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Factors influencing teachers' choice and use of tasks for formative assessment of Mathematics in grades 2 – 6

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A research report submitted to the faculty of Education,
University of the Witwatersrand,
in partial fulfilment of requirements for the degree of Master of Education
by coursework and research report.

Johannesburg, June 2005

Declaration

I declare that this research report is my own unaided work. It is being submitted for the first time for the degree of Master of education by Coursework at the University of Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination in any other University.

Bronwen Wilson Thompson 6 June 2005

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Abstract

This study explores teachers' understanding about ways in which assessment supports learning and teaching within the context of grappling with the new curriculum. It argues that formative assessment, supports a social-constructivist view of learning and teaching. It suggests that formative assessment functions in a fundamentally different way to summative assessment, and could assist teachers in moving towards a more conceptual approach to learning and teaching. Teachers' views are explored in focus groups in which teachers discuss their choice and use of either traditional or alternative assessment tasks, in their mathematics lessons. The findings suggest, however, that teachers' ability to use assessment in this way is influenced by their own views of mathematics learning, their current views of assessment, the amount of support provided in the assessment materials, and the practices of the school.

Key words

Formative assessment
Social constructivist
Focus groups
Phenomenography
Primary school
Mathematics
Assessment
Investigations

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Chapter 1

Introduction

1.1 Background

Over the course of the past eleven years my work has been in Mathematics in-service teacher education and as a primary school teacher. My teaching began in Saturday schools in the 1980's with primary and high school learners, which made me aware of some big gaps in the knowledge and experience of the learners. I did Mathematics in-service work, using a classroom intervention model, and noticed that there were conceptual aspects to mathematics that the teachers appeared not to recognise as significant when working with learners. These were frequently in the form of unanticipated answers or interesting misconceptions. In my next position as a mathematics in-service worker, I found the work of John Mason (1994) on noticing teaching moments useful in reflecting on my classroom-based work. My interest was in how teachers responded to what we identified as teaching moments. In most cases teachers gave learners a rule to correct or confirm what learners were saying. Personal circumstances led me into a classroom in 1996 where I attempted to apply some of the knowledge I had gained in my in-service work. I found the timetable and assessment system very constraining, and my more successful mathematical experimentation happened in other learning areas – for example, we discussed place-value in depth in a history lesson on Egypt, and 3-dimensional shape in technology. The shift towards Outcomes Based Education (OBE), despite its intentions, did not create much space in mathematics for investigations and projects in classrooms like mine.

My next in-service task was to teach teachers to use formative assessment as a way of both assisting them in using formative assessment to influence their own practice, and for addressing the teachers' mathematical misunderstandings. Teachers tended to do simple formative tasks fairly well, but found it difficult to describe learners' thinking, and appeared to look only for "correct" procedures. Their comments tended to be judgmental, and not necessarily based on the task.

During my next classroom teaching spell, in 2001, large classes, the timetable, parental pressure, and regular summative assessment still made an investigative approach difficult. I found myself doing many traditional worksheets for marks, to create opportunities for more investigative work that was not for marks. Investigations and games were popular with the learners and I also used alternative approaches in the extra classes for learners with difficulties, which was met with much enthusiasm and some success.

As an in-service worker, I reflected on my frustration that teachers did not "take up" innovative teaching practice as I had hoped, and as a teacher, I found that I too had difficulty implementing what I believed to be good practice. I have been party to many conversations about how teachers are "reluctant to change", and yet did not find it easy to use new approaches myself. I am deeply aware of both the value of change and the constraints that teachers face. Watson (2001) points out that a change in assessment policy does not translate into immediate changes in teaching practice. Adendorff and Smit (2001:83) show this in their study where they say:

> It seems that after numerous workshops hosted by [2 institutions] many teachers have not yet made the shift to a formative assessment teaching style.

Wickham and Versveld (1999) accept that an incremental view of change is more appropriate than expecting a "workshop conversion". I see existing assessment practice as a major constraint, so this study wishes to explore the extent to which shifts in assessment policy and practice could promote a change in mathematics teaching. I became interested in the use of alternative materials and formative assessment as a way of supporting change and "alternative" teaching practice, while remaining accountable to parents, learners, and the education community. This study explores in greater depth teachers' attitudes and beliefs about assessment with a view to using formative assessment in supporting learners and change in teaching.

1.2 Purpose of the study

I chose to find out what teachers think about formative assessment to help me evaluate it's potential in supporting change in teaching practice in a way that

allows teachers to feel that they are also accountable and responsible to the relevant stakeholders. Since most teachers are not familiar with using assessment formatively, I chose to provide a range of mathematics assessment materials for them to try in their lessons and then to provide an opportunity for them to talk about their experiences and to ask their opinions. I wanted to find out what kind of support they would need in using such tasks for formative assessment.

This study explores teachers' understandings and use of formative assessment processes in mathematics by:

1) exploring the factors that influence teachers' choice of formative assessment tasks
2) clarifying what teachers value in these formative assessment tasks; and
3) understanding ways in which teachers would use formative assessment in their classrooms.

I analyse what teachers say about their choice of assessment tasks to help me understand what teachers value in the tasks and the assumptions teachers make about teaching, learning, and assessment. This will show how teachers view formative assessment within the context of the classroom, school, and curriculum. It will also give insight into how much support teachers need in using formative assessment.

The main question that guides my research is:

> What factors influence teachers' choice and use of formative assessment tasks in mathematics in grades 2 - 6?

I specifically wanted to explore the tacit theoretical paradigm from which teachers may be viewing assessment, the ways in which teachers use assessment, and the degree of assistance teachers feel necessary for them to use assessment formatively.

In seeking to answer this main question, I ask the following sub questions:

1) How do teachers view the mathematics in formative assessment tasks?

2) What assumptions about assessment and mathematics do teachers make about different formative assessment tasks?
3) How do teachers plan to use the assessments they select?
4) What, if any, scaffolding, or support, built into the tasks do teachers find helpful? What additional support might they require?

1.3 Rationale

Much work in education, and mathematics education in particular, argues that a change in assessment practice can have a powerful influence on classroom practice (Pahad, 1999). Emery (2001:74) says:

> … while merely changing the curriculum does not necessarily bring about better education for all, by changing our classroom and assessment practices we can certainly make a start.

Research suggests that formative assessment has the potential to influence the following aspects of teaching and learning:

1) the nature of the interaction between teacher and learners (Conner, 1993);
2) the mathematics content dealt with in the classroom (Reeves & Long, 1999) ;
3) teachers' differentiation of tasks according to learners' needs and planning of teaching (Collis, 1992);
4) teachers' understandings of how learners develop mathematical concepts (Brodie, 2001);
5) teachers' evaluations of their own teaching (Mackintosh & Hale 1976); and
6) learners' experiences of mathematics learning (Boaler, 1997).

However, in the course of my in-service work, among teachers in previously disadvantaged and under-resourced schools, it seems that despite teachers clearly stating that a major use of formative assessment is to evaluate their own teaching methods, and to modify their teaching accordingly, they have struggled to do so. A large number of teachers, on seeing that learners have not reached the level of understanding that they had hoped for, said that they needed to re-teach the content, without mentioning different approaches or methods. Many teachers also found it difficult to observe and describe learners' emerging

mathematical constructs. They tended to view learners as either knowing or not knowing. It also appears that some teachers have a poor understanding of the development of the mathematical concepts involved (Rossouw, Rhodes & Christiansen, 1999).

This study hopes to gain insight into teachers' understanding of formative assessment for conceptual teaching with a view to contributing to ways of developing their understanding and skill in using formative assessment. The findings from this research could be useful in the following ways:

1) understanding what teachers value in formative assessment tasks so that tasks that they are likely to use appropriately can be developed.
2) understanding how teachers view the process of formative assessment so that appropriate support for both teachers and learners can be implemented within schools. This includes informing the development of mathematics assessment materials
3) developing in-service support programs based on the findings that better enable teachers to use and develop assessments that support conceptual mathematics teaching within an outcome-based context.
4) contribute to the mathematics education community an understanding of how teachers select and plan formative assessment within the context of outcome-based education in foundation and intermediate phase classrooms.

A formative use of assessment is informed by a constructivist view of knowing and learning (Ernest, 1991). In this view, learners are actively engaged in constructing their own understandings of concepts. Confrey (1990:112) describes the role of a constructivist teacher as:

> … encouraging the development … of a repertoire of powerful mathematical constructions, for posing, constructing, exploring, solving and justifying mathematical concepts and … the capacity to reflect and evaluate the quality of their constructions.

Formative assessment, therefore, can allow the teacher to gain insight into the constructions that learners are developing through, amongst other activities, observing learners and asking them questions. The interaction between teacher and learner is social in its nature and provides the opportunity for teachers to provide scaffolding (Bruner, 1985; Jaworski, 1990) through asking

appropriate questions. Learners also work co-operatively and this, too, provides opportunities for the social construction of knowledge (Confrey, 1990).

The choice of assessment tasks and exploration of what teachers value in them aims to reveal teachers' underlying assumptions about teaching, learning, and assessment of mathematics. This may help to clarify how the processes of formative assessment are viewed by practicing classroom teachers and the implications of these choices in classroom practice. It also gives insight into what kind of support teachers may need in need in making such assessment meaningful.

Through exploring what factors influence teachers' choice and use of formative assessment tasks in mathematics in grades 2 – 6 the study describes the tacit theoretical paradigms from which teachers view mathematics and assessment. The study explores how teachers view assessment tasks, the ways in which they use them, and what changes may be required for teachers to use the assessments formatively. It also explores how teachers view the mathematics embedded in the assessment tasks and what assumptions about assessment teachers bring to their use of these materials. It describes how teachers plan to use the assessments they select and considers the implications of these choices.

In the next chapter, I review the literature in order to frame what is meant by formative assessment in this study. It specifically looks at the role of assessment in supporting teaching and learning of mathematics. This study is located within a conceptual framework that takes a constructivist view of mathematics learning, and the roots and implications of this paradigm are explored. The study also acknowledges that learning, and thus assessment, happens within the context of both schools and broader society, and looks at ways in which mathematics assessment practices are affected by these contexts.

Chapter 2

Literature Review

2.1 Introduction

This review of the literature forms the background against which teachers' views of assessment are explored. Bernstein (1975) points out that teaching, learning, and assessment are integrally linked. Thus, any sustained curriculum change needs be supported by assessment to improve the learning and teaching of mathematics within OBE. Following Cornbleth's (1990) view that curriculum is a contextualised social process, I locate the discussion of the literature within the context of change in South African schools and the broader society.

Assessment in mathematics education can be seen in terms of the purposes for which it is intended. To frame the literature, I first distinguish broadly between the two ways teachers use assessment: formatively and summatively. I then discuss literature on assessment issues in three different ways: first, assessment and its relationship to teaching and learning mathematics; second, ways in which assessment relates to schooling; and, last, the manner in which assessment affects or reflects the values of society. These categories were adapted from those used by Niss (1993) in his discussion on the purposes of assessment as providing information to teachers and learners at a number of levels. He categorises the information as: (1) being about learner progress, (2) a basis for decisions or actions such as streaming of learners or selection for courses, and (3) a way to shape social reality by providing information that embodies the values of society and selects people accordingly.

2.2 Types of Assessment

The current literature tends to group assessment according to its educational purpose. This purpose is broadly referred to as either formative or summative (Conner, 1993). Formative assessment is usually integrated into the normal course of teaching and its purpose is to give teachers insight into the meanings that learners are making and to guide future teaching and learning (Gipps,

1994). Formative assessment is also used to identify particular learners' difficulties with a view to providing appropriate subsequent opportunities for learners to develop their understandings. Summative assessment gives learners marks and occurs at the end of a block, or period, of teaching. It aims to quantify the extent to which the learner has mastered the material that has been taught and the success of the course (Gipps, 1994). The success of the learner is rated, and this rating often forms the basis of a decision about learner progress. In most cases at primary school, the information determines if a learner may proceed to the following grade or not (Conner, 1993).

In the literature there is a broad agreement about what summative assessment is, as it is this use of assessment that predominates in schools. In contrast to summative assessment, a number of different assessment styles have been developed. Wiggins (1998) refers to these as "alternative" assessments. They include: performance-based tasks, authentic assessment, and, possibly, criterion-referenced assessment. In this study, I refer to these as "formative assessment" if the type of task lends itself to being used within a process-oriented view of learning. Such tasks typically provide teachers with qualitative information which can be used to give learners feedback and guide future teaching. These differently structured assessment tasks attempt to balance the predominant summative view of assessment and aim to offer alternatives.

2.3 Purposes of Assessment

Assessment, whether formative or summative, is used educationally at a number of levels: in the classroom, in the school, and in society. In the following section, I explore each of these levels in more depth. At the classroom level, I discuss assessment primarily as it impacts on learning. Other aspects of classroom assessment, accountability for example, I discuss later as part of schooling as it has implications at the institutional level. In the last section, I discuss ways in which assessment relates more broadly to society and it's values.

2.3.1. Assessment and learning

Most of the literature, especially that about formative uses of assessment,

points to shifts in the way mathematics knowledge, learning, curriculum, and assessment are viewed. The literature surveyed is discussed in relation to shifts in each of these areas.

2.3.1. i) Mathematical knowledge as constructed

Philosophical approaches towards mathematical knowledge have shifted from an absolutist towards a fallibilist understanding. Mathematical knowledge is based on logical reasoning and so, unlike other disciplines, does not rely on experience or observations. Historically, because of this feature, mathematics was seen as the discovery of truth. Axioms, on which mathematical knowledge was based, were assumed to be self-evident truths and theorems were deduced from these through logical reasoning: therefore, mathematical knowledge was considered truthful and absolute. This view, which formed the basis of much of the mathematical thinking at the time, is now known as an absolutist view of mathematics (Ernest, 1991).

