrote as follows (in an effort to substantiate this statement):

> *"One aspect that is heartening is the fact that learners do not hesitate to ask questions, nor are they afraid to explain what they think is happening, or how they understand a particular problem. It is evident that the teacher has made considerable progress in breaking down learner inhibitions."*

Timing of feedback has always been crucial to learning. In this regard teachers agree that feedback occurs as soon as appropriate or possible (immediately if possible depending on the circumstances prevailing). Allowing the learners the opportunity to assess their own performance by probing questions such as "How do you think you did" or "What could you have done differently?" was responded to as uncertain. *My experience is that teachers never actually prompt learners in this manner as a form of formative assessment, allowing learners the opportunity to self-assess.*

My perceptions correspond to teachers' response that they should develop and work on the strategy that involves starting with the more positive, then to address aspects that need improvement and end off be stressing the positive again. They are not sure whether they limit the amount of feedback at a given time to only one or two issues. *As far as I could detect feedback is rarely over elaborate.* In both evaluations, teachers are unsure whether they always suggest correct performance rather than emphasizing mistakes made by learners. *The sense of evaluating everything in terms of only right and wrong is still very strong and significant work still has to be done in this regard. Questions that allow sharing of viewpoints need to be used more.*

Teachers agree that they concentrate on skills and actions that can be changed. *There are numerous incidents where this was evident. One shortcoming that we agree on (even though responded to as uncertain for the second questionnaire evaluation) is the fact that they almost never ask learners to summarise outcomes related to discussion to ascertain what learning has occurred. This is one of the issues we pertinently address in the development of the learning material (mathematics modules).*

7.5.2 Teachers' questioning skills

The following questions deal with teachers' questioning techniques. Teachers deny that their skills with respect to all aspects of questioning are adequate. They admit that they do not actually plan key verbal questions (prior to teaching lessons) to provide structure and direction to their mathematics lessons*. We very often talked about this.*

For some reason teachers have never got to the stage where they addressed this issue. By developing mathematics learning material some effort is made to address this, but for practical reasons this is not always possible. These questions actually reveal a teaching approach to a particular topic and need to be applied in a way that prompt learners' thinking and give direction to a lesson. This is especially evident where a teacher has to teach the same lesson for instance to four different grade 7 classes on the same day. By the time he of she has to teach the final lesson it is apparent that a lot of thinking had occurred in the teacher's mind and progress related to lesson methodology was evident. At that stage of the day the questions posed are phrased much better, questions are much more direct, much less rephrasing of questions occurred, problems related to wording and the use of more appropriate words have been sorted out during the previous lessons.

The fourth group thus had the advantage that the teacher is much "better prepared". It is "this preparation" in practice, or at least much of it that should be done prior to the first lesson. Here it is a case of "practice makes perfect". It should be stated that this last lesson flows much better, the teacher is much more confident, much more aware of his wording, and much more alert as to when and how to phrase questions to elicit responses to make the lesson flow, and the learners respond better to questions that are pertinent and well-phrased. Consequently more learning occurs as well.

Teachers' reflective nature (Le Grange, 2001; MacIsaac, 1996) towards their teaching methodology needs to be developed further if they were to grow in this regard. There is still much room for growth and they need to make a deliberate effort to improve their questioning techniques, and be constantly aware of its importance in improving their teaching skills.

The next section of the evaluation questionnaire deals with teachers' uncertainty as far as taking special care in phrasing questions "clearly and specifically". Teachers are generally of the opinion that they have the ability to adapt questions to the level of their learners' abilities. *I found evidence of this during lesson observations, but this aspect is still being developed further*. Teachers responded as uncertain as to whether they pose questions logically and sequentially, as well as to whether they pose questions at various levels of difficulty during the first evaluation. *It is evident that they do not consider these issues, or in* *fact dealing with them during lesson preparation. Teachers' questions in class are very much restricted to knowledge recall, application of knowledge and rules, and algorithmic procedures. This is in line with their response that they do not predominantly pose higher order questions. In fact these types of questions were very seldom encountered. During the second evaluation there is a greater degree of certainty as to the use of different question types. This is linked to the use of the modular learning material which reflects a well-balanced assortment of higher order and open questions to stimulate learners' thoughts.*

Teachers agree that they normally follow up learners' responses by a declarative or reflective statement such as: "So you say that …" or "Do I understand you correctly …do you mean …?", or by declaring perplexity over the learners' responses, and sometimes also prompt learners to elaborate on their responses.

7.5.3 Dealing with learners' responses

The way in which teachers handle learners' responses has the potential to facilitate and enhance discussion. Some of the questions posed to learners deal directly with how teachers manage what they consider to be right and wrong answers. Teachers are adamant that they (more so during the second evaluation) do complement and reward learners for their verbal contributions, by giving them the assurance that it is good to at least try, even if they are unsure if the answer is completely right. *This may be so but it seems that criticism still tends to come easier. At the same time it needs to be said that I detect a deliberate effort being made by teachers to be less harsh and much more subtle and accommodating, and not to scare or intimidate learners.*

They also agree that in cases where learners fish for the right answer those learners are requested to commit to one answer only. In cases where learners are inhibited, unwilling or unable to answer, the question is repeated, or a hint is provided, or the question is rephrased. With respect to posing another question that will lead to the same solution they were not sure. Teachers gave varied responses as to whether they avoid getting upset or impatient when a learner resists answering a question - some were uncertain while other disagreed. They agreed that they try to get learners to think aloud rather than saying nothing. *This is however more difficult than it sounds as many learners just refuse to share an opinion. This seems to be more so with grade sevens coming from the intermediate phase (grades 4 to 6).*

Initially teachers generally have difficulty in adapting, changing or rephrasing 'the same' question to prompt learners to respond or to elicit comments from learners who were unsure of themselves. Over the three cycles teachers become more adept at doing this. They tend to rephrase with much greater ease.

