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**UNIVERSITY OF CAPE TOWN  
FACULTY OF EDUCATION**

**INVESTIGATING A GEOMETRY COURSE FOR  
IN-SERVICE TEACHERS**

**A minor dissertation presented in partial fulfilment of the  
requirements for the Degree of**

**MASTER OF EDUCATION  
Specialising in  
MATHEMATICS EDUCATION**

**by**

**GABEBA AGHERDIEN AGHGAB 001**

**SEPTEMBER 2004**

## **DECLARATION**

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signed by candidate

Gabeba Agherdien

University of Cape Town

September 2004

## **ABSTRACT**

### **INVESTIGATING A GEOMETRY COURSE FOR IN-SERVICE TEACHERS**

This study focused on Foundation Phase teachers' pedagogical and content knowledge. It investigated the impact that a geometry course (Shape and Space), had on the teachers levels of understanding of Shape and Space. The course was conducted over 5 days. A literature search revealed a few different tools in designing the course, the majority of which referred to either Van Hiele or Hoffer. Our course design however was instructed by the requirements of the Revised National Curriculum Statement (RNCS) and had to follow it closely.

The study consisted of 46 foundation phase teachers who were all from disadvantaged schools. A pre-test was conducted before the implementation of the course to assess teachers' content knowledge and to re-assess the course implementation. A post-test was conducted to gauge the effectiveness of the course.

My assessment of the general findings showed that the majority of the teachers had low levels of understanding of geometry (Shape and Space) before the course. These levels were still low after the course even though there has been an improvement in some of the items.

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## TABLE OF CONTENTS

<b>DECLARATION</b> .....	<b>ii</b>
<b>ABSTRACT</b> .....	<b>iii</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>iv</b>
<b>TABLE OF CONTENTS</b> .....	<b>v</b>
<b>LIST OF FIGURES</b> .....	<b>viii</b>
<b>LIST OF TABLES</b> .....	<b>ix</b>
<b>1. INTRODUCTION</b> .....	<b>1</b>
1.1. My Learning Experiences. ....	1
1.2. The Turning Point: 1989 – 1996. ....	3
1.3. My experience as a maths field-worker. ....	5
1.4. This Research. ....	6
<b>2. LITERATURE REVIEW</b> .....	<b>8</b>
2.1. Effective mathematics teaching .....	8
2.2. Knowledge content and pedagogy .....	12
2.2.1. Subject Matter knowledge.....	12
2.2.2. Pedagogical Content Knowledge.....	13
2.2.3. Curriculum knowledge.....	14
2.3. Geometry.....	14
2.3.1. Van Hiele model .....	14
2.3.2. Skills in geometry .....	15
2.3.3. Marrying van Hiele and Hoffer .....	17
2.4. Cognitive theories.....	17
2.5. Current research .....	19
2.6. In-service courses.....	20
<b>3. THE CONTEXT AND DETAILS OF THE TENDER AND THE COURSE ...</b>	<b>23</b>
3.1. The Context of the Study .....	23
3.2. Background to WCED tender document. ....	25
3.3. The Course.....	28
3.4. The Teachers .....	28
3.5. Background to Geometry (Shape and Space) Course. ....	30

3.6.	The Geometry Curriculum.....	30
3.7.	The Geometry Course.....	32
3.8.	The Foundation Phase Mathematics course: Shape and Space .....	35
3.9.	Focus.....	37
3.10.	Content of the Shape and Space Course .....	37
3.10.1.	Day One: Content Outcomes .....	38
3.10.2.	Pedagogical Outcomes.....	38
3.11.	Outcomes for Day 2 .....	39
3.11.1.	Content Outcomes.....	39
3.11.2.	Pedagogical Outcomes.....	39
3.12.	Outcomes for Day 3 .....	40
3.12.1.	Content Outcomes.....	40
3.12.2.	Pedagogical Outcomes.....	40
3.13.	Reasons for chosen activities:.....	41
3.13.1.	Activity Outcomes .....	41
3.13.2.	Assessment.....	43
<b>4.</b>	<b>ASSESSING THE COURSE .....</b>	<b>44</b>
4.1.	Data Collecting Instrument.....	44
4.2.	Designing the tests.....	44
	Cognitive Development and Achievement in Secondary School Geometry	
	Project (CDASSG).....	45
4.2.1.	RUMEUS.....	45
4.2.2.	Mayberry .....	45
4.2.3.	Revised Mayberry .....	45
4.2.4.	Fuys, Geddes, Lovett, Tischler .....	46
4.2.5.	HSRC and others.....	46
4.3.	The SDU tests in action.....	46
4.4.	Pre Test Results .....	48
4.5.	Lessons learnt from the pre-test results.....	61
4.6.	Post Test results .....	63
4.7.	The post-test results show:.....	70
<b>5.</b>	<b>SOME THOUGHTS ON THE TESTS.....</b>	<b>72</b>