One challenge to an absolutist view of mathematics was when axioms were no longer taken to be self evident. A shift in one of Euclid's axioms lead to a whole new geometry – non-Euclidian geometry. This suggests that mathematical knowledge is dependent on starting points and, so, mathematical knowledge can no longer be believed to be universally true (Davis & Hersch, 1981). For example, the axiom: "The angles of a triangle add up to 180 degrees". If Euclid's parallel postulate is not assumed, the angles of a triangle can add up to more than 180 degrees, as would happen on a sphere.

Mathematical proof relies on deductions and logic. But logic, itself, does not have certain foundations since it rests on irreducible assumptions (Ernest, 1991). This challenge to an absolutist view of mathematics sees mathematical knowledge as fallible and, therefore, open to being questioned (Ernest, 1991). Another aspect of proof is the assumption that logical reasoning is free from error. This, too, cannot be stated for sure. Mathematics knowledge is validated by other mathematicians. In this way, mathematical knowledge can be seen as socially constructed. Fallibilists believe that although mathematics has a close fit with the world, and is largely stable and autonomous, it remains fallible. The

body of mathematical knowledge has a historically shifting nature (Ernest, 1996).

Blaire (1981) suggests that the philosophical perspectives of teachers, along with what they think of as motivating for learners, influences the way in which they teach. Lerman (1983) takes this view further and argues that there is a strong relationship between teachers' views of mathematical knowledge and their style of teaching. He suggests that teachers view mathematics either as a body of knowledge or as a process of active problem solving. The ways teachers teach, then, either inducts learners into a system of rules or encourages problem solving. The latter approach is congruent with the view that mathematics is an evolving, fallible human construction. The increased emphasis on process does not detract from the importance of getting a correct answer, but it does emphasise the meaningfulness of that answer. Learners are still inducted into mathematical practices, but their ability to reflect on what they are doing and a greater appreciation of ways in which learners construct knowledge has resulted from this shift away from absolutism.

2.3.1 ii) Mathematics learning as construction

Constructivism is a theory of learning which holds that learners actively construct their own knowledge. Constructivism has its roots in the work of Piaget (1964). He refers to the knowledge structures that a learner holds as interrelated sets of schema. As a learner is exposed to new information or knowledge, the knowledge either fits into the structures, confirming the learner's way of thinking, or there is dissonance. If there is dissonance, the learner needs to modify his/her schema to make sense of the new information. Piaget refers to these two responses to new information as assimilation and accommodation respectively. In this way, the learner is actively developing his/her schema, and constructing their knowledge.

Constructivism within mathematics education suggests that learners learn by actively engaging with problems, as opposed to passively receiving knowledge (Von Glasersveld, 1987). Learning is no longer seen as learners being given facts and this has implications for teaching and learning. Noddings (1990:10)

says:

> … accepting a constructivist premise about knowledge and knowers implies a way of teaching that acknowledges learners as active knowers.

These views of learning assume that learners develop their constructs through direct experience. Radical constructivists would argue that each learner's experience is different and, therefore, the constructs that they develop are unique. The knowledge is constructed within the learner's own head.

Social constructivists argue that there is an interpersonal or social dimension to the learning experience that encourages learners to modify their understandings. Vygotsky (1978) views learning as that which occurs slightly ahead of the learner's current level of functioning. The new level of learning can be seen in Piagetian terms as accommodation because the learner has had to modif his / her schema. Vygotsky goes on to say that new learning can be promoted by active mediation by teachers, or "scaffolding". He (1978:86) refers to the Zone of Proximal Development (ZPD) as:

> … the distance between the actual level of development as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

In this case, the knowledge construct is a shared understanding that is co-constructed by the participants.

If teachers adopt a constructivist approach to learning – whether radical or social constructivism – it has implications for their teaching of mathematics and their approach to assessment. Outcomes-based education and alternative approaches to assessment have been influenced by constructivism.

2.3.1 iii) Teaching in a constructivist paradigm

Traditional teaching methodology is based on an absolutist view of mathematics where learners are required to learn rules and algorithms. It is based on the assumption that truth is embedded in the mathematics and that the mathematical procedure is the way of expressing that truth. Mathematics education, within this paradigm, consists largely of teaching rules and

algorithms. This approach to teaching, in which rules are transmitted from the teachers to the learners, does not support an engagement with mathematical ideas which might lead to the learner constructing conceptual mathematics.

The implications of using a constructivist paradigm are that learners are required to develop their schema through doing mathematical tasks in which they develop and refine their own mathematical rules and strategies (Jaworski, 1994). Similarly, Lerman (1983) suggests that problem solving provides learners with opportunities to actively develop their constructs, and Confrey (1990) argues that an investigative approach to learning is one in which learners construct and modify their own understandings as they work on a task. The literature generally recommends that learners be given problems or situations in which they develop and modify their own approaches to solving the problem or finding a generalisation.

Whether learners engage in problem-solving activity alone, or within a social setting, may depend on whether one adopts a radical or social constructivist view of learning. Ernest (1991) argues that we need to adopt a social constructivist approach to teaching and learning mathematics, premised on a fallibilist view of mathematics, for learning to be experienced by learners as empowering. He also notes that a problem-solving approach mirrors more closely the experience of working mathematicians. He explains that the process of problem posing and solving is common to learners of mathematics and mathematicians. Finding justifications, making conjectures, and theorising are creative aspects of doing Mathematics, whether in classrooms or universities.

Wertsch (1984) explains the nature of interaction with learners, from a Vygotskian perspective, in more depth. The “expert” and the learner need to reach a common understanding of the concept they are working with. This process of coming to understand what the next level of conceptual development is helps the expert to prompt the learner to move to a more sophisticated level of knowledge. The process of coming to a shared conception of what constitutes the learner’s new level of understanding, is referred to as intersubjectivity (Jaworski, 1990). The new level of understanding is at a more

sophisticated level than the learner's initial level, and it may provide new insight into the learner's thinking. This enables the teacher to provide scaffolding that is able to further develop the mathematical constructions of the learner.

Leder (1992) describes three different schools of thought regarding teachers' roles in mathematics classrooms. They are to facilitate (1) cognitive conflict, (2) socio-cognitive conflict, and (3) success-based learning.

The cognitive conflict approach is based firmly on the theory of Piaget (1964). The teachers' choice of tasks and questions needs to create cognitive conflict to encourage learners to re-structure their schema to accommodate the new information. Mathematics teachers need to be informed enough about their learners' levels of thinking, or be sensitive to their students, while setting mathematically challenging work that engages learners actively in developing their schema (Jaworski, 1994).

A socio-cognitive conflict approach to teaching learning includes a Vygotskian (1978) approach. A socio-cognitive conflict view of learning would argue that much of the cognitive conflict comes from social situations where more capable peers, or an adult, provide semiotic mediation. I view this semiotic mediation as conflict, to a greater or lesser extent, in that it challenges the learners to restructure their existing cognitive structures. Cobb (1995) says that classrooms have social qualities that require learners to move towards consensus – this happens as learners talk about their understanding and negotiate their meanings. This coming to a joint understanding, or intersubjectivity, constitutes the social construction of knowledge between the learners and the teacher or between different learners (Wertsch, 1984).

Hatano's review of cognitive studies (1996) discusses the role constraints play in learners' developing mathematical concepts. Some of these constraints are social in origin, while others are cognitive. Teachers provide constraints, either themselves or by working with the constraints learners bring to class. These limit the directions and approach learners bring to problem solving. In mathematics classrooms, for example, solutions need to be mathematical in nature, and there are limited interpretations to the problems.

Leder's (1992) 3rd category, success-based learning, sees learning as a result of cumulative experiences of success where the tasks are incrementally graded and the learner uses increasingly complex procedures. The learner's understanding develops as a result of the systematic presentation of routine calculations. Some learners are successful within this paradigm, and their understanding develops as task complexity increases. This offers an explanation for the success of learners who have succeeded within the traditional rule-based paradigm of mathematics teaching.

2.3.1 iv) Assessment within a constructivist paradigm

This section explores ways in which learning from a constructivist perspective, together with an investigative approach to teaching, is supported by a formative approach to assessment. Formative approaches are best suited to providing information for teaching and learning processes, while, frequently, assessment is required for other purposes, especially within the administrative systems of schools and society.

Historically, mathematics assessment has been influenced by psychometric testing (Gipps,1994). Traditional approaches to assessment have their theoretical roots in psychometric testing which strove to be "scientific", and empirical and quantitative, in its approach to measuring personality. Personality traits, in this model, were assumed to be universal and uni-dimensional. Psychometrists administered a battery of tests, from which a set of scores were obtained, each relating to a particular trait (Gipps, 1994). The assumptions of universality and uni- dimensionality have permeated much of the thinking about assessment within educational settings.

Gipps (1994) argues that more recent research and theory place a greater emphasis on the social aspects of learning and the complex multifaceted nature of learning. The banks of test items, that characterised older testing paradigms, are not always appropriate for measuring learning gains as they tend to ignore the role context plays in learning. Similarly, within mathematics education, especially from a social constructivist perspective, more complex integrated

tasks are more appropriate tools for assessing learners' understandings.

Leder (1992) suggests that genuine mathematical problems are those in which learners are enabled to reorganise their current thinking. Because the process of constructing concepts is developmental, assessment is most helpful in providing teachers with insight into the constructs learners are developing when it is part of the learning process and not at the end of the learning experience. She points out that assessment should produce an evolving view of learners and not a static one. In this study, I argue that a formative approach to assessment is more able to meet these needs.

Constructivists regard mathematical knowledge as a dynamic, developing construct, so tests based on the psychometric assumptions have limited value from a constructivist perspective. Vygotsky used tasks that required learners to work within their ZPD or slightly in advance of their normal level of functioning. The cognitive constructions that learners develop, and their ability to adapt their knowledge and skills to meet the demands of the problem, become more visible through activity and social interaction (Boaler, 1997; Leder,1992). Teachers also have access to a wider range of their learners' cognitive processes (Collis, 1992). Assessments could take the form of investigations or problem-solving, rather than closed questions where the processes often remain opaque. Assessment, therefore, provides an indication of the learners' progress relative to their past performance and the concept being taught. Summative tasks, on the other hand, would be considered too difficult and unfair if they were ahead of the learners' actual level of functioning.

If formative assessment and teaching are essentially a dialogue between the teacher and learner (Conner 1993), the tasks will differ in format and focus from those used summatively. Pirie (1989) says that a formative view of assessment also affects the nature of the assessment tasks, making them fundamentally different to summative tasks. The focus of the dialogue is not on the answer, nor which mathematics has been demonstrated, but the processes used and the learners' constructions. The dialogue performs two major functions: it provides insight for the teachers and feedback to the learners.

Feedback to learners using formative assessment has a different function to feedback within summative assessment. In formative assessment, the feedback is about the processes the learner used in the task, while in summative assessment it is about the learners' results, or answers. In formative assessment the learners, ideally, know what the criteria are and are able to consciously improve their performance on these criteria (Scriven,1967, in Mackintosh, 1981). Conner (1999) also reports research that found that summative type feedback in the form of marks did not produce significant improvements in learners' results. Leder (1992) says that the more time teachers spend in class discussion and responding to learners, the better the results, because the learners' questions elicit higher order thinking. Learners have more insight into what outcomes are required, through the use of rubrics and other feedback mechanisms, and this allows teachers and learners to evaluate their thinking (Cunningham, 1998). Feedback and class discussion of summative assessment does not usually function in the same way.

Constructivists question the objectivity and validity claimed by summative assessment. Social constructivists, for instance, question the objectivity of assessment because it assumes that learning can be assessed independently of the social context. They argue that the role of the assessor is integral to the context of the assessment. In formative assessment this effect is acknowledged and incorporated into the assessment process, thus improving the objectivity of the information collected.

A summative test consisting of closed questions, despite being easier to administer, assesses a narrower range of skills than more open-ended tasks which require learners to draw on a variety of skills. Killen (2003) and Cunningham (1998) question the validity of summative tests. Cunningham (1998) argues that summative tests are indirect measures of the student level, and should be treated with care as they do not represent the actual level of the student in relation to the construct being measured. He also argues that using value-free scientific language and interpreting learners' results statistically obscures the quality of the learning that has been achieved. Such a quantitative view of assessment lowers the quality of the interpretation of student responses.

Formative assessment does not preclude the use of summative assessment. Summative assessment, because of it's quantitative and standardised features, is useful for recording and monitoring systems. Learners' performance in summative assessment is likely to confirm what the teacher and learner know from working formatively, and to offer an opportunity for learners to quantify the level of learning they have achieved. A disparity between the findings of formative and summative assessment may lead teachers to explore the objectivity and reliability of their assessments. Approaching both formative and summative assessments with awareness of their limitations and fallibility will improve the overall use of assessment in teaching and learning. Summative assessments alone frequently do not provide adequate qualitative information about learning and, when done at the end of a block of teaching, make a limited contribution to teaching and learning.

The appropriate use of formative assessment relies on the professional judgement of teachers and their ability to value learners' constructions. This may be difficult for teachers who are still coming to terms with radical curriculum change. Pahad (1999) also says that the policy documents have not provided enough guidance about assessment. The new outcomes-based curriculum is to some extent constructivist in its orientation, but these assumptions have not been made explicit in the policy documents and most in-service and pre-service training do not overtly adopt this approach.