Dealing with wrong answers or responses is always a very delicate process. A special effort needs to be made not to discourage or embarrass learners. Teachers either strongly agree or just agree that they correct wrong responses without discouraging learners. Some agree or were uncertain as to first seeking help from the learner's peers in a constructive manner before correcting the particular learner. Most teachers disagree with the statement that they make sure "the right answer or solution is shared with all learners before continuing with the next question or section of the work". *Sometimes when a response forthcoming from a learner is not audible to the whole class, the teacher either needs to repeat it or some learner should do so to ensure that all learners have understood what was said. Teachers have, however, grown in the way they use wrong answers and responses to enhance awareness and facilitate learning and concept development.*

Teachers agreed that they provided hints to assist learners to find the solution. They responded that they were either unsure or did not really avoid the use of "Yes, but …" responses although it might send out a negative message to learners. To the question as to whether they frequently ask questions with more than one answer possible, they responded as uncertain. *I cannot recall that I have observed, nor recorded anywhere that this ever happened. Even occasions where learners used different problem-solving strategies for the same problem were not frequently encountered.* Teachers were uncertain as to whether they allowed at least 5 seconds response time to learners. *Allowing adequate time for learners to respond, and also accommodating the slower learners remain a real problem. Teachers have, however, become increasingly aware of the significance of allowing adequate time. Yet, teachers still tend to want to say too much too soon.*

Let's reflect on the following discussion between a teacher and a grade 7 learner. It should be noted that discussions of this nature was extremely rare two years ago. This in itself is a great accomplishment. At this stage, (25 October 2005) taking into account where the learner comes from (the Intermediate phase where learners are not necessarily exposed to peer conversation and expressing their own points of view to the teacher), the new grade 7s have only been exposed to our mode of teaching for about 7 months.

T: Here with me is Robert Maarman grade 7.2. How do you experience the mathematics class thus far?

R: I enjoy it, Sir.

T: And if you compare this year with last year (grade 6)?

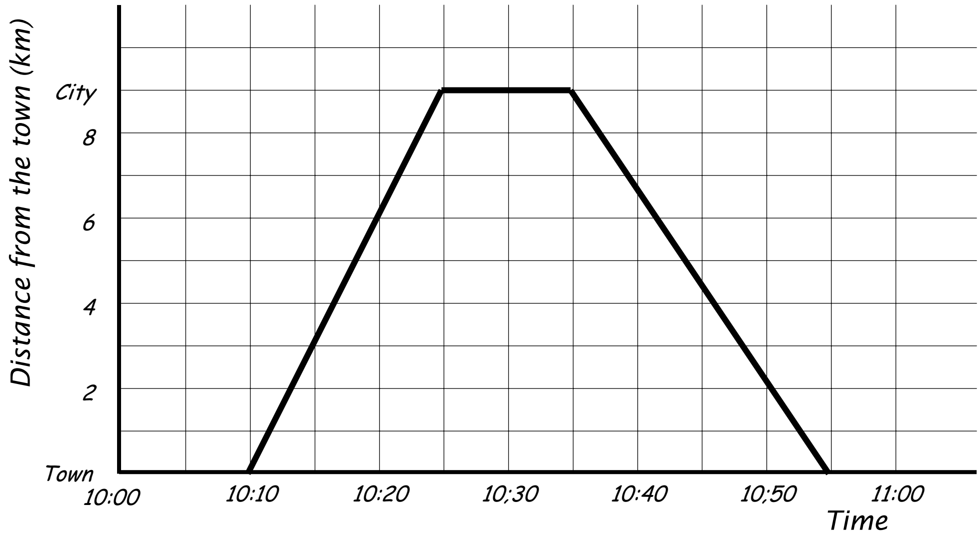
R: The help that I get from you is better than I received from teacher X last year, Sir.

T: And what do you think of the module booklets that we use?

R: It is nice, Sir.

T: Is it OK. ... What is happening here at activity 6 if you look at the sketch. What is the graph about?.

The following graph tells the story of a motor car trip between a town and a city.



a At what time did the trip start?

b What distance, in km, is already covered by 10:10?

c For how long did the driver remain in the city?

d At what time did the driver return home?

e How far (in km) is the town situated from the city?

f How long does it take the driver to travel from the town to the city?

g At what speed does the motorist drive to the city?

h Did the motorist drive faster or slower on his way back from the city to the town? Explain.

(van Etten, 2005:12; Module 5)

Silence – while he studies the graph.

R: It is about a motor car trip – between a town and a city.

T: Right. Ok uhm ... if you look at the town and if you look at the graph of the city ... what can you conclude? How does the part of the graph that depicts the trip to the city differ from from the part where he goes back to town.

Silence (for about 5-8 seconds).

R: His trip to the city went quicker than his return trip to town.

T: Where can you see it on the graph?

R: Here by the first line (pointing along the part of the graph that runs diagonally upwards), and at the other part the line is more spread out (meaning that the slope is less steep compared to the first section).

T: Another thing I want to ask you is - when you look at the graph – what is represented by horizontal axis and what is represented by the vertical axis?

R: The distance from the city in kilometer is represented by ... uhm....

T: Is it the vertical or horizontal axis?

R: The vertical axis

T: OK.

R: The time is the horizontal axis.

T: The time is the horizontal axis - OK.

T: How far is the town situated from the city? If a person could read from the graph – how far is the town from the city?

R: 9 kilometers

T: Where do you read off 9 km?

R: There where ... [silence].

T: It is 9 km, but where do you read it off on the graph?

T: On the vertical axis.

T: The vertical axis (he repeats). So your km is on the vertical axis? Look at the graph quickly. Now I must tell you – on this graph the time is nowww ... each space between two consecutive lines represents 5 minutes ... at what time did he start his trip?

R: To travel ...?

T: Yes, starting to travel from town, ...

R: [silence – he studies the graph] 10 minutes past 10.

T: 10 minutes past 10 (he repeats) and at what time did he arrive back home?

R: 11:00

T: Are you sure? Look again.

The learner looks but cannot seem to see his mistake. The teacher points out to him that it is actually 10h55.

T: How long did he remain in the city?

R: 10 minutes

T: 10 minutes. Each space represents ...?

R: 5 minutes

It is interesting that the teacher begins the conversation with open-ended questions, prompting the learner to respond, and allowing the learner to ease into the conversation. Interestingly the responses are very short. The learner's body language suggests that he is sincere and that he really means what he says. Most questions that follow are simply aimed at ascertaining whether the learner can make sense of what the graph represents, and not really higher order questions that would compel the learner to make deductions or interpret. This is, however, a good start. If the learner is consistently exposed to exercises such as this, a conversation such as this one should reflect much more elaborate and insightful learner responses. These moments of verbal interaction at least create opportunities for the teachers to listen to (and not only for) his or her learners, and not merely telling or transmitting information (Davis, 2000).