5.1. Introduction.....	72
5.1.1. The voice of the researcher/teacher educator.....	72
5.2. Stories .....	73
5.2.1. The Story of Pria.....	73
5.2.2. The Story of Wendy.....	73
5.2.3. The Story of ‘The Paarl Lady’ .....	74
5.3. What is it that these stories show/tell?.....	74
5.4. What the tests do not show. ....	76
5.5. Conclusion .....	80
<b>6. CONCLUSIONS AND IMPLICATIONS FOR PRACTICE.....</b>	<b>82</b>
6.1. Purpose of the study.....	82
6.2. Summary of Findings.....	82
6.2.1. Was there a shift in teachers’ content knowledge?.....	82
6.3. What I’ve learnt about Foundation Phase Geometry? .....	83
6.4. What has the course and the research taught me about this group of teachers?.....	83
6.5. Implications for teacher educators .....	84
6.6. The usefulness of the quantitative data to a mathematics in-service worker. ....	84
6.7. Conclusion .....	85
<b>REFERENCES .....</b>	<b>87</b>
<b>APPENDICES.....</b>	<b>98</b>

## LIST OF FIGURES

<b>Figure</b>	<b>Title</b>	<b>Page</b>
4.1	Pre-test result of Items 4 & 16	50
4.2	Pre test results questions 6, 22, 29	54
4.3	Pre Test Results (Questions 7, 11, 20, 25, 26 & 27)	60
4.4	Pre-Post test result of Question 4	64
4.5	Pre-Post Test Results Question 16	65
4.6	Pre-Post test result of Item 6	66
4.7	Pre-Post test result of Item 29	66
4.8	Pre-Post test result of Item 12	67
4.9	Pre-Post test result of Item 26	68
4.10	Pre-Post test result of Item 27	69

## LIST OF TABLES

<b>Table</b>	<b>Title</b>	<b>Page</b>
4.1	Pre-test result of Item 4	48
4.2	Pre-test result of Item 16	49
4.3	Pre-test result of Item 6	51
4.4	Pre-test result of Item 29	53
4.5	Pre-test result of Item 12	56
4.6	Pre-test result of Item 26	58
4.7	Pre-test result of Item 27	59
4.8	Pre-Post test result of Item 4	63
4.9	Pre-Post test result of Item 16	64
4.10	Pre-Post test result of Item 6	65
4.11	Pre-Post test result of Item 29	66
4.12	Pre-Post test result of Item 12	67
4.13	Pre-Post test result of Item 26	68
4.14	Pre-Post test result of Item 27	69

## 1. INTRODUCTION.

'I was bad at mathematics at school.' I am sure that that statement has been repeated ad nauseam by countless learners. When I matriculated in 1982, my mathematics teacher bluntly told me early in that year to change from the higher grade to standard grade, which I duly did. I still passed. Now, about twenty years later, I design and present mathematics courses for primary school teachers so that their skill levels can be improved. I had been an inadequate student at school, scared of mathematics and I was taught by teachers not in tune with what is required to teach effectively. I also landed up teaching mathematics without any formal mathematics training, so I think I know what it feels like to be poorly qualified, and trying to teach classes with more than fifty learners in a class.

This is what lies at the heart of my dissertation. I have used this research as an opportunity to continue a journey, which started a long time ago for me. It has to do with geometry – my own attitude to, and understanding of, the subject as well as the way in which the topic is taught in Foundation Phase classrooms. It also has to do with the challenge that faces in-service teacher educators as they offer workshops to practicing teachers in an attempt to broaden their content knowledge and teaching skills related to the specific topic.