Watson (2001), while acknowledging the discriminatory effects of external exams, warns that if formative assessment is used to say something definitive about students, or for high stakes testing in South Africa, the education system still runs the risk of replicating the inequalities of the past. These inequities are caused by continuing inequalities in teacher experience, class size, language of instruction, and socio-economic factors. She says alternative assessments are most valuable in what they tell the teacher about what learners know. They are not valuable if they are used to say something definitive about the learner.

Summative assessment continues to be used in providing quantitative information that is used in other spheres of schooling and society. This is

explored in more depth in the following sections: Assessment and schooling & Assessment and society.

2.3.2 Assessment and schooling

Assessment is conducted for purposes other than to improve teaching and learning. It is a tool that meets needs of the school as an institution, the education system, and society at large. Within schools, assessment plays a role in two ways: administratively and in implementing curriculum. At an administrative level, assessment is used to keep records of learners' progress, to facilitate transfer of learners between classes and schools, and as a means of being accountable to a variety of parties. At the level of curriculum, assessment can influence what is taught, and regulates teachers and teaching. These two aspects of assessment, administration and curriculum, do not operate in isolation and affect and are affected by each other.

2.3.2 i) Administrative uses of assessment

One function of schools as instruments of society is to make selection and streaming decisions which select learners for educational programmes and work (Niss, 1993). Mackintosh and Hale (1976) list six purposes of assessment. Only the first, diagnosis, is directly related to the learning of individual learners, and thus suited to formative assessment. Summative assessment lends itself to the other purposes enumerated by Mackintosh and Hale (1976): evaluating the effectiveness of the learning programme as a whole, providing guidance to learners for subject choice or careers, grading learners in relation to each other, selecting learners for particular programmes, and predicting learners' chances of success. Assessment is done to be accountable to a wide range of stakeholders, including parents, school management, and education departments (Black, 1989).

Summative assessment is usually norm-referenced, while formative assessment is usually criterion-referenced (Wood, 1991). Norm-referencing occurs when the performance of a particular learner is compared with the norm of the class or group. In this way, criteria indicating "acceptability" are established. Learners are judged in relation to their peers and their

achievements are ranked to indicate “success”. Because norm referencing is “scientific” and “objective”, and therefore assumed to be fair (Black, 1989), it meets the administrative needs of schools.

Black (1989) points out two reasons that schools have for using summative assessment: for transfer and for accountability. Transfer occurs when the responsibility for the learners’ progress passes from one teacher to another. A quantitative record of progress can assist a new teacher in beginning at an appropriate level and planning appropriate lessons. Similarly, schools use quantitative records to assist them in rewarding learners and recommending alternative learning programmes. For this information to be useful, it has to have an appropriate level of detail, and be based on a number of assessments. If the transfer is between or out of schools, the criteria for the assessment must be widely agreed upon, so that a wide variety of institutions can use them. As a result, the criteria are more narrowly defined and also more restrictive. Using summative data, although still problematic, is more appropriate for these purposes.

High stakes testing, such as those used for selection, grading, and prediction are traditionally summative and usually have a very narrow range of possible responses. This aids administration over large populations and ensures reliability. However, because of the high stakes, it encourages “teaching to the test”, frequently at the expense of a more balanced education. This kind of assessment has undermined the curriculum and narrowed what is taught to what is in the test (Gipps, 1990). Similarly, schools are evaluated and teachers are selected according to results achieved on high stakes tests and, as a result, the validity of these tests is questionable. Although standardised tests are intended to create equal access, by creating a standardised entrance requirement, they often contribute to the unfairness they set out to address (Black, 1989; Watson, 2001).

Summative assessment’s power lies in its quantitative nature; this power also lends it a reputation for fairness and objectivity which is not always well placed. Conner (1987) warns that summative assessment should be used with care, especially in primary schools. It ranks and grades learners, and forms the basis

of making comparisons between learners. This introduces an element of competition between learners, which is often stressful, especially to young learners. Also, if used exclusively, learners experience "failure" without having an opportunity to demonstrate their reasoning abilities (Conner, 1997). Cunningham (1998) acknowledges that the need for accountability is inescapable but suggests that this can be balanced by using summative tests wisely in conjunction with performance or formative assessments.

2.3.2 ii) Assessment and school curriculum

The above discussion shows that at the level of the school the assessment practice, whether official or not, impacts on what is taught. A move towards a greater emphasis on formative assessment is likely to influence what is taught and how it is taught. Using formative assessment encourages a closer connection between teaching, learning, and assessment. Formative assessment requires teachers to have a clear conceptualisation of the curriculum and better understanding of the cognitive processes of learners (Black, 1989). Cunningham (1998) argues that the practice of "teaching to the test" within formative assessment is desirable because a broad range of instructional goals are embodied in the test.

Schools operate as communities of practice (Lave,1991), with novice teachers being introduced into schools' assessment practices by "old timers". Whether the knowledge base within communities of practice remains stagnant, or is responsive to change, is influenced by the nature of the community. The degree to which moves toward formative assessment are taken up by teachers is determined by administrative and community features of the school. Formative assessment requires a higher level of teachers' knowledge about assessment and professional judgement than traditional approaches to assessment (Watson, 2001). One of the most important factors in test construction is ensuring the test's alignment with the instructional goal (Cunningham ,1998). Pahad (1999) warns that South African teachers do not necessarily have the required understanding of assessment and shows ways in which teachers have wrongly used qualitative results to produce year-end marks. Poor understanding of assessment, together with poor content knowledge (Reeves and Long, 1999), militate against the possibility of using

formative assessment to improve learner understanding and teacher insight without informed support at the school level (Reeves and Long, 1999).

Torrance (1995) questions the potential for an assessment-driven curriculum at school level. He warns that the World Bank in developing countries has supported this model, and he raises questions as to whether the practice of "teaching to the test" creates the required paradigm shift in the teachers' minds from an absolutist view of knowledge to a constructivist one. Similarly, the shift from a content-focussed curriculum towards a process-driven one does not necessarily follow from a change in assessment practice.

It appears that change in assessment practice alone is insufficient to lead to meaningful curriculum shifts at a school level. The bureaucratic aspect of assessment, while exerting power over teachers and schools, does not empower them with the necessary understanding to make a meaningful sustained shift in practice. Insight into what influences teachers' choice and use of assessment may assist in matching administrative needs with curriculum needs.

2.3.3 Assessment and society

The discussion above illustrates how assessment is used to develop and select learners to meet the needs of society, and how society influences the curriculum. Standardised tests have a long history of being developed and used as a fair selection tool that can create access for all into desired positions (Black, 1989). Written assessment tests were developed in China over 2000 years ago to overcome a system of parentage and patronage by allowing access to sought after civil society posts. Assessment practices that followed were also intended to allow fair access to a wider number of participants. Despite this, Niss (1993) views selection as a major purpose of assessment and refers to it as the shaping of social reality. The selection criteria built into tests reflect the values of society. The practice of ensuring that learner marks fall into a standard bell curve reinforces this view of "normality" and reproduces, rather than challenges, the stratification of society. This approach to assessment that reinforces the status quo relies on summative assessment because of its quantitative nature.

Pahad (1997) says that summative approaches to evaluation were used in Apartheid South Africa as a judgmental tool for selection and to reinforce social divisions in society. Under the apartheid system this served to maintain racial divisions and to exclude certain people from access to power. I would agree that summative assessment, in conjunction with a divided society and unequal education opportunities, performed a gate-keeping function in South Africa, but the role of summative assessment in perpetuating the inequalities in society is not limited to Apartheid South Africa.

Assessment and its issues, like curriculum, is part of what Cornbleth (1990) refers to as a contextualised social process. It is strongly influenced by both the structural context of the educational system, and also the socio-cultural context of broader society. Curriculum is developed within the structures, beliefs, and norms of the educational system, while impacting on, and being impacted by, economic, ideological, social, and cultural factors within the social context. Curriculum 2005 was developed in response to political, social, economic, and ideological changes that occurred in South Africa. The curriculum was implemented at a structural level – the various departmental levels, schools, and in classrooms, but also reflects and hopefully will impact on broader society. The move towards formative assessment in the curriculum can be seen as part of a greater move towards social processes that are more inclusive and that meet the educational needs of a wider section of the population within a changing society.

The new curriculum, which places an emphasis on formative assessment, has the potential to create broader access and support for learners from a variety of backgrounds, and to challenge the authoritarian nature of teaching and learning (Pahad, 1997). Summative assessments are viewed as being biased toward white middle class learners. Progressive teachers believe that public schools should promote positive social change and frequently cite this as a reason for the shift towards alternative assessment practices (Cunningham,1998). Formative assessment, with it's greater emphasis on process, allows a broader range of responses or, as discussed by Bernstein (1975), entails a looser classification of knowledge. This allows a range of learner experiences into classroom discourse, thus creating access to less advantaged learners. The

implementation of a curriculum that is new for all learners challenges teachers to provide appropriate learning experiences for all learners, and not to simply assimilate new learners into the existing culture in the classroom.

Ironically, there is little international evidence to show that disadvantaged students perform better on performance-based tests. Cunningham (1998) cites studies that show that disadvantaged groups may do worse on formative assessments. Similarly, there is no guarantee that alternative assessment practices are immune to distortions caused by pressure for accountability from politicians and the high stakes consequences of using assessment for selection purposes.

South African Teachers experience political and social pressure at present. The poor performance of South Africa in international comparative studies of Maths and Science performance (http://nces.ed.gov/timss/results.asp) puts pressure on the government to show some improvement in future. Although politicians and educators responded by questioning the test (Howie, 1998), there is evidence (Reeves and Long, 1999) that teachers' and learners' conceptual development is indeed poor. After ten years of democracy, the government is also under pressure to show that the levels of education are improving and that disparities of the past are being addressed.

Leder (1992) points out that change in assessment practices usually lags behind curriculum change. Since Curriculum 2005 has been through a revision process, and the implementation of the revisions are not yet complete, the lag in clarity in assessment is not surprising. The need for social change is apparent, and clarity around assessment policy and the provision of materials and coherent training are required to support the teaching and leaning of mathematics (Emery, 2001).

2.4 Conclusion

The literature surveyed suggests that formative assessment both supports a constructivist view of learning and an investigative approach to teaching. Although the extent to which formative assessment is able to meet the broad social goals of South Africa's emerging democracy is debated, it offers an

alternative paradigm to summative assessment. Formative assessment supports an outcomes based approach to mathematics education within a constructivist paradigm.

Using a formative approach to assessment has the potential to support learners in their learning and teachers in their understanding of learner difficulties. Assessment alone is insufficient to change ways in which curriculum is implemented, but it is a necessary component of such change. Assessment is integrally tied with curriculum, the administration of schools, and society and, thus, is a powerful component of curriculum change. Teachers play a pivotal role in implementing the curriculum, but can only do so with appropriate support at school and bureaucratic levels. Formative assessment, because of its qualitative orientation, represents a significant departure from existing thinking about mathematics assessment that has been influenced by experience and training around summative assessment.

This study seeks to explore teachers' current understandings of assessment, and how it is informed by their views on mathematics, learning, and teaching. The study also takes account of constraints to change from within the schooling system and societal pressure. Some insight into these factors may assist in informing teacher development and materials in this area.

Chapter 3

Research Design and Methodology

3.1 Introduction

The purpose of this report is to understand teachers' views and opinions about assessment, with a view to understanding their conceptualisations about formative assessment. It is a small-scale study, and uses a content analysis to analyse what teachers say about their use of assessment (Cohen and Manion, 1994). The qualitative nature of the study provides insight into the range of conceptions held about assessment within teachers' understanding of the curriculum, teaching, and mathematics.

I did not frame the tasks from any particular theoretical perspective. The teachers are interviewed using semi-structured interviews in focus groups. The data was collected and analysed with a view to understanding teachers' perspectives before attempting to interpret the data in the light of a particular theoretical framework. I used a phenomenographic approach to the data analysis to assist me in understanding what teachers' views were. Phenomenography is discussed in more detail below.

3.2 Phenomenography

Phenomenography is a research methodology that was developed within the framework of higher educational research to solve practical pedagogical problems (Marton, 1999). It is interested in the content of peoples' thinking. Phenomenographers repeatedly found that there are a limited number of qualitatively different ways in which people view and experience the world. These different understandings can be sorted into conceptual categories, or ways in which phenomena appear to people. The goal of phenomenographic research is to discover the structural framework in which these categories of understanding exist. I used phenomenography to understand what conceptual frameworks teachers hold about assessment, and ways in which these conceptions may influence their approach to using formative assessment in

mathematics teaching.

Phenomenography is not a branch of phenomenology; rather, it has its roots in common sense reflections on teaching and learning (Marton, 1999; Kelly 2002). Phenomenography, however, has the same epistemological assumption as phenomenology, which is that all knowledge is rooted in our experience of the world. Phenomenology tends to focus on the essence of experience, while phenomenography tries to characterise the variations of experience. Phenomenographers describe the various relationships between the world and the individual. This relationship may be expressed in behaviour, thought, or immediate experience. For phenomenographers, only the immediate experience would constitute the phenomena under consideration (Marton, 1999). I requested teachers to talk from their experience of using the assessments they chose in their classrooms but, later in the focus group interviews, I also asked teachers about more general opinions.
The research method employed by phenomenographers is primarily a semi-structured, open, deep interview during which participants reflect on their experiences (Marton, 1999; Kelly, 2002). The questions are as open-ended as possible to allow participants to answer the dimension of the question that reflects their own understanding of the issue (Marton, 1999). This study uses synergetic focus groups which have the advantage over individual interviews because the data arises out of participant initiated discussion (Willmett, 2002). Willmett (2002) points out that a phenomenographical approach may be particularly appropriate where the issues dealt with may be sensitive or controversial. The approach seems appropriate for my study because teachers are under pressure with the demands of curriculum change and may be insecure about the adequacy of their approaches.