7.5.4 Formative assessment skills

Formative assessment needs to be a transparent and democratic exercise. Teachers (unlike during the first evaluative questionnaire) have become increasingly aware of and responsive to their responsibility in this regard. They agree that they were sharing learning outcomes with learners, as well as providing information as to why a particular part of the work was deemed to be relevant or essential. For some it took longer to get into the habit of sharing outcomes on a regular basis. The learning outcomes appear on the first page of the pilot modular learning material. These outcomes are in line with the RNCS and compel teachers to work through each meticulously, informing both teacher and learner of what the focus would be. Learners are constantly invited to make verbal contributions and teachers try build and expand on these.

As facilitators we have to a large extent succeeded in helping teachers to see grades 7, 8 and 9 as levels of the same phase, with less emphasis on the individual levels. This assists teachers in being less worried about covering all aspects of the curriculum in one year, but to manage and organise the curriculum in a way (through integration of learning outcomes in mathematics) that ensures continuity and growth. This shift in attitude and approach allowed teachers more freedom to get learners to construct meaning and explore. Teachers still need to grow as far as devising tasks that allow learners to construct their own knowledge is concerned.

The emphasis is still too much on knowledge and application of knowledge (earlier discussed under questioning). Constructivism as the philosophy of learning, underlying outcomes-based education needs to be emphasised more regularly since its significance has not yet been fully realised. They responded as being unsure whether the tasks devised by them indeed foster a constructivist approach to learning during the first evaluation. *With* *the development of our modular learning material we made a deliberate effort to create opportunities allowing learners to a great extent to construct their own knowledge.*

Teachers have definitely become adept at facilitating small group learning and agree that they in fact allow learners to work on a common outcome in small groups more so now than before. Teachers view positive encouragement of learners as very important, although they are not sure whether they use specific and focused comments. I think they were not clear on what the particular statement in the questionnaire meant, but based on my observations their comments have become more specific, focused and useful. Although they strongly encourage learners to help their peers, I think that the importance and impact of this is not optimised. Another facet that needs to be developed further is peer assessment.

7.5.5 Teachers' listening techniques

As far as the development of their listening skills are concerned we still have a long way to go as teachers still operate mainly on the Davis'(1994) first two levels of listening. Teachers agree that when a question is posed to learners they mainly listen for a particular answer. At the same time, however, teachers are not sure whether they evaluate the learners' responses by judging it as a preconceived standard or answer. They apparently did interpret these two consecutive questions to have the same meaning. Also with the question that states "My primary reason for asking questions is to find out whether the learner knows the right answer", they did not want to commit themselves. Then again they agree that they listen primarily to assess the learners' acquired knowledge.

At the same time teachers also now say that they listen to the subjective sense that learners make when responding to their questions. *It is, however, questionable whether they have the skills to make complete sense of what learners say or sometimes fail to say.* Teachers agree that they reflect by frequently questioning the deeper meaning of their ideas or answers in relation to the learners' responses. *Compared to the previous evaluation when they were either unsure or disagreed, they now generally seem to be more aware of learners' responses, and more reflective in dealing with it.*

7.6 CONCLUDING REMARKS

This action research study was aimed at ascertaining the importance and role of communication, in particular feedback, in enhancing formative assessment inside the mathematics classroom. During the first cycle it was evident that conditions inside the mathematics classrooms were preventing or hampering this from being realised. To put it differently – if we as researchers were to assess the nature of communication patterns inside the mathematics classroom, then at least those communication patterns needed to exist. What we found was that teachers were generally in control of all aspects of their learners, and that communication was mostly a type of monologue with very little response from learners – closed questions characterised by "yes" or "no" answers were the order of the day. The feedback from learners if not ignored (maybe not deliberately) was not optimally utilised to enhance learning. Teachers seldom displayed the ability to engage learners meaningfully or reflect consciously about what they were doing.

As a research team we intentionally intervened to address and counter those 'intervening' factors, and made a constructive effort to create conditions where dialogue and communication among peers could flourish. These actions of intervention involved creating an atmosphere conducive to constructivist teaching methodologies, training teachers in managing and facilitating small group work, making teachers aware of and training them in aspects related to feedback, listening, and questioning, and introducing modular learner material to optimise teaching and communication time.

In the course of time we (as project team) realised that limited subject knowledge was one of the main reasons why teachers lacked the ability to engage at a much higher level with learners. This was what was preventing them from operating at Davis's (1994, 1997) hermeneutic level of listening. Learners' reading problems were directly addressed by the modular learning material by confronting them with text, teachers and learners were simultaneously exposed to relevant contexts and a wide range of question types as suggested by Bloom's (Bell and Fogler, 1995; Curzon, 1985) Revised Taxonomy.

Form the outset we realised the importance of whole teacher development. If classroom communication was to be developed and enhanced, we needed to have enthusiastic teachers willing to develop themselves holistically, and expose themselves to our critique and intervention strategies. We succeeded in forming a support group through regular classroom visits and fortnightly focus group sessions, together with occasional social gatherings. All of these had a definite therapeutic effect on teachers' growth and commitment to improve. The progress that we made with respect to communication is summed up by Bryan's words (during a focus group discussion on the importance of questioning (which directly relates to listening and formative assessment) on 06 September 2006:

> *"The workshop on questioning that we had previously (some time ago in 2003), and the facilitators' guidance made me aware of the importance of questioning. As a result I am always conscious of the importance of phrasing questions correctly, and of making sure that learners properly understand what I want them to do or to answer."*

Fullan (cited in Hammonds, 2002:3) argues that learners' learning "is enhanced when they understand what is expected of them, when they get recognition for their work, learn quickly from their errors, and receive guidance in improving their performance". Furthermore, awareness of higher and lower order questioning should also reveal knowledge and the ability to distinguish between the two. Ability as to when to apply higher order questions to stimulate and advance higher order thinking not only to "arouse curiosity and interest" to focus learners' attention, but also to "elicit views, feelings and experience", thereby stimulating discussion, (Fisher, 1995:16) need to be further developed. Teachers, however, towards the latter part of the project apply questions in a much broader sense than merely assessing recall of knowledge, that is, more than merely checking understanding, revising or diagnosing difficulties. They also used questioning to prompt learners to share their own viewpoints and experiences.