### 1.1. My Learning Experiences.

As I try to put my thoughts into words about my experiences, so many ideas fly through my mind. Why the need to share my own experiences and not that of other practicing teachers? Surely being the researcher only of others' work would be far easier than making myself vulnerable and putting myself up for scrutiny and critique? I am passionate about teaching! I enjoy teaching and working with teachers, as the learning process is a two-way process. I learn from the teachers and their learners and, in having conversations with them, some of my issues in 'teaching' get them thinking about their own teaching and learning. It is a great pity that this two-way process was not possible when I was a high-school pupil.

School life was great - except for mathematics! I had good friends, and was an average pupil who always passed everything relatively well – except mathematics. I had great

teachers who eventually became my friends – except my mathematics teacher. Even years after matriculation when that very same teacher attended one of my presentations, I was still filled with trepidation. I had friends who tried to make me understand theorems, showed me easy ways of remembering formulas, but very little seemed to stick. The mathematics teacher emphasised rote learning, concentrated on making sure that his top students obtained first class passes, and neglected the rest of the class. Geometry tests mostly involved proving one or two theorems. Learners then would either get zero, fifty (if they got one of out two right) or hundred percent. Early in the year the teacher ‘ordered’ (not advised) me to switch from higher to standard grade, even though I had achieved adequate marks in my previous years on the higher grade. I duly complied, and passed relatively well. I often considered dropping the subject and taking an ‘easier’ subject, but all and sundry advised me against it.

The good, mostly mathematics-free years of my life were spent at the University of the Western Cape, where I qualified in Physical Education and Arabic. I can now look back on my experiences as a learner. I felt that I had been recognised by my teachers as a centre of consciousness who created her own learning from the curriculum on offer and who could take responsibility for her own teaching and learning, and the learning of her learners. Teaching Physical Education was uncomplicated, despite being subjected to vigorous scrutiny, but this was mostly fun to all involved. Even the mathematics involved in bio-kinetics could be related to my subject, made sense in the real world and could be applied practically.

The methodologies used in Physical Education were useful for my teaching. The standard theoretical methodologies were easily and essentially linked to practical applications. This was not the case with some of the auxiliary subjects I studied, such as Shakespeare in English literature courses, which until this day has no practical (note, I did not say aesthetic) value for me. I remember working hard at memorising for exams in the other courses I had taken through the years, which were reminiscent of my schooling. Due to my bad experiences in mathematics I resisted further formal studies in that subject. Who would benefit from such study and would I ever revisit it in any way? I believed that

whatever I studied needed to impact on or have an influence on my work otherwise it would not be worth going through all the examination angst.

## 1.2. The Turning Point: 1989 – 1996.

In 1989 while teaching at Eros Cerebral Palsy School, I was required to teach mathematics to the Standard 6, 7 and 8 classes. This unnerved me as I was not qualified as a mathematics teacher nor did I have any pedagogical knowledge of teaching the subject. I was left with no choice - 'teach maths' or 'no post'! Wilson (1994:33) notes that the relationship between teacher and pupil is necessarily asymmetric. The teacher is the 'authority in his academic subject and the student is ignorant of it.' My situation was completely different. I was ill equipped, scared, had only a rudimentary knowledge of mathematics, and possessed non-existent resources to teach the subject. However, I also had a class of learners who had the utmost faith in me, so I knew that I could not let them down.

I decided to stay and take up the challenge by trying to make the best of a very scary and fearful situation! Through a series of fortuitous circumstances in a search to equip myself to become a mathematics teacher and obliterate my anxieties about mathematics, I decided to study some mathematics content through private tuition. I began to attend in-service courses run by the Mathematics Education Project<sup>1</sup> (MEP) under the directorship of Associate Professor Chris Breen at University of Cape Town (UCT).