The data is transcribed and examined for both similarities and differences between the experiences of the participants. Kelly (2002) notes that the purpose of the analysis is twofold: (1) to capture experiences faithful to individuals' conceptualisations of particular phenomena and (2) to categorise conceptions and explore relations among them. He says that the findings are considered valid if the final categorisations arrived at are a faithful representation of peoples' experiences. This is done through bracketing, or

suspending one's preconceived ideas about the phenomenon being studied (Kelly, 2002; Marton, 1999).

Bruce (2002) examines the interaction between the researcher and the data in more depth. She argues that the analysis is a process of both construction as well as one of discovery. She points out that the focus of phenomenographic studies has shifted from an emphasis on variation to focusing on the theoretical frameworks people hold. Bowden (1995) refers to this latter approach as developmental phenomenography because it is undertaken specifically to help the subjects of the research to learn. The overall purpose of my study may be developmental, to inform future teacher development, but for the participants in the study, there was no agenda to teach them. This makes the study more "pure" than "developmental" (Bowden, 1995) in its phenomenographic approach.

3.3. Sample

Fourteen teachers from three schools participated in the study. The schools were selected because they had some reputation among parents in the area for doing OBE well. I hoped to understand teachers' developing conceptions of assessment as they grappled with curriculum change, so the schools were purposefully selected (Brown and Dowling, 1998). Of these schools, two (schools A and C) were government schools. One (school A) had a large majority of black learners with a non-racial teaching staff. The other two schools (schools B and C) had predominantly white teachers. The third (school C) was a private school with approximately half the learners being white. All the schools were relatively well-resourced.

The schools had different styles of recording and reporting in assessment:

School A

Teachers were required to collect marks from class work during the term as well as having two exams a year. The term mark was composed of marked class-work and regular cycle tests. It counted 50% or less of the year mark. The reports gave an overall percentage, a rating scale of 1 to 5 for each section of work within the subject, and a comment.

School B

Teachers completed a mark schedule. The term marks in mathematics were divided into number, operations, and problem solving. A percentage mark is given for each component as well as an average. These marks came from tests and class-work. Learners also complete a self-assessment that is included in the report.

School C

Teachers complete observation sheets and collect marks from class work. The report focuses on the specific outcomes for each subject and rates learners on a 4-point scale for each outcome. Teachers provide extensive comments for each learning area.

Teachers from schools A and C described themselves as having OBE reports, while teachers from school B said that they had traditional reports.

All 21 teachers from the selected schools were invited to participate. Their participation was voluntary. Some teachers chose not to participate at all, while others did not want to be filmed but participated in the group discussion without being filmed. Of the original sample of 21 teachers, 14 teachers' comments were transcribed and analysed. All teachers were assured that their participation or lack thereof, would not be reported to school management. In some schools teachers elected to observe rather than participate, and some teachers excused themselves completely.

Because the teachers participated voluntarily, I could not apply strict selection criteria. However, the teachers had the following in common: they taught Mathematics along with other subjects, and reported that they had some knowledge of formative assessment.

The principals were supportive of my use of alternative forms of assessment in the study. Two of the three principals saw the assessment tasks beforehand, while the third said she was always open to new ideas. Schools and teachers were assured that they would not be evaluated in any way. Teachers gave their informed consent before participating in the study. The proposal was passed by the Ethics Committee of the University of the Witwatersrand.

3.4 Research methods and instruments

The research process consisted of two main phases: (1) development and piloting and (2) the main study.

3.4.1 Development and piloting

- I selected assessment tasks and piloted them. The "alternative" tasks were piloted either in the classrooms of teachers who were not involved in the study or with individual children of the appropriate age. The activities were and refined and developed on the basis of these pilots.
- I piloted the focus group interview format, together with the interview questions. It was also an opportunity to discover some of the technical aspects of using a video camera for data collection.

3.4.2 Main study

- Teachers were given a selection of tasks suitable for the phase they taught, along with an introduction to the study and a schedule of interview questions.
- Teachers selected tasks and used them in their classrooms.
- Teachers participated in a focus group interview. This interview was filmed.
- The interviews were transcribed verbatim, using gestures and references to tasks for clarity where needed.
- The data was categorised and analysed using a phenomenographic approach.

These phases are described in detail below.

3.4.3 Assessment tasks

The assessment tasks were based on activities found in journals and textbooks (see appendix 2 & 3). The tasks were laid out so that they looked similar in order to minimise the initial impression of the task being a factor in task selection.

A number of variables were specifically built onto the task. These were:

a) Amount of teacher support
b) Approach to mathematics
c) Mathematics topic
d) Task type

The following grid illustrates how the tasks were classified. They are discussed below in more depth:

		(a) Teacher support		
		Extensive	**Some guidance**	**Little or none**
(b) Approach to Mathematics	**Known**	(c) Number (d) Investigation	(c) Graphs (d) Project	(c) Shape & space (d) Short task
	Challenging	(c) Graphs (d) Short task	(c) Shape & space (d) Investigation	(c) Number (d) Project
	Embedded	(c) Shape & space (d) Project	(c) Number (d) Short Task	(c) Graphs (d) Investigation

Figure 1. Classification of assessment tasks

These variables were differentiated in the following ways:

3.4.2 i) Amount of teacher support

The tasks varied in the amount of support they offered teachers in using them for assessment purposes:

- Tasks with extensive support included the task, notes on how to set up the activities, guidance on probing questions, and observation sheets with categories marked.
- Tasks with some support included the task, notes on how to set up the activities, guidance on probing questions, but no assistance in recording the observations.
- Tasks with little or no support consisted of the task and, in some cases, some suggestions on setting up the activity.

3.4.2 ii) Approach to mathematics

The way in which the mathematics was approached in the tasks varied in the degree to which it was similar to what was in textbooks and syllabi. Although not mutually exclusive, the categories were broadly described as known, challenging, or embedded:

- Known mathematics. These tasks only required learners to work at a

level of complexity suggested by syllabi and textbooks.

- Challenging mathematics. These tasks assumed a beginning level that is within the range suggested in syllabi and textbooks, but which required learners to move into more complex areas.
- Embedded Mathematics. These tasks usually presented the mathematics within a context where the operations or task requirements were not immediately obvious, or required learners to draw from a variety of mathematics topics.

The categories built into the sheets were based on my own experiences of using these tasks in classrooms, and were influenced by Piaget's (1964) stages of development and the developmental stages described by Fennema, Carpenter, *et. al*. (1996; Ell, 2001).

3.4.2 iii) Mathematics topic

The selection of activities were from the following topics in the curriculum:

- Number. This included basic operations and number patterns.
- Graphs. This included data collection and handling.
- Shape and space. This included transformations; two-dimensional, and three-dimensional work.

3.4.2 iv) Task types

Each assessment pack included the following types of tasks:

- Traditional pen and paper test, which was a typical "end of year "exam for each grade. It covered all topics in the syllabus. Teachers were encouraged to select either parts of the test or the entire test.
- Investigations, which were open-ended tasks in which learners were required to work towards a generalisation.
- Short tasks, which were worksheet-based tasks and which explored different aspects of a topic. There was not necessarily one correct answer to these questions.
- Projects, where learners were required to do some research and present their findings in a report or class presentation.

For the purposes of this study, I have referred to investigations, short tasks, and projects as “alternative” assessment tasks based on the assumption that they lend themselves to being used formatively. This does not preclude them being used in a summative manner.

3.4.4 Procedure

The tasks were piloted before they were given to the teachers in the study. The traditional tasks were given to individual learners doing that grade at the time and I marked them. The marks achieved were similar to those achieved in their own class. The learners did not report that any of the work was unfamiliar, and they did attempt all the questions.

The “alternative” tasks for the intermediate pack were tested either in the course of normal teaching by colleagues, or myself, who taught in the intermediate phase. The foundation phase pack was tested in classrooms while I observed their use. The materials were adapted on the basis of observations and feedback received during the pilot. The only significant change that resulted from piloting the instruments was that I added a more explicit observation sheet to the activities that were described as having extensive support.

3.4.4 i)Piloting the tasks

Teachers all received a selection of assessment tasks (see appendix 2 & 3) and were required to select at least one activity to try in their classes. They then were asked to participate in a focus group in which they discussed the tasks. There were 2 focus groups in 2 schools – one discussing the foundation phase assessment materials, the other discussing intermediate phase materials. In the last school, because of the small staff, both phases were combined. The teachers were given the focus group questions beforehand to facilitate the discussion in the focus group. The following questions were in the schedule:

1. What made you choose this activity?
2. Tell your colleagues how the activity worked in your classroom. How did you use it for assessment? Did the findings influence your planning or understanding of the learners? If so, in what way?
3. Would you use the task as an assessment in future? If so:

- How would you conduct the assessment in future?
- How would you evaluate the learners?
- In what way would you use the results?

4. Is there any activity you would definitely not use? What about it was problematic?
5. Comment on the support given to the teachers. What, if anything, do you think was necessary? What was unnecessary? Do you have any other questions about the use of the activities for assessment?
6. Comment on the level of the mathematics. In what ways do you think it is suitable, or not suitable, for your learners?
7. Do these assessments differ in any way from assessments you have used before? If so, how?
8. These assessments are intended to be used formatively. What, if anything, do you think could be gained by this approach to assessment?

The interview questions were too narrow and teachers tended to report their findings, rather than responding to each other. Time did not permit me to come up with a different way of phrasing the questions, but I chose to have an open-ended discussion at the end of the teachers' report back. Question 8 explicitly asks about formative assessment and Question 2 alludes to the uses of formative assessment. This may have lead to teachers selecting what they viewed as formative tasks. Since I really wanted to understand how teachers view formative assessment, I left the questions in and chose to analyse the data in that light.

I experimented with the format of the focus group interview. After experimenting with different methods of recording, I chose to film the teachers using a camera on my lap. A unidirectional microphone and having a third person present would both be more intrusive. I agreed that teachers who did not wish to be filmed would sit out of the view of the camera.

3.4.4 ii) Focus groups

During the focus group discussions, I initially introduced myself and thanked participants for their time and put teachers at ease. The focus group interviews

had two phases:

- First, the groups discussed the structured questions in the interview schedule. The questions focussed on the variables built into the task.
- Second, once the discussion in the interview had exhausted the above questions, I asked teachers to speak more generally about assessment.

I asked the questions as they were given on the interview schedule. I only responded to the teachers' comments reflectively, without giving my own opinions. Despite this, the possibility of the Hawthorne effect being at work is strong, as teachers still tried to anticipate my agenda based on the tasks and questions provided. I have no evidence to suggest that the teachers did respond to what they believed to be my agenda. Teachers may have been unsure of my agenda as the variety of tasks given reflected a number of approaches to assessment.

The focus group interviews were between 40 and 60 minutes long. In two of the schools, schools A and C, teachers were interviewed together with colleagues who taught in the same phase in their school. In school B, the whole staff participated. None of the teachers interviewed taught only mathematics in their schools.

3.4.4 iii) Transcription

The interview aimed to access the views of the teachers. The teachers' utterances were transcribed fully enough to ensure that teachers' meanings were captured. The sound was clear and I had video footage against which to check my understanding. I referred to gestures from the video where it seemed necessary to illustrate what was being said. Teachers also referred to samples of learners' work to illustrate what they meant. However, there is likely to be more meaning in gestures and non-verbal communication than what I could capture The excerpts from the transcription that I quote in the study were more fully transcribed to ensure that the meaning is clearer to the reader.

3.4.4 iiv) Data analysis

I based my analysis on the phenomenographic methodology. This technique investigates the qualitatively different ways teachers think about assessment. It

categorises their utterances to identify different ways of thinking about assessment. In the initial analysis, I broke each utterance into phrases to isolate chunks of teachers' meaning and coded each phrase as teaching, learning, or assessment. I found that these dimensions were not easily recognisable within the teachers' utterances without reading too much into them. In many cases, teachers did not talk in the terms in which I had framed the tasks. The selection of tasks offered to teachers did not always present a range of factors for each topic of mathematics. In most cases, teachers said that the topic that they were teaching at the time guided their choice.

I found that it was difficult to differentiate clearly between teaching, learning, and assessment, especially in the light of formative assessment, which purposefully integrates assessment into teaching and learning. This also was an unconscious attempt at imposing my categorisation onto the data. It was inappropriate in the light of the methodology I had selected. A second round of coding became necessary.

In the second round of coding, I created a list by using a word or phrase to capture what teachers said in a word or concept. I frequently used the teachers' own words at this stage. Later, if it appeared, taking the context of the utterance into account, that teachers were talking about the same phenomena, I collapsed the categories into one broader or more inclusive category. The categories, at this stage, seemed unrelated to each other or the research question. Some of these categories include: reliability, group work, reporting, observation, content, teaching tables, and so on (see appendix 1). This approach fitted more easily with phenomenographic methodology and was more open to what teachers were saying.