Apart from addressing issues related to feedback and communication we also made an effort to provide educators with "the tools to engage in change productively". We as a research team inevitably also dealt with Fullan's (1993:2) "four core capacities for building greater change capacity: personal vision building, inquiry, mastery, and collaboration". Not only have we created instances for teachers to reflect on why they "came into teaching" (Fullan, 1993:3-4), but also developed inquiry in order to form and reform personal purpose. We furthermore used "mastery" to develop effectiveness and "deeper understanding", through "collaboration" (Fullan, 1993:5).

In this study we have managed to increase teachers' awareness and knowledge with respect to issues addressed in the research questions in Chapter 1. More importantly, however, is the fact that these four teachers have grown significantly holistically, and have become much more skilful at managing learning through improved questioning, communication (feedback) and facilitation skills. Our teachers' development and growth in confidence are evident in the sense that both Bryan and Pedro are being used by the WCED to help run workshops for teachers. All of them also make valuable contributions at the cluster meetings arranged by the WCED for mathematics teachers.

Does this dissertation in any way contribute to the enhancement of the learning of mathematics in general and to the Senior Phase Mathematics learning in particular? Without hesitation I would say yes. In the South African context I have not come across any literature that deals with feedback in such an in-depth manner, or dealing with feedback analytically in terms of both questioning and listening and its impact on formative assessment. Not only is the origin, meaning, and application of feedback as it relates to communication, formative assessment and mathematics learning researched, but ways to improve communication patterns in the classroom are action researched as well.

Next, it is quite possible that critics would ask whether this intervention model would be practical or economically viable. Maybe such a model would be too expensive, but if we want to make a significant impact or bring about noticeable change we have to start treating teachers as human beings and not as mere bricks in a wall (Pink Floyd) or as just spokes in a wheel. The diverse needs of teachers have somehow to be recognised and addressed. If the well-being of the nation is our major concern, our actions should reflect just that. Affordability should thus not be an issue. It remains a given that there are and were many factors that we had no control over, that either retarded progress or prevented progress. Another concern is sustainability. After 3 to 5 years of intervention and corroboration one wonders what measures can possibly be built into a project such as ours to ensure that teachers stay on a 'high' and maintain a certain quality of professionalism? In this regard at least three of the project teachers have expressed the wish to study further.

At this stage it may be opportune to pose the following questions: Who needs to read this? Who could benefit from this research? The content of this dissertation has important implications for the improvement of communication in the classroom generically, but specifically for the learning of mathematics at school level. This dissertation contains a body of knowledge that is systematically organised and to my mind contains most elements that are crucial for enhancing the learning of mathematics in particular.

This research creates opportunities for further research in a South African context. The following are some of the research questions that might be worthwhile pursuing through qualitative research:

- In what way(s) do(es) classroom organisation hamper or enhance communication in the mathematics classroom?
- In what way(s) do(es) classroom management facilitate classroom communication.
- Is there a difference in learner achievement between quiet classrooms and noisy (learner peer conversation) mathematics classrooms. Why?
- How can teachers be assisted to ascertain the levels of learners' development in terms of Piaget or Van Hiele, for instance, to make knowledge more accessible and interesting to learners in particular grades, and to inform their teaching on an ongoing basis?
- How can pre-service students be guided in their classroom orientation and practical teaching to effectively apply listening, questioning and feedback in order to prepare them for their role as facilitators of learning?
- How can mathematics be made more accessible to second or third language speakers.

My experience in this study raises the following question: How can carpenters or builders be accurate or creative if they do not know how their tools can be used or do not possess the required knowledge of the qualities of the materials (wood, etc) or how to use their skills to enhance what they are doing? In the same vein, how can communication – as means to facilitate understanding and learning – be effective if teachers do not continually, that is on an on-going basis – realise the power of their communication tools such as listening and questioning to enhance feedback? The curriculum writers and trainers of student teachers and in-service teachers need to revisit the curriculum to reposition the role of communication and specifically that of feedback, listening and questioning. Apart from ensuring that teachers' content knowledge goes deep enough, teaching methodologies should be geared towards establishing communication patterns that compel both learner and teacher to speak about mathematics and create frequent opportunities to be involved in discussing issues related to the content, and problem-solving.

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APPENDIX A: CONTRACT WITH PARTICIPATING SCHOOLS

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imstus

INSTITUTE FOR MATHEMATICS AND SCIENCE TEACHING UNIVERSITY OF STELLENBOSCH

INSTITUUT VIR WISKUNDE- EN WETENSKAPONDERWYS

STELLENBOSCH UNIVERSITEIT

Contract of co-operation between ______________________________________ (school) and IMSTUS in 2002/2003

The West Coast Winelands Schools Project is aimed at supporting teaching and learning of Mathematics and Natural Science. IMSTUS believes that this initative can be successful.

IMSTUS accepts responsibility for realizing the following outcomes for 2003:

- dat onderwysers aan die einde van hierdie tydperk oor meer Wiskunde- en Wetenskap kennis beskik*; educators would have acquired more Mathematics and Natural Science content knowledge;*
- dat onderwysers aan die einde van hierdie tydperk oor beter didaktiese vaardighede sal beskik volgens die eise en verwagtinge van Kurrikulum 2005; *educators would have acquired better didactical skills according to the expectations contained in Curriculum 2005;*
- dat die twee-of drieweeklikse besoeke van 'n fasiliteerder aan u skool, volgens 'n voorafbespreekte program, gerealiseer is*; fortnightly or three-weekly school visits by a facilitator would be realized;*
- dat onderwysers aan die einde hierdie tydperk beter begrip van deurlopende assessering, sal beskik*; educators would have a better understanding of continuous assessment;*
- dat onderwysers beter toegerus sal wees betreffende die konseptualisering en implementering van aktiwiteite wat aanpas by die omstandighede, behoeftes en milieu van u skool; *educators will be better equipped as far as conceptualization and implementation of activities that suit conditions, the milieu and the needs of the school are concerned;*
- dat nuwe materiaal, wat aansluit by die leefwêreld van die leerders, in Wiskunde en Natuur- en Skeikunde ontwikkel is vir implementering; *new material linked to learners' life experiences, in Mathematics and Natural Science will be developed;*
- dat vakkomitees in skole en/of clusters gevestig is om vakverwante-gesprek tussen kollegas van naburige skole te ontwikkel; *learning area committees in schools and / or clusters are to be formed to develop subject-related communication among peers of neigbouring schools*
- dat IWWOUS se insette voortdurend ge-evalueer is deur middel van deurlopende evaluering / *that IMSTUS' input would be assessed be means of continuous evaluation;*
- dat IWWOUS aan onderwysers, wat aan die voorgeskrewe kriteria voldoen het, 'n sertifikaat aan die einde van die tydperk sal oorhandig; en / *a certificate would be issued to those educators at the end of the project who qualify with respect to the prescribed criteria; and*
- onderwysers vooraf in te lig oor die meetinstrumente wat gebruik gaan word om die kwaliteit van die intervensies te bepaal.*; timeously inform educators about the measuring/ assessment instruments / to be used to assess the quality of the interventions.*

DIE SKOOL ONDERNEEM OM / The school undertakes to:

	Ja/yes	Nee/no
▪ hierdie inisiatief as deel van 'n "hele skool"-benadering te bevorder / *promote this initiative as part of "whole school" development*		
▪ onderwysers sal aanmoedig om die twee IWWOUS-werkwinkels by te woon / *encourage educators to attend the two IMSTUS workshops;*		
▪ onderwysers sal aanmoedig om die netwerkvergadering een maal per kwartaal by te woon; *encourage educators to attend the cluster meeting once every term*		
▪ onderwysers aan te moedig om met mede-onderwysers van naburige skole saam te werk; *encourage educators to develop working relationship with educators of neighbouring schools;*		
▪ die fasiliteerder(s) by die skool te ontvang en konstruktief saam te werk ter bevordering van onderrig en leer; *to receive facilitators at the school and to work with them in a constructive manner;*		
▪ die fasiliteerder(s) in die klasse te ontvang / *allow the facilitators to observe lessons*;		
▪ waar nodig met IWWOUS te skakel in verband met organisatoriese en/of vakspesifieke aangeleenthede*; make contact with IMSTUS to sort out organizational and / subjected related matters when problems arise;*		
▪ Graad 9 leerders aan te moedig en te ondersteun om Wiskunde en Natuur- en Skeikunde op Hoër Graad in Graad 10 – 12 te neem; *encourage and support grade 9 learners to take Mathematics and Natural Science on the Higher Grade in Grades 10 to 12;*		
▪ die materiaal wat deur IWWOUS ontwikkel en aanbeveel word, te gebruik; *use the materials developed and recommended by IMSTUS;*		
▪ die onderwysers te help om binne vakgroep te vergader en vak-vergaderings binne die skool te hou; *assist educators in forming subject groups and to meet regularly to discuss subject related matters.*		

HIERDIE KONTRAK WORD BEËINDIG / This contract is ended

- indien die vennote oordeel dat die moontlikheid tot redelike verwesenliking van die uitkomste nie meer bestaan nie; *if the participants deemed the realization of the project outcomes not to be possible*
- indien omstandighede ontstaan wat sinvolle voortsetting van die projek in die betrokke skool in die wiele ry; *if circumstances exist within a school that would prevent meaningful continuation*
- indien fondse onvoldoende is / if funds are insufficuient.

Handtekening: Skoolhoof Signature: Principal	Datum / date
Handtekening: betrokke onderwysers Signature: teacher concerned	

Handtekening: Direkteur IWWOUS/fasiliteerder? Signature: Director IMSTUS / facilitator	Datum / date

Kriteria vir 'n Wiskunde en/of Wetenskap sertifikaat:
Kriteria for issuing a Mathematics and / or Natural Science Certificate
Sertifikaat A:

- ***'n*** *100%* ***bywoning van*** *alle* ***kursusse en werkwinkels***
  a 100% attendance of all courses and workshops

- 'n **75%** Bywoning van **alle** clustervergaderings.
  a 75% attendance of all cluster meetings

Sertifikaat B:

- ***'n*** *100%* ***bywoning van*** *alle* ***kursusse en werkwinkels***
  a 100% attendance of all courses and workshops

- 'n **75%** Bywoning van **alle** clustervergaderings.
  a 75% attendance of all cluster meetings

- 'n Leerdertaak afgelê deur Gr 9 leerders om te bepaal of daar noemenswaardige verbetering in leerderuitkomste plaasgevind het gedurende leerders se Gr 8 jaar en deel van graad 9 jaar;
  a learners' task completed by Grade 9 learners to determine whether they made significant progress towards achieving the learning outcomes

- 'n Leerdervraelys ingevul deur leerders aan die begin en einde van 2003.
  a learner questionnaire completed by learners at the beginning and end of 2003.

APPENDIX B: LETTER OF CONSENT SIGNED BY TEACHERS

Letter of consent

We, the undersigned, hereby give consent to the following project intervention actvities:

To allow Mr Stanley Anthony Adendorff (IMSTUS facilitator) to visit our classrooms to observe and participate in lessons presented by ourselves.

To allow Mr Stanley Anthony Adendorff (IMSTUS facilitator) co-teach or present demonstration lessons.

To cooperate and part-take in the intervention efforts, focus groups sessions and lesson reflections as democratically decided upon.

To implement and use modular materials developed by IMSTUS in our classrooms in an effort to address communication and reading problems by changing our classroom management.

To allow Mr Stanley Anthony Adendorff to take pictures and make video-recordings of our lessons.

To allow Mr Stanley Anthony Adendorff to use these pictures in his doctoral dissertation.

To give Mr Stanley Anthony Adendorff permission to use our actual names in his dissertation.

To give Mr Stanley Anthony Adendorff permission share his findings in a manner that is both professional and honest.

Signed on the .... at ....

Catherine Coetzee: ....

Arthur Adonis: ....

Pedro Fortuin: ....

Bryan Pieterse: ....

Godfrey van Aarde: ....

Kayleen Lombaard: ....

Ingrid Barbery: ....