My first geometry workshop encounter was presented by Chris Breen and Wendy Colyn in 1989. This was a vastly different experience from that remembered at school, in that I could 'do' the mathematics and felt comfortable being squashed 'like sardines' in the 'lecture' amongst about 300 other teachers. I recall vividly the experience of working with visualization and intuition, as well as talking and working from experience. This was the first of many other workshops and courses that followed which provided me with a very

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<sup>1</sup> The Mathematics Education Project (MEP)- a non-governmental organisation, was an in-service university-based project, which explored the teaching and learning of Mathematics in both formal and non-formal settings.

different experience of geometry in that it did not only focus on theorems and proofs. The geometry that I experienced in these courses was fascinating.

My confidence as a mathematics teacher grew tremendously and my attitude especially towards mathematics changed to a realisation aptly described by Adler:

Knowing about teaching and becoming a teacher evolves, and is deeply interwoven in ongoing activity in the practice of teaching. Knowledge about teaching is not acquired in courses about teaching, but in ongoing participation in the teaching community in which such courses may be a part.

Adler (1996: 3)

It grew to such an extent that in 1992 I was appointed to run in-service work with MEP. In this way my professional development as a mathematics teacher continued while working full-time at the Mathematics Education Project (MEP) as a field-worker doing in-service work with primary mathematics teachers. During this period, I had the opportunity to consolidate my learning and thinking around geometry.

Various academics and colleagues crossed my path in this period and contributed to my learning of geometry in different ways. Chris Breen's workshop on transformation geometry was an eye opener to me as my school learning had only exposed me to Euclidean geometry. I had understood geometry to consist mainly of memorising theorems. The visit of David Henderson from Cornell University opened up the world of spherical geometry for me, and this was exciting and interesting both in terms of the content as well as teaching style that he demonstrated. Then Dick Tahta from England visited us, and he presented a course on visual geometry with the strong emphasis on verbalising your thinking in such a way that others have access to your thoughts. One activity done by Dick involved the use of a Great Dodecahedron poster, where we had to focus on the poster and simply say aloud what it was that we saw. Eleven years later I still use this activity on my courses. This period of time in MEP saw the emergence of valuable and interesting work done by colleagues around the teaching and learning of geometry.

### 1.3. My experience as a maths field-worker.

My experience of learning geometry in this way was in stark contrast to what had been happening in the classrooms. The geometry content in the first three years of schooling (Foundation Phase) was limited to the recognising, naming and describing of the four basic shapes: an equilateral triangle, square, circle and rectangle. Learners were not required to recognize any other triangle as being a triangle. The geometry content was left as the very last part to teach in the year. Sometimes teachers did not have the necessary skills or the content knowledge to teach this section of the work so left it out. No three-dimensional geometric figures were taught and learners had very little knowledge of quadrilaterals. Number work dominated the curriculum as taught in schools, so if there was no time to teach geometry it was not considered to be a problem. Far too easily learners could go through Foundation Phase schooling without having done any work in geometry.

The Mathematics Learning and Teaching Initiative (MALATI) summarised the teaching of Geometry in South African Schools at the time as follows:

- a) The description and classification of plane figures (for example parallelograms and cyclic quadrilaterals)
- b) The study of the properties of these plane figures.
- c) The direct comparison of these figures and their properties.
- d) Deduction using congruence of figures as a basic tool (some of the properties are deduced from others). This is done within the specific axiomatic deductive system originally used by Euclid. Proof is used as a form of verification.

(Malati 1999: 1)

MALATI's experience of the state of geometry in Primary schools echoed my experience: "Our observations of work with primary teachers have suggested, too, that many of the teachers teach little or no geometry to their classes. Where this is done in the primary school, this is usually restricted to the identification and naming of simple geometric figures such as a square, triangle, circle and rectangle" (Malati 1999: 1).

In our work with teachers during MEP courses, colleagues and I shared some of our experiences and beliefs about our teaching and schooling. These took place in forums such as courses, workshops school and classroom-based work. We even included topics that were not in the syllabus in our geometry courses, such as three - dimensional objects and two-dimensional shapes.

#### **1.4. This Research.**

The opportunity to explore some of the dimensions of the teaching of geometry in Foundation Phase classrooms came when I was part of a MEP team running an in-service course for teachers working for the Western Cape Education Department (WCED) in 2002. I was particularly involved in the Space and Shape section of the course and I decided that this would serve as an ideal occasion for me to explore some of the dimensions involved in preparing for and then delivering the course.