I then placed the teachers' responses onto a matrix, which categorised their responses along the dimensions of traditional test vs. alternative assessment and formative view of assessment and summative views of assessment (see figure 1, p67) . The resulting scatter showed a clustering of utterances in the summative / traditional quadrant and the alternative / formative quadrant. It became apparent that the mathematical topic was a further dimension along which teachers' comments could be classified. A further sort then showed that

the alternative / formative comments and activities adopted a broader more integrated view of the mathematical topic while those in the traditional / summative quadrant were more specific areas of content. There were exceptions to the general scattering described above; these are also discussed in the findings. Again, I questioned the extent to which I was imposing my interpretations onto the data, but have recorded and discussed my findings as they are, nevertheless, informative.

In analysing the data, I only used categories that were referred to by teachers in all three schools, despite teachers having different views within these categories. I identified common categories, within which teachers may have a range of experiences and views, to enable me to structure my own understanding of what teachers saw as significant issues. The discussion of the data tries to capture the range of views presented. Some teachers were more vocal than others, so a careful sort of the data had to be done to ensure that the opinions of very talkative teachers were not given undue weight. The sorting process also showed that in two schools there appeared to be similar views of assessment, while in the third, teachers held a wider range of views, despite there being a low staff turnover.

In discussing the data, I began to draw on my own theoretical framework. In many cases, teachers' utterances indicate that the teachers work from assumptions different to my own and that this influences their choice and use of assessment. The degree to which a researcher should do this is debated by phenomeographers (Bruce 2002; Kelly, 2002). I found my analysis was limited to describing the categories that teachers mentioned, and any attempt at understanding their conceptualisation automatically lead to my drawing on my theoretical framework. I have attempted to do so explicitly, after my descriptions of teachers' views, to enable readers who may draw on a different framework to reach their own conclusions.

3.4.5 Validity and reliability

The concepts of validity and reliability have their origins in quantitative research. Traditionally, validity questions whether the research instrument measures what it intends to measure. In qualitative research, validity, or the extent to which the

picture reflected is true, is more meaningful than reliability. In the literature about phenomenographic research a number of ways of improving validity are discussed (Kelly, 2002; Bruce, 2002). I draw on this work in my discussion of my study.

Reliability within a qualitative framework is difficult to establish in qualitative studies, as it would require, in my study, a second researcher to get the same findings using the same informants and questions. This is impossible because teachers may have shifted their views as a result of participating in my study.

Cohen and Manion (1994) point out that validity is a common problem in using interviews because respondents may not be truthful. This could also be exacerbated by the use of a focus group because of the possibility that respondents influence each others' responses. Because the interview questions I used do not have "right" or "wrong" answers, it would have been difficult for participants to give me the desired answer, especially since department policy about assessment was not clear at the time of the interviews (Pahad 1999). This lack of clarity means that teachers are more likely to talk about their own sense-making and experience. The use of the group encouraged debate, and gave the teachers space to express a variety of opinions. Asking teachers to talk about their experience, with the tasks they selected, also limited the degree to which their colleagues or the interviewer influenced them, since they were talking about their personal experiences.

Kelly (2002) and Cope (2002) address the problems of validity within phenomenographic studies. Kelly summarised the task of the phenomenographer as first capturing conceptualisations faithful to participants' conceptualisations, categorising these conceptualisations, and then exploring the relations among them. In his survey of phenomenographic research, Kelly says that the approaches they take to validity are content validity and construct validity. Content validity relates to the faithfulness of the capturing of the participants' conceptualisations; construct validity refers to the methods by which data is analysed and interpreted. A further aspect of validity refers to the practical aspects of data capture – in this study video footage was used. These aspects are discussed in more detail below.

3.4.5 i) Content validity

Generally, phenomenographic studies are seen to have content validity if the final categories are faithful representations of people's experience. Kelly (2002) suggests that three ways of maintaining content validity are: (1) to capture data without interpretation or influence; (2) by capturing an immediate response from the participant which has not been reflected on in the light of previous experience; and (3) covering all aspects of each conceptualisation present in each interviewee. I attempted to meet all these criteria, with varying degrees of success.

- **Capturing data without interpretation or influence**

Phenomenographers suggest researchers bracket their assumptions during the data collection phase. Since I had worked in the education field as a teacher, done in-service work with teachers and written a literature review for the research proposal in advance of the data collection, I did have experience, questions and opinions. The variables that I built into the tasks reflected areas that I had found problematic myself. However, I tried to stick closely to the questions in the interview schedule to enable teachers to express themselves freely, without being unduly influenced by my questions or responses.

- **Capturing an immediate response from the participants**

The focus group interviews were done within the same week that the teachers tried the task they has chosen. This did allow teachers some time to think about the tasks and assessments. Also, because the questions were given in advance, some teachers did think about their responses. The use of a focus group meant that teachers could influence each other's responses or clarify their own views in the process of the interview. I think this does not necessarily affect the validity of the data, because I acknowledged in the research design that the study aims to gain insight into teachers' conceptualisations as they grapple with changing assessment practices. I also acknowledge that, as mentioned by Gipps (1994), the concept being measured is dynamic.
I could have checked the validity of my transcripts with the teachers to check

that I have accurately captured their meaning, but it took me a long time to transcribe and analyse the data and the constructs I am looking at will have changed in the interim. Also, the participation of teachers in the focus group, as well as discussions I had with teachers after the formal interview where I shared my own opinions and experiences, will have affected the teachers' understandings. This would have lead to a new intersubjectivity developing between the participating teachers.

- **Covering all aspects of each conceptualisation**

I attempted to cover all aspects of each conceptualisation by asking all the questions of all the teachers. However, as will be seen in the data analysis, teachers did not respond to all the questions. Teachers also appeared to have difficulty talking in conceptual terms, and gave sparse answers to many of the questions. Cohen and Manion (1994) in their critique of focus groups, point out that it is difficult to ask probing questions because they can exclude the other members of the group. My experience confirmed this.

3.4.5 ii) Construct validity

Phenomenography, in attempting to categorise individual responses, tacitly assumes that truth exists and that people hold an integrated picture of truth. However, there is no single truth (Kelly, 2002) and people may hold a number of contradicting truths simultaneously. This is especially true of people in the process of developing and testing their understandings.

Kelly (2002) mentions that construct validity can be enhanced by providing qualitative categories of description and a full account of how the data analysis and interpretation was reached to allow others to judge the reasonableness of this categorisation. I provide the transcripts of the interviews as well as coding categories in the appendices to facilitate this validation.

3.4.5 iii) Reliability

Two typical methods for establishing reliability are: test-retest reliability and inter-rater reliability (Neale & Liebert, 1980).

Test-retest reliability requires the researcher to question the same sample on the same instrument on two different occasions. A test is considered reliable if there is a high correlation between two scores obtained by an individual on the same test administered on two different occasions (Neale and Liebert, 1980). As discussed above, this view of reliability assumes that the construct being measured is stable. In this study, such an assumption is not valid. The sample of teachers was specifically selected because they are grappling with change in assessment practice and the experience of participating in the focus group would have changed their views of assessment.

I could have used inter-rater reliability by working with a colleague who had a similar interest in developing a set of codes, or categorising the teachers' responses, the reliability of the data could have been improved. My time frames, along with the fact that fellow students were engaged in their own research with their own pressing deadlines, made this impractical.

Kitwood (1977, in Cohen and Manion, 1994:282) criticises interviews as a research tool, and argues that reliability is enhanced by structuring questions and the interview tightly, but that this is at the cost of validity. The first half of the focus group discussions were more tightly structured, and the outcomes could be quantified and possibly replicated more easily than the second, more open-ended part. The findings from the first part were more generalisable, but were not as helpful for understanding teachers' meanings as the analysis of the second half.

This study is a small-scale qualitative study and, as such, is not generalisable. However, it opens up areas which could be investigated more fully. The data confirms or throws light on some issues in using formative assessment, and contributes to the growing research in this area.

3.4.6 Ethics

The prospective participants were given an information sheet detailing the purpose of the study and their role before giving written consent to their participation. The data is written up in such a way that the informants and their

schools remain anonymous. The video and transcriptions will not be used for any purpose other than this study without the permission of the participants. An application to the committee for research on human subjects was approved.

I offered to do a workshop on any aspect of assessment that the teachers requested to thank them for their participation and to offer an opportunity for professional development. Most teachers expressed interest in the findings but did not express any particular interest in an assessment workshop. One school requested a mathematics workshop focusing on fractions. This was conducted soon after the data was collected.

The other two schools requested that I tell them my findings. I intend writing up a summary of the findings on the completion of this report and will liase with the principals of the schools to discuss ways in which I can best communicate my findings.

Chapter 4

Discussion of the data

4.1 Introduction

It has frequently been argued that teachers' knowledge of mathematics has been a stumbling block in their adopting OBE practice (Reeves and Long, 1998). While my study neither confirms nor denies these findings, I argue that teachers' existing knowledge and beliefs about mathematics learning and assessment also play a role in their struggle to adopt OBE practices.

My findings suggest that teachers are making a transition from a traditional view of teaching and learning to a new way. It would be difficult to describe their views of learning as constructivist, as many of their statements show an atomised view of mathematics and it's learning. Similarly, teachers' views of assessment are also strongly influenced by their existing beliefs, characterized by assumptions based on their experience of summative assessment.

4.2 Discussion of data

In the initial analysis of the data, I categorised the teachers' statements according to the view of assessment they were taking in that instance. The matrix below shows that teachers' stated views of assessment fell mainly in two quadrants of the matrix.

		VIEW OF ASSESSMENT	
		Summative	**Formative**
TASK TYPE	Traditional	35%	11%
	Alternative	5%	49%

Figure 2. Classification of teachers' statements

Teachers tended to use traditional tests summatively. The reasons teachers gave were that the tests related directly to the syllabus, that they could use the marks, or that the results confirmed what they already knew about their learners. Some teachers said they would use such tests as a "baseline" at the beginning of the year or that they were good revision exercises. In this case, they are using traditional tests in a more formative way.

Teachers who used alternative assessments reported that they found them interesting and that they and the learners enjoyed them. Most teachers were unsure what they should do with the results of the assessments. The schools' assessment policies, formal or not, played a major role in how useful teachers found their observations. A more in-depth discussion of the findings illustrates the points above.

Fourteen teachers responded in the focus groups and spoke about their choice of assessment task. Twelve of these teachers selected and conducted one activity in their class, while one did two activities and another did four.

The focus group interviews had two phases. First, teachers answered questions that were based on the 4 variables that were built into the assessment tasks. These variables were: (1) task types, (2) amount of teacher support, (3) the way in which the mathematics is approached, and (4) syllabus topics. Second, teachers discussed how they used the assessment and things they found interesting or significant while doing the tasks in their classrooms. I discuss these two phases of the focus group discussions, and then conclude by drawing an integrated picture of teachers' views and understandings about assessment within their implementation of OBE.

4.2.1 Which assessments did teachers choose?

The packs of assessment tasks given to the teachers included the following variables: a range of task types, amount of teacher support, the way in which the mathematics is approached, and syllabus topics. Twenty tasks were provided in the pack and thirteen of these were selected. The tasks the teachers chose are discussed in terms of the above-mentioned variables.

4.2.1 i) Task type

Each assessment pack included:

- Traditional pen and paper tests
- Investigations.
- Short tasks and games
- Projects.

Of the eighteen tasks selected by the teachers in the sample, thirteen were "alternative" assessment tasks (see appendix 2 & 3). As discussed in chapter three, this could be a consequence of the Hawthorne effect (Neale and Liebert, 1980), whereby participants tend to behave as they believe the researcher would like them to. However, their choice appears to contradict the widely held perception that teachers are reluctant to use alternative tasks for formative assessment (Vandeyar and Killian, 2003).

Of the alternative assessments selected by teachers, six of the thirteen were investigations while the others were short tasks or games. Investigations are the most unfamiliar task type to teachers, and can be seen as a way of teaching within a constructivist paradigm (Jaworski, 1994). This choice could indicate openness toward alternative assessments. Teachers may have chosen them because of their unfamiliarity. When asked about this aspect of the assessment most teachers did not answer directly; as discussed later, teachers usually cited syllabus content as their reason for their choice. None of the teachers referred to the tasks as "investigations", but they did talk about how they wanted the learners to reach generalizations.

In the following excerpts, one teacher recognised the investigation task as leading to algebra, while another refers to patterns as the desired outcome (see figures 3 and 4).

School A

Teacher 1: Okay, well we chose this one … um, they seem to struggle with that sort of thing – logical problem and um… where they basically have to deal with n … an algebraic type problem …

Use the pattern below to answer the questions:



1. 2. 3.

How many dots are there in picture number 5?

How many dots in the 20th pattern?

Explain how you could work out how many dots there would be in any number of the pattern.

Figure 3. Rectangular Numbers Activity

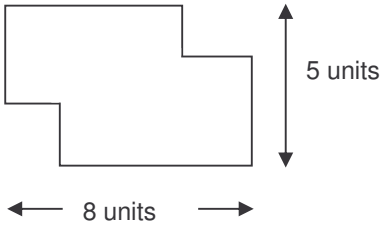
School B

Teacher 7: Most of the children actually worked out, by looking at the picture and by building it, that the eight by eight most of them …managed to work out that there was some sort of pattern for the square so they did even if they did it by a physical table … for the one there's four even if they didn't actually work out the formula … Most of them got as far as compiling a table and a pattern… which I was quite surprised about in some cases … most of the groups, the better groups or the one's who stayed focussed on the activity the whole of the time. Actually worked out well. It's 5 plus the corners.

Sipho works in a pool and paving shop that sells square ponds and paving to surround the ponds. The paving blocks are all 1 unit square.

Customers tell Joe the size of the pond and Sipho has to work out how many paving blocks they need.