APPENDIX C: TEACHERS' PROFILES

WESKUS-WYNLAND PROJEK (PIKETBERGKRING 6)

3 PERSOONLIKE INLIGTING van die WISKUNDE-ONDERWYSER

Confidential infromation of the Mathematics Teacher

Name en van/ *Names & surname*: ....
Skool / *School*: ....
***Telefoonnommers*: 1. Skool /*school*: (.....) .... 2. *Huis/ home*: (....) ....**
Telephone numbers 3. Sel / *cell*: ....
4. *Faks* **/ *fax*: (....) ....**
Aantal jare betrokke by wiskunde-onderrig / years expereince as a mathematics teaching: ....

1. Tot op watter graad voel u gemaklik om wiskunde te onderrig/ *Up to what level do feel comfortable teaching mathematics*: ....

2. Is wiskunde die leerarea waarin u oorspronklik opgelei is (die leerarea waarin u op kollege of universiteit gespesialiseer het) om onderrig te gee? / *Have you been trained as a mathematics teacher initially (is it your field of specialization)* ....

3. Wat dink u is u sterk punte sover dit wiskunde-onderrig betref? / *What are your strengths as a mathematics teacher?*
....
....

4. Wat is u behoeftes/probleme in wiskunde-onderrig wat u voel dringend aandag behoort te geniet / *Share the problems / needs in mathematics teaching that you feel require urgent attention:*

4.1 Leerarea-inhoud (eie vakkennis) / *Learning area content (own subject knowledge):* ....
....
....

4.2 Onderrig-metodes / *teaching methodology*: ....

4.3 Deurlopende-assessering / *continnuous assessment*: ....

4.4 Organisasie en Administrasie / *organization and administration*: ....
....

4.5 Klaskamer-atmosfeer / *classroom atmosphere*: ....
....

4.6 Ander/*Other*: ....
....

5. Wat het vir u die meeste gedurende die afgelope 4-5 jaar ten opsigte van die leer en onderrig van wiskunde verander? *What were the most radical changes with respect learning and teaching the past 4 – 5 years?*
....
....

6. Wat stel u u self ten doel hierdie jaar? *What are your objectives for this year?*
....
....

7. Wat verwag u sal die fasiliteerder doen of moet doen?/*What do you expect of the facilitator?*
....
....

APPENDIX D: LESSON OBSERVATION SHEET

MATHEMATICS: CLASSROOM OBSERVATION FORM*

NAME: ______________________ SCHOOL: _______________________

CLASS:__________ PERIOD: ________ DATE: ____________________

Directions: Rate the teacher on each aspect, allocating the highest value for unusually effective performances. In the space provided before each statement, place the value that most closely reflects your rating.

Excellent	Outstanding	Good	Fair	Requires attention	Not Applicable
5	4	3	2	1	NA

_______ Outcomes for this lesson were made clear to learners
_______ Lesson was well planned and organised
_______ Presentation style was appropriate and effective
_______ Relevant examples, metaphors, analogies used to establish connections with learners' previous experiences and learning
_______ Lesson time was well managed
_______ Critical thinking and analysis were modelled and encouraged
_______ Teaching techniques required most of the learners to be actively involved
_______ Respect for diverse opinions was communicated
_______ Warm, accepting, open classroom atmosphere was evident
_______ Teacher interest in information was communicated
_______ Teacher interest in learners' learning was communicated
_______ Teacher mastery of learning area content was evident and thorough
_______ Appropriate and effective use was made of audio-visuals, computer or other technology to support presentation/lesson outcomes
_______ Teacher easily relates to learners
_______ Teacher responded appropriately to learner questions and comments
_______ Teacher integrated aspects from other areas within & outside of mathematics
_______ Teacher displayed sensitivity to learners' feelings
_______ Teacher demonstrated enthusiasm for teaching and learning
_______ Teacher discovered learner misconceptions and misunderstanding
_______ Learners attended to what was happening during the lesson
_______ Teacher moved around in class with ease, interacting with learners

Date of feedback discussion with teacher: ____________________________

Teacher comments:	**Facilitator comments:**
_________________________	_________________________
Signature of Teacher	**Signature of Facilitator**

***adapted from Hampton University, Virginia**

APPENDIX E: TEACHER SELF-EVALUATION AND FACILITATOR EVALUATION

Questionnaire
Rate yourself in terms of the following that is how you saw yourself 3 years ago as to how you see yourself now in 2005:
On a scale of 10 ranging from 10 (outstanding/excellent) to 1 (drastically need to make changes/seek help)

	2002	2005
1. Outcomes for all lessons are made clear to learners		
2. Lesson are well planned and organized		
3. Presentation style appropriate and effective		
4. Relevant examples, metaphors, analogies used to establish connections with learners' previous experiences and learning		
5. Lesson time well managed		
6. Critical thinking and analysis are modelled and encouraged		
7. Teaching techniques require most of the learners to be actively involved		
8. Respect for diverse opinions is communicated		
9. Warm, accepting, open classroom atmosphere evident		
10. Teacher interest in information is communicated		
11. Teacher interest in learners' learning is communicated		
12. Teacher mastery of learning area content is evident and thorough		
13. Appropriate and effective use was made of audio-visuals, computer or other technology to support presentation/lesson outcome		
14. Teacher easily relates to learners		
15. Teacher responds appropriately to learner questions and comments		
16. Teacher displays caution when phrasing questions to learners		
17. Teacher plans oral questions prior to lesson		
18. Teacher asks higher order verbal questions		
19. Teacher integrates aspects from other areas within & outside of mathematics		
20. Teacher displays sensitivity to learners' feelings		
21. Teacher demonstrated enthusiasm for teaching and learning		
22. Teacher discovers learner misconceptions and misunderstanding		
23. Learners attends to what is happening during the lesson		
24. Teacher moves around in class with ease, interacting with learners		

APPENDIX F: QUESTIONNAIRE

Instrument to determine mathematics teachers' feedback skills in the classroom to be used as a facilitator observation sheet and for individual teacher self-evaluation***/ Instrument om onderwysers se terugvoer vaardighede in die klaskamer vas te stel. Vir gebruik as observeringsblad en vir onderwyser se self-assessering***