This dissertation will take the form of an exploration and will be multi-purposed. On the one hand, I will use the opportunity to become familiar with a wide range of literature in Chapter Two. I plan to cover the topics of teaching and learning Geometry, as well as issues related to in-service professional development of teachers. This material will serve to inform my practice and later analysis.

Chapter Three will contextualise the study in that it will focus on the tender by a particular Provincial Department of Education to run an in-service course for Foundation Phase teachers on the new curriculum content knowledge. Details of the teachers, and the context in which they teach, as well as the design of the course, will be covered in this chapter.

Chapter Four will focus on the tests that were given to the teachers in pre- and post-test format in order to assess whether the in-service course had caused a positive improvement in the teachers' content knowledge. The design and implementation of the test as well as the results of the items concerning the specific section on Shape and Space will be discussed.

Chapter Five will provide an alternative commentary, which attempts to broaden the focus and consider factors, which lie beyond a simplistic pre- and post-test evaluation of the course. Finally, in Chapter Six I will reflect on my exploration and not only what I have learned from the experience.

In closing this introduction, I would like to draw attention to the following. Consider the following example in an I.Q. test. The student is asked to identify the odd one out amongst cat/cow/car/horse. Most would identify the car to be odd, as the others are animals. One or two children would identify the horse as being odd as the word starts with an 'h' whilst all the others start with a 'c'. My eight-year-old daughter, after stating the above two examples, further decided that 'cat' could also be the odd one out, as it is small, in contrast with the other large objects.

In many ways, my journey will be similar to the different responses to the above. Sometimes there will be evidence-based data, sometimes a 'gut-feel' approach will be evident, and at times my thinking may be construed to be different, even flawed. This is inevitable as one's story is inevitably shaped by one's own experience and belief system (Davis 1994). My intention is to go beyond the objective markers of content and tests and to try to get a broader picture. I work with the enthusiastic teacher who has no teaching aids as she engages with her 64 learners in a class in Guguletu, as well as the lacklustre teacher in gang-infested Manenberg (with gunshots audible). Both experience a different reality, and urgent intervention is needed. A course on Shape and Space or Geometry is not going to cause any dramatic changes. What I would hope for is that a course may form a small thread of a greater collage, so that, on stepping back, each strand imperceptibly blends, blurring out the individual components.

## 2. LITERATURE REVIEW

In this chapter I review literature on aspects of teacher education, which relate to the impact of geometry on in-service teachers' levels of understanding. In searching through the internet, journals and documents, I looked for studies that related to the teaching and learning of geometry, teacher conceptual and pedagogical content knowledge, in-service education, and the effects thereof.

### 2.1. Effective mathematics teaching

What do teachers need to know in order to teach mathematics effectively? Anecdotes abound about teachers with no formal qualifications who were brilliant educators; similarly stories of highly qualified personnel who 'could not teach' are etched in our memories. Recently, the content knowledge of mathematics teachers has been under the spotlight (Long 2003; Ball 1993, 2003). This has been a direct result of research indicating that teachers have poor subject knowledge and are also unable to make their knowledge accessible to learners (Ensor et al 2002; Long 2003). Research studies done by Kruger, Summers, & Palacio (1990) and McNamara (1991) indicate how teachers' limited subject knowledge 'inhibits not only what they are able to teach but their ability to deploy techniques and explanation, to correct pupils' misunderstandings and cope with their (students) difficulties in leaning' (McNamara 1991: 118).

Howie (1997) indicated that inadequate subject knowledge of mathematics, as well as poor motivation on the side of teachers, led to a lack of inspiration and confidence in the classroom. This had an evidently negative effect on the process of learning mathematics. Nieuwoudt & van der Sandt (2003: 224) stated that the teachers are then 'poor role models for learners'; the implication being that 'few of these learners would want to become teachers one day'. Nieuwoudt & van der Sandt (2003) in their investigation of teachers teaching grade 7 geometry found that most teachers did not even attain a Van Hiele Level 2, which is characterised by recognition and explicit characterisation of shapes by their properties.