1. How many paving blocks will they need for a pond that is 8 by 8?
2. Can you find a rule that Sipho can use for any square pond?
3. Can you find a rule that Sipho could use if the shop also sold rectangle ponds?
4. Can you find a rule that works for ponds that are this shape?



This pond will need 40 blocks.
Check that you agree.

This suggests that these teachers did have the mathematical knowledge to do the tasks themselves. There were two cases where teachers said that the task was more complex than they had thought when they selected the task, but they were able to find a solution and use the tasks in class.

Summative views of assessment are based on empirical approaches to measurement (Gipps, 1994). Black (1998) discussed ways in which validity and reliability contribute to building teachers' confidence in their assessments. Reliability refers to the replicability of results on a particular assessment. Validity refers to the degree to which the test measures what the teacher sets out to measure.

The teachers in the above excerpts both said that they would not use the tasks they tried as assessments. The reasons given were that it was unfair as an assessment, or that the tasks were unfamiliar to the learners. This is the response of one teacher:

School B

Researcher: As a form of assessment ….?

Teacher 7: Because it was beyond the normal. It wasn't anything I would use, I didn't even take them in because the group that got as far as 64 and stopped… [um] I said well let's look at it if you're going …. You can't say they're stuck on level one … because if you've interfered how can you assess? Because you have to interfere …They've got an answer …. um, ja, … and they were ready to sit back for the rest of the lesson.

This indicates a particular view of validity and reliability that was expressed by a number of teachers. They presuppose that a test should be a repeat of familiar work that has already been learnt and reproduced under test conditions. Test conditions are seen as necessary to make the test fair. It assumes that standardising the conditions gives each learner the same chance of success. In the light of this, they also see intervention by the teacher as problematic because it interferes with validity. These assumptions have their root in the psychometric view of assessment (Gipps, 1994) which assumes that knowledge, like psychological traits, is stable and able to be separated from the

context of the test. This assumption is challenged by Lave (1991) who suggests that learning is situated in the context in which it is learnt. Knowledge is not independent of the context in which it is acquired.

Teachers who chose short tasks and games also expressed concerns about validity being compromised. Black (1998) points out that reliability is often maintained at the cost of validity. The teacher quoted below reflects a view echoed by many of the teachers. While saying that she cannot "see who understands what", she assumes that learning demonstrated in an individual pen and paper test is more fair. A correct answer on an individual test, may show procedural knowledge but does not necessarily show conceptual understanding.

School B

Teacher 3: I must be honest, I'm still very much in favour, especially in something like maths, in individual assessment … Once you go into a group it's hard to see exactly who is doing the work, who understands what.

Teachers who selected traditional tests gave them under test conditions and did not question their validity or reliability. One teacher pointed out that the way I asked the questions differed from the way that concept was usually asked in her class and that many learners could not recognise the concept.

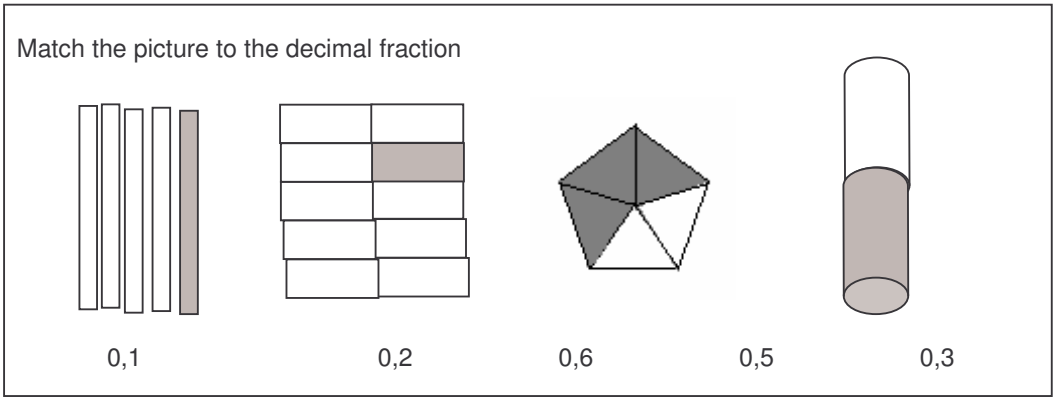


Figure 5. Decimal fractions test item

School A

Teacher 3: Certain of the things were done differently to how we've done them in class and I thought number patterns, I thought that my …. my lot would be able to manage it but

> as they were working I found for example that decimal fractions … they can convert fractions to decimal fractions … some of them were given to them in picture form, and they just couldn't get it right.

Later in the same discussion she commented that:

> Teacher 3: They couldn't do it so it wouldn't have been a fair assessment because it tells us that they can't necessarily apply what we taught them in a different form.

Teacher 3 believes validity presupposes familiarity. This also points to an assumption that the purpose of assessment is to reproduce knowledge under test conditions. This view characterises a belief, typically held by people from within a summative perspective, that tests measure what has already been learnt (Killen, 2003). In this case, the questions in the test represented fractions graphically rather than in standard notation. I would argue that it does represent a fair test of the learners' concept of fractions. The findings of the test provide helpful information about the learners' conceptions and could be well-used formatively.

Thus, a belief that summative assessment is reliable and, therefore, fair, affects teachers' willingness to use alternative assessments summatively. Teachers also do not question the validity, beyond face validity (Killen and Vandeyar, 2003), of summative assessments, and so do not fully accept the need for a move away from traditional summative testing.

4.2.1 ii) Amount of teacher support

The tasks varied in the amount of support they offered teachers in using them for assessment purposes:

- Tasks with extensive support included: the task, notes on how to set up the activities, guidance on probing questions, and observation sheets with categories clearly described.
- Tasks with some guidance included: the task, notes on how to set up the activities, guidance on probing questions, but no assistance in recording the observations.

- Tasks with little or no support consisted of the task and, in some cases, suggestions on setting up the activity.

All of the tasks that teachers did not select could also be described as "alternative" assessment tasks.

Teachers did not answer the question about the amount of support provided on the task during the focus group interview. When I asked the question directly, some teachers met the question with silence, while other teachers said that they had not really thought about the tasks in that way. Teachers were not critical of this aspect of the assessment pack at all. It is significant, though, that all the activities that teachers did not select were those where little or no information about how to use the task as an assessment was built into the task (see appendix 2 & 3).

In contrast, teachers who selected and successfully used tasks with extensive support commented on the observation sheet. Teachers either reported that the sheet gave them a format they could use, or that they used it as a guide for constructing their own observation sheets. The following teacher used it as it was, and reported that it helped her to discriminate between her learners.

Addition Bingo

	Does not have any strategy for adding	Counts on fingers to add single digit numbers	Makes errors when numbers require adding	Adds numbers using concrete methods, e.g. counting on fingers, tallying, etc.	Adds numbers effeciently. Counts on from the largest.	Applies knowledge of bonds. Works abstractly.	
							Comment
Name							
1							
2							
3							
4							

Figure 6. Observation sheet for addition bingo

Learners play bingo.

Use 2 dice marked as follows:



0, 1,2,3,4, 5 10,11,12,13,14,15

Learners take turns to throw the dice, add the numbers and cover the answer on their board. The first learner to cover all numbers in a row (vertical, horizontal or diagonal) is the winner.

Figure 6. Addition Bingo Activity

School C

Researcher: And as an assessment?

Teacher 2: I straightaway got my three ability groups. Those that used fingers, that didn't count on that counted all the numbers … those that got stuck with numbers more than ten, and … didn't know what to do.

The next teacher modified the sheet supplied to describe categories according to her own criteria. She uses shifts from using descriptive language (for example, "uses fingers") to judgmental language (for example, "weak").

School C

Teacher 3: I used the tick list but it didn't fit with the activity I devised … I used it … I wrote "Used fingers accurately", "Used fingers …" I used the tick list but … I devised but I wrote ... "Used fingers accurately", "Used fingers sufficiently", a star for the very bright child who was working in the abstract, "Average", "Weak" for fingers all the time.

Both of the above teachers worked at the same school, school C, which has a policy and report system that encourages the gathering of qualitative information, but the use of categories like "average" and "weak" are used in policy documents from before the implementation of the new curriculum.

Despite the fact that no one said so, it appears that teachers do need support and well-structured materials in using "alternative" tasks for assessment purposes. Alternative assessment tasks are not readily available to teachers and it is difficult for teachers to develop such materials – especially as they are built on a constructivist approach to learning. Guidelines that help teachers to recognise and value learners' conceptual development may help teachers to develop and trust their judgement. Teachers did not attempt to develop use their own observations or knowledge of learners to develop assessment criteria.

4.2.1 iii) How the mathematics is approached

The way in which the teachers spoke about the mathematics in the tasks depended on the extent to which the questions were similar to the approach used in textbooks and exemplars in the syllabi. Although not mutually exclusive, the categories were broadly described as "known", "challenging", or "embedded":

- Known mathematics was seen as that in which the mathematics task is in the curriculum and requires learners to work at a level of complexity suggested by syllabi and textbooks.
- Mathematics that was described as challenging assumes a beginning level that is within the range suggested in syllabi and textbooks but requires learners to move into more complex areas.
- Mathematics referred to as embedded in the task is usually presented within a context where the operations or task requirements are not immediately obvious, or may require learners to draw from a variety of mathematics topics. The level of complexity could be described as either "known" or "challenging".

Of the fourteen teachers interviewed, thirteen linked their choice to their syllabus, while one said he chose a task because it was unfamiliar. Of these, eleven tried to link the task to something they were currently doing in mathematics. The remaining two linked their choices to other subjects they were teaching at the time: one linked it to Science, and one to Life Orientation. Teachers felt most comfortable with tasks I'd classified as "known". For example:

School C

Teacher 1: We chose the addition bingo, the one with the number range from one to twenty.
Researcher: This is grade 1?
Teacher 1: That's what we were doing … bridging of ten. And also the other activities weren't appropriate for what we're doing.

Another teacher commented that the tasks were not all at the appropriate level. For example, the following teacher says that the number range was wrong for the grade:

Teacher 2: Just in grade 2 don't really go higher than 2 times, 3 times, 4, 5 and10. A few liked working with the 6 but it wasn't really a whole class activity.

Despite teachers opting for familiar presentations of the mathematics, many of the activities were still different in some way to what teachers had done in class. Issues arising from this difference are discussed later. In cases where teachers selected "challenging" tasks they still were guided by the syllabus, but were less comfortable with their choice.

School B

Teacher 7: I did the area, the squares with the areas around …I have just done area in science and we did area of the square and the circle so I thought it was kind of related to what we were doing.

One teacher chose an investigation because he said it looked different to what they were used to.

School A

Researcher: So familiarity is a factor [in your choice]?

Teacher 1: I chose it because it was different.

Researcher: You liked the difference.

All the teachers who selected summative tasks reported a close link between the syllabus and the assessment.

School A

Teacher 3: [With reference to the grade 6 summative test] Um, we've covered the skills this year. We saw that they struggled with word problems. We did give them something with one word problem … number patterns, we've done.

On one level, it is a practical choice for teachers to choose a topic that relates to what they are doing at present. Underlying this statement is the assumption that topics are taught in a particular sequence in the year. Teachers appear not to have a spiral approach to the curriculum within a year, but they do across years. In mathematics, new learning builds on earlier learning, but within OBE it is assumed that learners work at their own pace and have numerous opportunities to demonstrate that they have achieved an outcome. The fact that teachers did not choose tasks that required learners to draw on a number of

skills from a variety of topics may also relate to teachers not having adopted this approach to learning, despite the attempts in Curriculum 2005 to do so.

4.2.1 iv) Mathematical Topic

The tasks in the assessment pack dealt with the following topics from the curriculum: number, patterns, shape and space data handling. Within the number topic, activities included basic operations and number patterns.

Nine out of the twelve topics selected by teachers were about basic operations within the topic of number. Another two topics dealt with number patterns. The following teacher justifies her choice in terms of her syllabus:

> **School C**
> Teacher 3: I chose four in a row, initially just to start them off as to how it worked because we were in the middle of multiplication.

Despite the fact that the three focus group interviews took place at different times of the year, only one teacher selected an activity from a different topic: symmetry from the shape and space topic. This seems to reflect the preoccupation with number, especially basic operations, in primary school classrooms. The curriculum has not been explicit in what proportion of time should be spent in this area, but based on the fact that the interviews also focussed almost entirely on number, I suspect the vast majority of classroom time is spent on this aspect of the syllabus. Teachers tended to see their syllabus as a sequence of topics that build on each other. They also had differentiated incremental steps as is done in old curricula with an emphasis on an algorithmic approach to calculation. This is seen in this transcript from a teacher who did not select an activity because it involved division by a two digit number:

> **School B**
> Teacher 6: But I'm actually at the moment doing division with one number. Ten, hundred, thousand and multiplication (of) them of all the short method. So although they haven't done … two numbers with them, so I stayed away. I thought I haven't even started it with them.

Nine of the twelve activities selected involved multiplication. Many teachers spoke of their frustrations that learners do not know their tables and most said

that that there was no approach other than rote learning to overcome this problem. However, they selected activities that did not require rote learning.

In the transcript below, a teacher used an alternative task (figure 7) which required learners to grapple with the way multiplication worked and develop some understanding of factors.

Neo was playing dice. She told Tebogo that the product of the numbers she had rolled was 36. Mary said she must have rolled a 6, 6 and 1. Neo said that she had rolled a different combination. What are the other possible combinations that Neo could have rolled?