5 strongly agree; 4 agree; 3 neutral; 2 disagree; 1 strongly disagree	5	4	3	2	1	
1. Sending effective messages /***Die stuur van effektiewe boodskappe***						
1.1 The teacher clearly owns his/her message by using personal pronouns like 'I' and 'My' / ***Die onderwyser maak duidelik die boodskap sy/haar eie deur die gebruik van persoonlike voornaamwoorde soos 'Ek' en 'My'***	5	4	3	2	1	
1.2 Messages are complete, unambiguous and specific. The teacher makes it clear to which word, idea, equation he/she is reacting / ***Boodskappe is volledig, ondubbelsinnig en spesifiek. Die onderwyser maak dit duidelik tov watter woord, idée, vergelyking hy/sy reageer***	5	4	3	2	1	
1.3 Verbal and non-verbal messages are mostly congruent with one another / ***Verbale en nie-verbale boodskappe is kongruent met mekaar***	5	4	3	2	1	
1.4 The teacher frequently asks for feedback about how his/her messages are being received by learners / ***Die onderwyser vra gereeld terugvoer van leerders oor hoe hulle sy/haar boodskappe ontvang***	5	4	3	2	1	
1.5 The teacher makes the messages appropriate to the learners by fitting it to their frame of reference / ***Die onderwyser maak die boodskappe van toepassing op die leerders deur dit te koppel aan hul verwysingsraamwerk***	5	4	3	2	1	
1.6 The teacher describes his/her feelings by name, action or figure of speech / ***Die onderwyser beskryf sy/haar gevoelens deur dit te noem, aksie of figuurlik***	5	4	3	2	1	
1.7 The teacher describes the learner's response, behaviour or method that lead to the feedback: "You said that …" / ***Die onderwyser beskryf die leerder se respons, gedrag of werkswyse wat gelei het tot die terugvoer: "Jy se dat …"***	5	4	3	2	1	
1.8 The teacher describes other learners' responses or behaviour without evaluating or interpreting / ***Die onderwyser beskryf ander leerders se response of gedrag sonder evaluering of interpretering***	5	4	3	2	1	
1.9 The feedback occurs as soon as appropriate after the learner's response (immediately if possible, or later depending on events)./ ***Die terugvoer geskied so gou as wat die situasie verlang na die leerder se respons (onmiddellik indien moontlik, of later, afhangende van wat gebeur)***	5	4	3	2	1	
1.10 The feedback reveals the teacher's real feelings about the learner's response (surprise, approval, expressing agreement, disappointment, etc) / ***Die terugvoer weerspieël die onderwyser se ware gevoelens (verbasing, …. teleurstelling, ens.)***	5	4	3	2	1	
1.11 The teacher allows learners the opportunity to assess their own performance: How do you think you did? What could you have done differently? / ***Die onderwyser laat leerders toe om hul eie pogings te assesseer: Hoe dink jy het jy gevaar? Hoe sou jy dit anders kon doen?)***	5	4	3	2	1	
1.12 The teacher's feedback strategy involves starting with positive, then areas needing improvement, and ending with positive (+/-/+) / ***Die onderwyser se terugvoer strategie behels om met die positiewe te begin, dan dit wat verbetering nodig het, en dan te eindig met positief*** (+/-/+)	5	4	3	2	1	
1.13 The teacher always suggests correct performance rather than emphasizing the learner's mistake(s) / ***Die onderwyser maak altyd aanbevelings tov hoe om te verbeter, eerder as om die foute te beklemtoon***	5	4	3	2	1	
1.14 The teacher limits the quantity of feedback given at any particular time to 1 or 2 issues / ***Die onderwyser beperk die hoeveelheid terug voer op enige bepaalde tydstip tot 1 of 2 aspekte***	5	4	3	2	1	

1.15 The teacher concentrates on skills and actions that can be changed /***Die onderwyser konsentreer op vaardighede en aksies wat veranderbaar is***	5	4	3	2	1	
1.16 The teacher asks the learner to summarise the outcome of the discussion to ascertain what learning has occurred / ***die onderwyser vra vir die leerder om die uitkomste van die besprekingop te som om te bepaal watter/of leer plaasgevind het***	5	4	3	2	1	

An instrument to ascertain teachers' questioning and listening skills and techniques						
5 strongly agree; 4 agree; 3 neutral; 2 disagree; 1 strongly disagree **Algemeen/General**						
1. My skills with respect to all aspects of questioning are adequate / ***Ek is tevrede met al my vraagstellingstegnieke en vaardighede***	5	4	3	2	1	
2. I plan key verbal questions (prior to lessons) to provide structure and direction to my mathematics lessons / ***Ek beplan sleutel verbale vrae (vooraf) om struktuur en rigting aan my wiskunde lesse te verskaf***	5	4	3	2	1	
3. I take special caution with phrasing questions clearly and specifically / ***Ek neem spesiale sorg deur vrae noukeurig en duidelik te formuleer***	5	4	3	2	1	
4. I have the ability to adapt questions to the level of my mathematics learners' abilities / ***Ek beskik oor die vaardigheid om vrae aan te pas by die vermoens van my wiskunde leerders***	5	4	3	2	1	
5. I usually pose questions logically and sequentially / ***Ek stel my vrae gewoonlik logies en in bepaalde volgorde***	5	4	3	2	1	
6. I ask questions that are at various levels of difficulty / ***Ek stel vrae van verskillende moeilikheids vlakke***	5	4	3	2	1	
7. I mostly ask higher order questions / ***Ek stel hoofsaaklik hoër orde vrae***	5	4	3	2	1	
8. I normally follow up learners' responses by / ***Ek volg leerders se response gewoonlik op deur***	5	4	3	2	1	
8.1 a declarative or reflective statement / ***'n verklarende of reflektiewe bewering***	5	4	3	2	1	
8.2 declaring perplexity over the learner's response / ***Sê wanneer 'n leerder se respons verwarrend of die betekenis daarvan onduidelik is***	5	4	3	2	1	
8.3 inviting the learner to elaborate / ***die leerder te versoek om uit te brei***	5	4	3	2	1	
Dealing with right answers from learners: / *Hantering van korrekte antwoorde van leerders*						
1. I complement and reward learners for their contributions / ***Ek komplementeer en beloon leerders vir hul bydraes***	5	4	3	2	1	
2. I give learners the assurance that it is good to try, even if they are unsure of the answer / ***Ek verseker leerders dat dit goed is om te probeer, selfs al is hulle onseker van hul antwoord***	5	4	3	2	1	
3. If the learner fishes for an answer I ask him/her to commit him/herself to one answer / ***Wanneer leerders vis vir antwoorde, vra ek dat hulle hulself tot een antwoord moet verbind***	5	4	3	2	1	
Onwilligheid/Inhibitions						
If learners are inhibited or unable to answer / ***Waar leerders onwillig is of nie in staat is nie***						
1. I pose the question again / ***Stel ek weer die vraag***	5	4	3	2	1	
2. I provide a hint / ***Verskaf ek 'n leidraad***	5	4	3	2	1	