Frith, Bowie, Gray & Prince (2003) in their assessment of the mathematical literacy of students entering first year courses at University of Cape Town, noted that 14% of medical students and 18% of science students could not calculate 10% of a given number. They also found that 33% of medical students and 36% of science students failed to recognise that 5% is the same as 0,05. The mathematical knowledge of students in the Humanities Faculty was even worse. We have to take into account that a significant percentage of the latter enter the teaching arena.

The Ferguson study of 900 Texas school districts found that teacher content knowledge influenced learner achievement more than any other single factor in mathematics and reading instruction (Darling-Hammond 1998). A strong correlation between teacher subject knowledge and student achievement was found in a study of 1,043 Belize third grade students in the article Standard VIII, Knowledge of Content (2003). Mullens (1996) refers to the finding that teachers' knowledge of mathematics and mathematical ability consistently related to student learning of advanced mathematics.

Research done by Ball & Mosenthal (1992) has also shown that teachers with weak content backgrounds teach much differently than their colleagues with stronger content ones and those with weak backgrounds had difficulty choosing and designing problems and asking appropriate questions. These teachers also tend to rely more on textbooks (Lee 1995). Not only is how a subject is taught influenced by weak content knowledge, but also what is taught. McNamara (1991) and Ball & McDiarmid (1989) hold the view that teachers with limited knowledge may avoid teaching certain subjects, fail to challenge misconceptions and try not to encourage student interaction. These teachers may have a tendency to teach their subject in a rule-based way and avoid whole class discussions or other interactive circumstances that would expose their lack of knowledge. Lee (1995) indicates that teachers with a strong content background tend to conduct classroom activities and discussions in a free-ranging way that facilitates learning. They also chose better metaphors for explanations.

South African researchers, Taylor & Vinjevold (1999) link teachers' poor conceptual knowledge to a superficial understanding of what is required for adequate teaching and

learning, resulting in teacher-centred activities as well as very superficial engagement with the conceptual development of the learners. This is confirmed by an assessment by Ensor et al (2002) who refer to the fact that teachers do not assist learners to tease out knowledge principles from a set of activities. They refer to conclusions that in some of these classes the topic itself is unclear and that learning will be shallow at best unless learners understand and interact with the concept and principles. Brodie (2001) suggests a framework of teacher knowledge based on the work done by Ball and Cohen (1999). The categories were conceptual knowledge of the subject, knowledge of the learners and knowledge of the pedagogy. For them knowledge of the subject is important and knowing the subject matter in ways which enable teaching.

Huang (1998) in a Taiwanese study concluded that “Teachers’ efforts to put the ideas and recommendations of mathematics reform into practice have been effected by the teachers’ knowledge about mathematics and pedagogical content knowledge”. This finding is consistent with the belief that an improvement in teachers’ subject knowledge will improve mathematics results (Long 2003). Breen (2003) cites Adler (2002) and Brodie (1999) and draws awareness to the fact that ‘despite the input by FDE course, teachers experienced difficulties in changing their practice’ (Breen 2003: 686). Long (2003: 194) also refers to a quote by Cochrane-Smith and Lytle ‘Teachers who know more, teach better’. She however also emphasises the fact that Adler and Reed (2002) state that ‘although there clearly is no consensus on what knowing more and teaching better mean, this ‘simple idea guides the practice of all teacher development programmes’ (Long 2003: 194).

Adler (2003) expands on the idea of content knowledge and adds that pedagogy also plays an important role. Her eloquent example of a hurdler very aptly describes the requirements of a good mathematics teacher. A hurdler must be both a sprinter and a high jumper, yet is not recognised as a specialist in either of the two. Similarly a mathematics teacher must be well grounded in mathematics as well as in education. Yet s/he is not recognised as a specialist in either field, but in the field of mathematics education. A connection has to be made with content knowledge of mathematics and the pedagogical training to mould seamlessly into the art of teaching the subject.

Cohen and Ball (2001) succinctly drive home this point when they elaborate on the entirely different outcomes in third-grade classes from the same school, with similar student compositions and two teachers who were similarly qualified. They noted that the difference lay in the manner of instruction, or in my view - to re-enforce Adler's above-mentioned notion - the successful marrying of content and pedagogy.