Figure 7. Dice activity

School B

Teacher 4: So to choose something from the pack that was relevant to what we're doing now that could be used was quite difficult … but I chose a couple of the worksheets which we did, this one where the little girls played dice … She has 3 dice and she gets the product of 36 … So I thought we're always whining about tables, let's do this as a bit of an extension activity … and we started working to see what adds up to what. They battled, they battled … to say 6X6 = 36 but didn't want to add in the times 1… so I feel from the tables point of view they certainly enjoyed it …as a different way of looking at their times tables.

The teacher commented that it was an extension activity. She appears to have a conceptual view of mathematics despite not expressing it in constructivist terms. It is possible that with the availability of more tasks that lend themselves to formative assessment, teachers could develop their understanding of working formatively with learners' mathematical concepts.

The mathematics in all the activities selected was either known to the teachers, or they selected it because it appeared to be known, and the complexities only became apparent as the activity progressed.

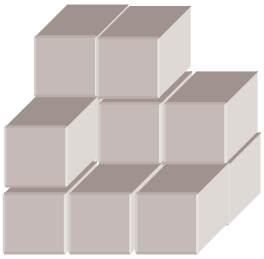
School A

Teacher 1: I, I didn't look at it closely enough when I choose it 'cause I thought it was fairly easy and then when they got busy (laugh) … it was actually quite difficult. I actually sat trying to work out the last part myself. I couldn't get it right either.

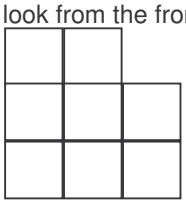
This can be seen as evidence of the view that teachers transmit known knowledge, an assumption of a traditional approach to mathematics teaching, in which mathematics is seen as true and unquestioned. In the case of teachers, this body of knowledge is embodied in the syllabus. A fallibalist (Ernest, 1991) orientation may be more open to selecting activities that lead to understanding that is beyond what is in the syllabus. Teachers, who teach from within a fallibalist paradigm are not expected to present learners with mathematics which they themselves do not know. However, an openness to the possibility that new understandings of mathematics can be constructed – even by learners – would foster their interest in learners finding "new " ways of working with open-ended problems.

Conversely, teachers were also asked to say which tasks they would not select and to give their reasons.. Six of the eight topics that were not selected by teachers dealt with spatial concepts. Both of the tasks described as "too difficult" were spatial tasks involving visualization of three-dimensional cubes. This kind of task is new in the curriculum at this level.

A stack of blocks is shown below.



This is a drawing of how it might look from the front if you look at eye level.



Draw how it might look from the back at eye level to it.

Draw how it might look viewed from directly above it.

Draw how it might look from the left at eye level to it.

Draw how it might look from the right at eye level to it.

Figure 8 Different views activity

School A

Teacher 3: And the one where you have to draw the block from the back and from the side. I thought that was too hard. They're only starting with geometry … basic names of… [shapes]

Teachers seem not to see three-dimensionality as part of the curriculum and think it's too difficult. This is another contributing factor to their preference for number activities. Two of the activities that were selected focussed on number patterns, but also had a spatial dimension. In both cases, they were two-dimensional representations which appears to indicate that the teachers have a preference for activities that have two dimensions, as was done in the old curriculum. The assumption behind separating two-dimensional from three-dimensional space shows a fragmented view of the syllabus and a tendency to teach concepts in isolation.

4.2.2 What did teachers find interesting or significant in their use of assessments?

This section of the discussion refers to the unstructured part of the focus group interviews with the teachers. The teachers' comments are grouped to reflect their views on topics that came up in this open-ended part of the discussion. In summary, teachers expressed a wide range of views about using group and pair work for assessment, ranging from their being supportive to critical of its use in assessment. Learners' responses were sometimes surprising to teachers, as was the learners' difficulty in expressing themselves mathematically. Teachers appeared unsure of how to use their findings in their teaching and, in two of the three schools, in reporting. The findings suggest that the schools' assessment practices, whether formal or not, were a major factor in the teachers' choice and use of formative assessment.

4.2.2 i) Teachers' views of group and pair work

The use of group and pair work within a constructivist framework is to provide scaffolding in the form of social interaction to encourage learners to work within their ZPD. This social interaction also gives teachers access to ways in which learners construct their knowledge and to intervene where necessary to assist in the learners' conceptual development. Ways in which learners take up such intervention is also of interest to teachers as it may indicate learners' concept-formation in the mathematical topic.

All of the teachers who chose “alternative” assessment tasks used group or pair work. None of the teachers who selected alternative tasks required that learners hand in individual work.

One teacher reported that he put learners in pairs to allow for peer teaching:

School A

Researcher: Do you think it is a problem to use group assessments?

Teacher 1: Not really with OBE. I can’t say why I chose to put them in pairs. I think I put them into pairs … I knew there were some that would just sit and look at it and go into a total blank. If they could discuss it and brainstorm …

Another teacher who used pairs reported that it ensured that all learners had an appropriate level of challenge:

School C

Teacher 4: … and very interesting to see who the leaders were and who the followers.
By the end of the activity they would rather go and work with someone who was their own ability level.

A third teacher gave each group a different activity and used groups to facilitate peer teaching:

School B

Teacher 1: I just want to tell you that I gave them a certain period of time in which to complete the activity. And then they had to come up and show the class what they had achieved and the class actually liked that, being shown and taught by the group who…

All these excerpts show teachers who have experience of working with learners in groups and have a sense of the role of social interaction in facilitating learning. The teachers did not seem to see themselves as doing assessment, except for one who reported that she could see how different pairs played the game required by the task and who would then select ability groups from her observations.

Much of the open-ended discussion showed that teachers were ambivalent about group-work, especially it’s use in assessment:

School B

Teacher 3: As a parent, I also don’t want to see what the child sitting near my child can do. I want to see what my child can do.

The teacher below questions the reliability and validity of group assessments:

> Teacher 2: Group work, projects – one does the work and three copy … there is no doubt about it and they all get assessed at the same level. The ones who work get angry … because they are working and carrying three, or there may be two out of five working putting this together, and the other three cruise and they get the same marks.

Teachers are concerned about evaluating individuals in group processes:

> **School A**
> Teacher 4: What I find with groups is that it [that is, the child's' ability] doesn't really come out.

While another teacher said that it was also unfair to give everyone in a group the same mark.

Part of the problem is that teachers are thinking about using qualitative information from a formative task that was used formatively for summative purposes. It may indicate that teachers need to develop a deeper understanding of how to use formative findings. Teachers' concerns about the reliability – and even validity – of formative tasks also needs to be taken seriously. While a deeper understanding of a constructivist paradigm, along with experience of using assessment tasks formatively, may help deal with teachers' concerns of validity, problems around reliability remain. Some form of recording or systematic observation could be introduced to increase the reliability of formative assessment. The observation sheets provided attempted to do this, but teachers remained unconvinced.

4.2.2 ii) Learners responses to formative tasks

Despite their reservations, teachers who selected investigations and games reported that learners enjoyed the "alternative tasks". Learners in the following teachers' classes appeared to enjoy the challenge and being actively involved in problem-solving:

> **School B**
> Teacher 1: Well, I actually did a discussion with them today and they loved all four activities.

> **School A**
> Teacher 1: One thing I must say about this [investigation] is that they kept going on it, they didn't want to stop.

Teachers also enjoyed the activities as they had an influence on classroom culture. In these cases, teachers saw this change as positive and found ways to manage it:

School C

Teacher:4: So it was wonderful it was really nice. As an assessment it is quite a noisy activity, they get very excited, but I didn't have large groups.

School B

Interviewer: What did you think of the competitive element?

Teacher 2: (Laughs)

Teacher 1: When somebody got a row of four in my class I rang the bell!

Teacher 2: Oh my word!

The use of investigations, activities, and games created a wider variety of different classroom 'cultures'. A traditional view of teaching and learning may inhibit the use of such activities. They also require teachers to draw on a range of classroom management styles. Although the teachers who selected the alternative tasks were able to manage the learning situations, classroom management may have been a factor in other teachers selecting traditional assessment tasks. However, the data could neither confirm or deny this.

4.2.2 iii) Learners' expression of mathematical concepts

Teachers who did "alternative" tasks referred to language as a difficulty in doing the activities. They tended to see the difficulties of second language learners in interpreting the problems as less significant than the difficulties of all learners to explain their thinking and observations. The following two teachers refer to their learners' difficulties:

School C

Teacher 4: To slow the game down they had to verbalise how they got their answer. And some of them battled to actually verbalise their answer, they just couldn't explain actually how they got the answer.

School B

Teacher 1: What we found here was that we couldn't … we actually found the language very difficult to come to a conclusion about the pattern that was formed on this side … It was difficult to put it in words.

Learners found it difficult to explain their thinking and to use language to explain how they were thinking to their peers and to their teacher. Vygotsky (1979) describes language as a tool, because learners use language to assist them in grappling with concepts. This process of grappling differs from a procedural approach to "doing" mathematics because learners are seen as actively refining their understandings as part of part of developing their mathematical knowledge. Teachers appeared not to have this perspective and were unsure how to help their learners to express their concepts.

4.2.2 iv) Reports of unexpected or new insights into learning processes

Alternative assessment tasks ideally allow teachers to identify and work with the learners' current conceptions and assist them in developing their understandings. Most of the teachers using assessment tasks formatively reported being surprised at some of their observations. This can be seen as a new focus on the process of children thinking mathematically rather than on the product which is the focus of summative assessment. Teachers reported both being surprised at how well some children were thinking as well as at the idiosyncrasies of their learners' thinking. The following teacher reported being surprised that the level of the learners' thinking was beyond his expectation:

School B

Teacher 7: Most of them …managed to work out that there was some sort of …Most of them got as far as compiling a table and a pattern ... which I was quite surprised about in some cases. [See activity in figure 2.]

Another teacher noticed an inconsistency in the learners' responses which helped her identify a particular aspect of the fraction concept that learners had not grasped.

Draw a red circle around the diagrams that show half.

Put a cross on the drawings that show a quarter.

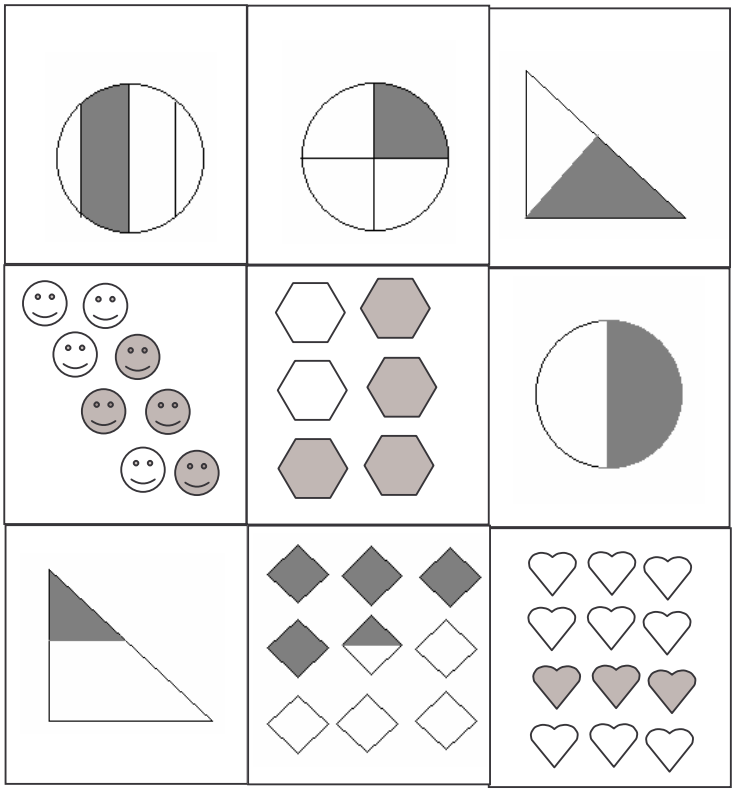


Figure 9 Fractions test item

School B

Teacher 4: For example, on the one with the diamonds where there was one that was in half – that they could tell it was a half.… The other one that surprised me was this triangle one … mm … they could see that it was actually a quarter… However, all of them said that the circle was just sliced like that which proves that the part … that it had to be equal in size …hadn't sunk in.

A third teacher noticed an instance where learners had limited their view of symmetry to mean only a vertical axis of symmetry.

School C

Teacher 5: … can only fold it vertically you know these … um … [about symmetry] you know this one over here also caught them [Refers to the arrow shape.]. You know on the paper it was sideways on and they said that. [(It wasn't symmetrical.] I said that if you turn that around ... oh ja, then it is symmetrical. It was very interesting because I hadn't actually thought that they were seeing it that way.

Ask the learner to sort the shapes into two groups. Symmetrical shapes can be cut in half and one half will be a mirror image of the other. In non-symmetrical shapes, the halves will be different.