3. I rephrase the question / ***Herformuleer ek die vraag***	5	4	3	2	1	
4. Pose another question that will lead to the same solution / ***Stel ek 'n ander vraag wat tot dieselfde oplossing sal lei***	5	4	3	2	1	
5. I avoid getting upset or impatient when a learner resists answering a question / ***Vermy ek om ontstel te word indien 'n leerder nie wil antwoord nie***	5	4	3	2	1	
6. I make an effort to be supportive and encourage learners / ***Wend ek 'n poging aan om ondersteunend en aanmoedigend te wees teenoor leerders***	5	4	3	2	1	
7. I endeavour to get a learner to think aloud, rather than saying nothing / ***Ek poog om 'n leerder hardop te laat dink, eerder as om niks te sê nie***	5	4	3	2	1	
Dealing with wrong answers / Hantering van verkeerde antwoorde						
1. I correct the learner without discouraging her / ***Ek korrigeer sonder om die leerder te ontmoedig***	5	4	3	2	1	
2. Before correcting the learner, help is sought from his peers in a positive manner / ***Alvorens ek die leerder reghelp, word die insette van sy porture eers verkry***	5	4	3	2	1	
3. I make sure that the right answer or solution is shared before continuing to the next question or piece of work / ***Ek maak seker dat die regte antwoord of oplossing met almal gedeel word, voordat met nuwe vrae of werk begin word***	5	4	3	2	1	
4. I provide hints to help get learners closer to the solution / ***Ek verskaf leidrade om leerders na die oplossing te lei***	5	4	3	2	1	
5. I avoid "Yes , but …" responses since it rejects the learner's ideas / ***Ek vermy "Ja, maar …" response, want dit verwerp die leerder se idees***	5	4	3	2	1	
6. I avoid "Yes , but …" responses since it sends out a negative message / ***Ek vermy "Ja, maar …" response, want dit stuur 'n negatiewe boodskap uit***	5	4	3	2	1	
7. I often use "Yes, but …" when responding to learners' responses / ***Ek gebruik dikwels "Ja, maar …" in reaksie op leerders se response***	5	4	3	2	1	
8. I frequently ask questions with more than one possible answer/ ***Ek stel dikwels vrae waarvoor daar meer as een antwoord moontlik is***	5	4	3	2	1	
9. I consider different levels of questioning when posing questions to my learners / ***Ek oorweeg ek oorweeg verskillende vlakke van vraagstelling wanneer ek vrae stel***	5	4	3	2	1	
10. I allow more than 5 seconds waiting time for learners to respond to my questions / ***Ek laat meer as 5 sekondes wagtyd toe vir leerders om op my vrae te reageer***	5	4	3	2	1	
Assessering/Assessment						
1. I share learning outcomes with learners (saying what you as teacher hope they will learn)/ ***Ek deel die uitkomstes met die leerders (deur te sê wat jy hoop hulle sal leer)***	5	4	3	2	1	
2. I inform learners as to why they are learning a particular aspect of the work / ***Ek lig leerders in aaarom hulle 'n bepaalde deel van werk moet leer/doen***	5	4	3	2	1	
3. I invite and build on learners' contributions/ ***Ek moedig leerder bydraes aan en bou daarop***	5	4	3	2	1	
4. I devise tasks that allow learners to construct their own knowledge/ ***Ek ontwikkel take wat leerders instaat stel om hulle eie kennis te konstrueer***	5	4	3	2	1	
5. I allow learners to indulge in group work on a common outcome/ ***Ek laat leerders toe om in groepe gemeenskaplike uitkomstes te bespreek/ aan te pak***	5	4	3	2	1	
6. I spur learners on by means of encouraging remarks/ ***Ek moedig leerders aan die hand van positiewe opmerkings***	5	4	3	2	1	
7. I spur learners on by specific and focused comments/ ***Ek moedig leerders aan met spesifieke en gefokusde kommentaar***	5	4	3	2	1	
8. I strongly encourage learners to help their peers/ ***Ek moedig leerders sterk aan om hulp by porture te soek***	5	4	3	2	1	

9. I encourage and allow learners to assess their peers/ ***Ek laat portuurassessering toe en moedig dit aan***	5	4	3	2	1	
Listening techniques						
1. When posing a question to a learner I mainly listen for a particular answer / ***Ek luister gewoonlik vir 'n bepaalde antwoord wanneer ek 'n vraag stel aan leerders***	5	4	3	2	1	
2. I evaluate the learner's response by judging it against a preconceived standard or answer ***/ Ek evalueer die leerder se respons deur dit te beoordeel tov 'n voor-opgestelde standard of antwoord***	5	4	3	2	1	
3. My primary reason for asking questions is to find out whether the learner knows the correct answer / ***My primêre rede vir vraagstelling is om uit te vind of die leerder die korrekte antwoord weet***	5	4	3	2	1	
4. I listen mainly to assess learners' acquired knowledge / ***Ek luister hoofsaaklik om leerders se verworwe kennis te assesseer***	5	4	3	2	1	
5. I listen to the 'subjective sense' learners' make when they respond to my questions / ***Ek luister na die gevoelswaarde wat leerders daaraan toevoeg wanneer hulle my vrae beantwoord***	5	4	3	2	1	
6. Frequently question the deeper meaning of my ideas or answers in relation to the learners/ ***Ek bevraagteken gereeld die dieper betekenis van my idees en antwoorde in verhouding tot dit van die leerders.***	5	4	3	2	1	

Ideas taken from Bonwell & Eison (1999)