Kennedy (1990) adds to this concept in that he acknowledges that what students learn is greatly influenced by how they are taught. Yet measuring content knowledge is fraught with difficulty. Research has shown that College credits do not necessarily imply adequate content knowledge. The assumption that a major in a field of study indicates an adequate understanding of the topic is not substantiated by studies. Kennedy (1991) ascertained that majoring in a subject did not guarantee depth of understanding. He also found that those with subject majors often have the same difficulty in explaining fundamental concepts as those without a major. In a previous study he (Kennedy 1990) asserted that teachers should be 'fluent' (his quote) in their subjects. He elaborates on this fluency by indicating that it encompasses up-to-date knowledge of specific concepts, understanding of the complex relationships in the subjects as well as the everyday relevance of the subject. He is as emphatic as Adler that the content knowledge required for teaching is different from a content field specialist.

Studies by Barba & Rubba (1992) show that knowledge of a subject as a learner is different from the extensive subject knowledge required for teaching. They hold the view that novice teachers, though they may possess the same amount of content knowledge as other more experienced teachers, do not have structures in place for teaching. They also contend that learning in a particular field does not require a structure for information retrieval, as does the teaching profession. Information needs to be reorganised for instruction, and this requires a depth of understanding about the subject and about the learner. From a comparative study of pre-service and in-service teachers, Barba & Rubba (1992) found evidence to show that experience improves teachers' ability to structure

information for teaching. This revealed that pre-service teachers 'function at structuring mode' while in-service teachers 'function at the tuning mode' (Standard VIII nd: 2).

Reynolds (1995) found that in-service teachers used better metaphors for teaching, but the role of content knowledge cannot be overlooked. Experienced teachers that lack subject matter knowledge had difficulty selecting appropriate explanations.

## **2.2. Knowledge content and pedagogy**

Shulman (1986) was intrigued by what he termed the missing paradigm in teaching, which is the question as to how knowledge gets transformed by teachers into a form that a student could understand. He broadly divided his conceptual analysis of the knowledge that teachers required into three categories, namely:

- i. Content knowledge,
- ii. Pedagogic content knowledge
- iii. Curricular knowledge

### *2.2.1. Subject Matter knowledge*

Kennedy (1998) alludes to the fact that the quantity of subject knowledge required differs amongst observers. Those who believe that children basically learn from their curriculum material indicate that teachers should have the ability to read and follow directions. Others are of the opinion that teachers need only know the subject matter covered by the curriculum as they presume that is precisely what teachers would and should be teaching (Long 2003). My feeling is that learners asking questions that stretch beyond the curriculum content often confronts teachers. Instead of simply replying that students need not to know that content, or need not to solve or tackle such a problem, teachers should be able to stimulate debate and offer insight into such situations. This requires knowledge beyond the official curriculum. Kennedy (1998) and Long (2003) also points to another viewpoint, namely that teachers need not even know the content of the official curriculum if they have the ability to reason from evidence or from other sources of knowledge.

Kennedy (1998) further lists five distinct definitions that fall within the 'conceptual understanding' category in her review of subject matter knowledge. Long (2003: 197)

defines the term as ‘the corporation of new concepts into existing schema’ and this requires engagement with the concept in an integrated way. These five are:

- i. Sense of proportion. This requires knowledge about distances, quantities and time zones, and is described as having an understanding of the world.
- ii. Understanding central ideas. This alludes to pattern recognition, with recognising a sequence of prime numbers being an example of it.
- iii. Relationship amongst ideas. An exploration of justification and proof, one of the central themes in mathematics, is an example of this strand of thought.
- iv. Highly elaborated knowledge. The learner or teacher on this level should have deep insight and lots of examples about the topic. The higher order cognitive strata of understanding, deliberating and problem solving come into effect.
- v. Reasoning on this level requires the ability to reason about events. Solving problems and develop rational and stated principles in justifying solutions, are also required.