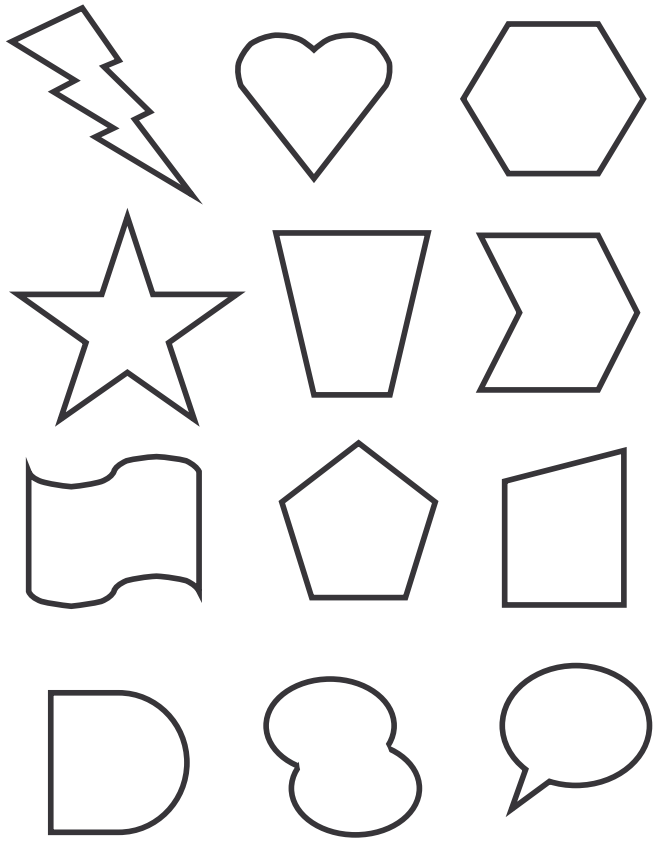


Figure 10: Symmetry activity

In the above excerpt the teacher intervened by asking a question. This could be viewed as providing scaffolding to assist learners in developing their own conceptual knowledge by working within the learners' ZPD. An understanding of constructivism and scaffolding would assist teachers in developing activities or questions that could develop the learners' thinking within their ZPD. This is the only instance of a teacher responding to their findings in this way.

4.2.2 v) Teachers views and opinions about observation

Teachers in the pilot group asked for a more structured way of recording their observations. This led me to develop the observation sheets as part of the "extensive support" offered to teachers in the assessment pack. Most of the alternative tasks that teachers used required systematic observation. The teachers in the study had a wide variety of views about observation. They varied from finding it impossible to quite useful. It appears that their responses could be grouped according to the assessment practices of the schools.

The teachers from school C tended to use the observation sheets. This school prides itself on doing OBE assessment and has an OBE type report, which requires a lot of comments and a choice of four levels for each outcome. When asked to comment on the use of observation sheets, two teachers responded that they had used them. In the following excerpts, one teacher says that she was comfortable with the observation sheets while the other modified the sheet to meet her needs.

School C

Teacher 2: I often work with my class list where I put my own criteria – wrote them, then filled them in.

Another teacher in this school explained how she used group work to make the observation manageable:

School C

Teacher 3: [The activity] really had to have small groups – it is actually quite an involved game. One group had finished and they went to the … then I realised you actually have to watch them to see how they … wonderful game, it really worked very well.

In school B, teachers' opinions about observations were more mixed. Some comments showed that they were not used to doing tasks that required observation:

School B

Researcher: Any comments so far about its use as an assessment.

Teacher 2 No, I didn't because … um … I mean … No, we're not octopuses. We cannot have eyes in the back of our head. We cannot be assessing the children while you're … I … while you're trying to stimulate them, direct them, and guide them, discuss with them and then you're still trying to mark … and umpire the fights. I found that impossible to do.

Teacher 4: I was just about pulling my hair out trying to assess what the children were actually able to do or whatever…

While another teacher was more willing to grapple with the practicalities:

Teacher 7: I actually thought about that quite carefully, and I thought that what I would do if I was to do this often is only take two groups and leave the rest of the class to get on with this activity.

The teachers in school B did not record individual learners processes on the observation sheet, saying it was too difficult. However, they did report on individual learners in the focus group interview. Teachers from this school said that they preferred allocating marks as they do on their reports. The comments of the following teacher appeared to reflect the views of the staff as a whole:

> Teacher 2: And you see, Bronwen, as well, I mean we do not have an OBE type report because … but I like what we do … You cannot give an A symbol for English because one child can do beautiful prepared reading but cannot read unprepared work … one child can write well, the other child can't … So how can you round this out … So we actually divide … So even numeracy is divided into number concept, operations, problem solving. And that is on the report. And each child is marked in those areas. And, yes, your speech is less – we have a lot of children whose home language is not English.

School A tended to prefer marks rather than comments for reporting purposes. In the focus group interview, teachers refer to the products of learners' work in terms of the marks achieved rather than their observations. This occurred in both formative tasks and summative tasks.

> Teacher 4: When I marked it, I realised most of them found it very easy or easily except for the question where they had to work out the difference between the two heights. That's more an application type question. It clearly shows the girls that is struggling with maths – they either got one out of five or zero out of five.
>
> Teacher 3: And as I went on, marking these papers … but what I've realised is that the reasons they couldn't solve the whole problem and not to the whole answer.

The school assessment practice or *de facto* policy has a direct effect on what information teachers consider important and ways in which this information is gathered and used. Filling in observation sheets and qualitative observations are not helpful to teachers who, as in the last school (school A) discussed above, are require to submit mark schedules with a prescribed set of marks recorded for each term.

Schools' assessment teams are responsible for drafting school assessment policies. However, their views of assessment are influenced by their understanding of mathematics teaching and learning. While summative

assessment is valued above formative assessment, and schools do not have clear policies about how formative data is gathered, used and reported, it is likely that teachers will continue to feel that their needs are best served by summative assessment. Since, as pointed out by Bernstein (1975), teaching, learning, and assessment are interdependent, a shift towards constructivist learning is unlikely to occur without a related shift in assessment policy and practice.

4.2.2 vi) Ways in which teachers' use of formative assessment affected their teaching

A major distinction between formative and summative assessment is the way in which teachers use the findings. Formative assessment is developmental and allows teachers to plan their teaching more consciously to meet the developmental needs of their learners. Teachers were asked how they would use the information gained through the formative tasks. The following two teachers talk about how it would influence their teaching:

School C

Teacher 4: You actually can use it to re-teach.

Teacher 3: I think you've got to use it to build on.

Teacher 4: I also thought you could use it as a teaching strategy, because once you've found the kids that only use their fingers I could tell the children that from now on you're only starting with the biggest number. It doesn't matter if you throw the five first and then the eleven. Actually teach them what to do in that game. Or you say you're only going to use units, start with the end numbers, and then you're gonna add the tens. Because some of them do that automatically and others wouldn't know how to.

Teacher 4 says she would tell the learners what to do and thus loses the opportunity for learners to grapple with the underlying commutative law. It appears that she resorts to whole class teaching and returns to an approach that gives the learners steps to follow rather than developing their own conceptual knowledge. This could be evidence that she has not been exposed to or internalised the assumptions of constructivist approaches to learning.
In cases where summative assessments were used, the teachers interpreted the responses as a need to re-teach the work. The underlying assumption is

that drill and practice or reiteration of the steps is required to deal with the learners' problems. For example:

School A

Teacher 5: A lot of children couldn't cope with the multiplication even though we've done it, so I went back and revised it in class.

This teacher sees mathematics learning as a function of knowing the rules and applying them correctly.

Teacher 2: Ja, if you don't know your multiplication and your division, you can't solve lots of your word problems as well. Even if you give them the rules of saying like … when you do division that thing of you divide daddy-mommy-sister-brother … they are used to that rule. Still they know I have to divide now, I have to multiply now, but sometimes their numbers are going wrong because basically they don't know their times tables.

This illustrates a limitation of summative assessment. Teachers knew what learners were getting wrong but, in the absence of qualitative information, were unable to make any other intervention apart from re-teaching or providing mnemonics to remember procedures and rules. Formative assessment provides qualitative information, and may offer teachers a wider range of teaching options. However, teachers may still choose rote or traditional methods.

Teachers from all three schools said they would use one of the traditional tests as a baseline assessment at the beginning of the year to get to know their learners. This could be seen as a formative use of a traditional task. Two teachers in the sample selected parts of summative assessments to use as baseline assessment tasks.

School A

Teacher 4: At the beginning of the year, I would choose [a grade 5 assessment] to see who needs extra support from the previous grade.

School B

Teacher 4: We discussed these papers at the back. And we thought what we might do was give the grade 6 in January just to see if they did get through all of that …. grasped all of that …and for me to take the grade 4 …

The Education department policies recommend that a baseline assessment be done at the beginning of each topic. Some teachers, mostly from school A, liked the tests in the pack because they contained excerpts from the whole year's work. By assessing a whole year's work at once, teachers would find it difficult to develop a deep understanding of learners' conceptual development on each topic. Thus, teachers are still likely to use such a test summatively. Assessing each mathematical topic using baseline assessment may help teachers to respond to more specific learner needs.

It appears that most teachers do not have a constructivist view of mathematics learning and so are likely to experience difficulty working with observations. This was illustrated above in that teachers missed opportunities for providing appropriate scaffolding and re-taught the content in a rule based way.

4.2.2 vii) Ways in which teachers used their findings in reporting

An important function of summative assessment is to justify decisions that affect learners (Killen, 2003; Niss, 1993), streaming, or paths. The following teacher illustrated this use of assessment:

School A
Teacher 3: There were four kids where we were not sure actually if they should go to the next standard and I actually used this because it's like the basic operations that they needed … the fact that they couldn't even follow the rules, not even knowing their tables, that made me aware that they couldn't cope with grade 7 work.

She used the tests as confirmation of what she already knew.

A different teacher, in school C, with OBE type reports, said that she would use comments made during observations to assist her in writing reports.

School C
Teacher 3: When you are writing reports can say … write, still needs concrete apparatus.

The same school expressed concerns that their own reports and assessment practices do not provide useful information for parents:

School C
Teacher 5: [The reports are] so vague and ambiguous for the parents.

Teacher 6: No comparison between…[inaudible] … others … you as the teacher knows where the child is, the parent doesn't.

Teacher 4: It's very restricted too. Can, middle, can't. You're frightened to say "can" because then you've got nowhere to move him to.

Teacher 5: The whole picture doesn't come through. I've got loads of children like that….

Teacher 7: Parents want more specific feedback about where they are in class and not to be bogged down with how he co-operates in a group or how he thinks his way through it.

This was echoed by teachers in schools A & B. For example:

School A

Teacher 3: You also don't want to see all sorts of rubbish that doesn't make any sense to you.

School B

Teacher 2: You land up with a child with a round figure of three … you know a round symbol, satisfactory, but they might be an outstanding … presenter of poetry. So I think we're taking too much away. Umm … one symbol for numeracy and one symbol for literacy and one symbol for English and then comment, comment, comment, comment.

It appears that the expectations teachers and parents have of reports reflects a summative view of assessment and a traditional view of learning. This means that parents have difficulty making sense of outcomes-based reports. Most of the schools' assessment practices appear not to have made adequate progress in reporting that reflects an outcomes-based approach in a useful way either.

Since one of the purposes of assessment is accountability (Mackintosh, 1981), the reporting system is not fulfilling this purpose adequately. If teachers' current understanding is hampering their ability to adopt OBE practices, this is likely to be true of parents too.

In the light of the above discussion of findings in relation to assessment tasks and of assessment in general, it is apparent that assessment cannot be viewed in isolation. It is integrally tied to teaching, learning, and curriculum. Teachers are unlikely to be able to use formative assessment in mathematics meaningfully without coming to a deeper understanding of outcomes-based

curricula, a constructivist view of mathematics learning, and learner-centred methodologies. A discussion of the above findings gives some indications of teachers' current understandings of these areas and ways in which they affect their implementation of outcomes-based mathematics education.

4.3 Conclusion

The new curriculum represents a significant departure from the old. It has different theoretical underpinnings and assumptions about teaching, learning, and assessment. Primary school teachers are in a process of developing new understandings of this mathematics curriculum, methodologies, mathematics learning, and assessment through practice and in-service work.

Teachers' current content knowledge did not present itself as a factor in the sample of teachers interviewed in that they all were able to do the mathematical tasks correctly. The new curriculum, however, does place a greater emphasis on patterns, shape, and space and data handling than the old curriculum and teachers tended not to choose topics in these areas. This could be indicative of teacher's knowledge or them viewing the new curriculum in the light of the old syllabi, which focussed almost entirely on basic operations.

Another aspect of the old curriculum, still evident in teachers' conceptions of mathematics, is that of mathematics being a set of algorithms which are learned through doing calculations with a different set of steps for each type of calculation. This conception can interfere with teachers' ability to adopt a process-oriented view of learning and may lead them toward telling learners procedures, rather than supporting them in the development of their own concepts. Another possible consequence of this view of mathematics is that learners develop a fragmented view of mathematics that makes it difficult for learners to see its relevance or usefulness in working with everyday applications or integrated mathematics tasks.

The new Mathematics curriculum lends itself to a constructivist view of learning. There was no evidence to suggest that learning was conceptualized in this way

by the teachers and it appears not to have been made explicit to teachers, or at least has not entered teachers' discourse.

Teachers' use of formative assessment could assist them in seeing evidence of learners actively constructing their knowledge. However, teachers also need some conceptual understanding of mathematics concepts being constructed to enable them to understand their observations developmentally, instead of seeing them as mistakes that require re-teaching or more drill.

Teachers' constructs about mathematics learning and assessment are still heavily influenced by the old curriculum and practices. Teachers in the sample appear to be in various stages of assimilating and accommodating new outcomes-based curricula. The curriculum has been implemented at a policy level, with little support around the shifts in content. Teachers' developing concepts could be supported with careful scaffolding and some easy-to-use formative tasks. Some of the scaffolding could be in content, but it also needs to include issues of learning and assessment. The imposition of policy has had the effect of fragmenting teachers' views of assessment, in much the same way as traditional teacher-centred teaching has done for learners. This points to the need for materials, activities, and professional development for teachers that allow teachers to develop integrated and robust understandings of learning, teaching, and assessment.

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