### 2.2.2. *Pedagogical Content Knowledge*

Shulman refers to the above as the ‘ability to represent important ideas in ways that make them understandable to students and to translate important and complex ideas into concepts that are accessible to students’ (quoted in Long 2003:198). Shulman (1986) alludes to metaphors having an important function in the explanation of vital ideas and being integral to teachers’ array of strategies. It must be emphasized that the strength of the metaphor is dependent not only on the abilities of the conceiver, but also on the perceptive abilities of the receiver. The latter may be confused unless they are able to extract the key concept from the metaphor. This is described as the ‘pedagogical gap’ by Long who describes ‘the task of teaching is to close the gap and the particular approach to classroom pedagogy, teaching and assessment may be more or less successful in the closing of the gap’. This is summarised to be the ‘comprehensibility to the audience’s gap’ (Long 2003: 199). Another view from Ball (2000) is that of integrating three problems. These are: what teachers need to know, how they have to know it, and helping them to learn how to use it. By grounding the difficulty of teachers’ content preparation in practice, it could help to bridge the gaps that have limited progress in teacher education.

The task is made more difficult with the known diverse mathematical ability of any class. The teacher should adopt different strategies with different groups of students, even if dealing with the same topic, in order to make the principles involved more explicit, and for all learners to benefit.

Measuring pedagogic content knowledge, however, is a relative new field and needs the sustained effort of many researchers. Research done by Stoddart, Connell, Stofflett & Peck (1993) from Grade 8 showed those elementary teacher candidates had limited knowledge of the scientific and mathematical concepts that they would be teaching. Even though these teachers ranked in the upper 25% of their high school classes, they incorrectly answered basic math and science questions. Their test scores improved dramatically after they were exposed to conceptually-based teaching methods.

### 2.2.3. *Curriculum knowledge*

This issue is important in South Africa, with the flux from apartheid discrepancies to the confusion of 2002, Curriculum 2005 and now the Revised National Curriculum Statements (RNCS).

## 2.3. **Geometry**

The first theoretical framework I draw on is the Van Hiele mode of development in geometry because of its emphasis on higher thought levels, as well as its ability to indicate 'direction and potential for improving the teaching of mathematics' (Fuys, Geddes, Lovett, Tischler 1988:191).

### 2.3.1. *Van Hiele model*

The Van Hiele model aims to equip the teacher /researcher with a mathematical model with which to observe children's interaction with mathematics (Hoffer 1983). He described five distinct level of development and appreciation of geometry learning and noted that a good grasp of one level is required before progression can take place to the next. Discontinuity in the learning process means that a distinct vocabulary and reasoning ability exists between levels and 'jumps' often take place from one level to the next.

- Level one: Recognition/Visualisation. At this level a basic vocabulary exists with learners able to recognise shapes as a whole as well as being able to reproduce a given picture. Differentiating between similar figures can take place. Visual inputs are used for reasoning and little consideration is given to the properties of its components.
- Level two: Analysis. The properties of figures can be analysed on this level and figures are recognised to have component parts. The converse, where the component parts are linked to the original figure, also applies. The concept of definition is accepted and taken to be binding in the resolution of arguments. Definitions are not fully understood and the interrelationships between figures are not grasped.
- Level three: Ordering/informal deduction. At this level the interrelationship between figures is understood, as well as the importance of accurate definitions. The properties of figures, as well as different classes of figures is appreciated and recognised. A full appreciation of the significance of deduction has not yet developed, nor is the role of axioms fully comprehended.
- Level four: Deduction. The learner demonstrates an understanding of the significance of deductions, as well as the roles of theorem, proofs and postulates. Proofs can be constructed, arrived at in a variety of ways and reasoning can take place formally within the context of a mathematical system.
- Level 5: Rigour. The importance of precision in tackling the foundations and interrelationships within mathematics and structures is fully appreciated and comprehended. Studies on theoretical abstract concepts can take place even in the absence of concrete ones.

### 2.3.2. *Skills in geometry*

Hoffer (1983) identified five areas of basic skills that he considered important in high school geometry. Though the teachers in my course were primary school teachers, these teachers, who went to high school and of whom some had tertiary education, should be analysed for these skills.

#### *Visual*

It is abundantly clear that geometry is a visual subject. However, the usual aspects often serve primarily as a tool for proofs. Visual manipulation is an essential tool for learning.

*Verbal*

There is a myriad of terms to learn in geometry and precise definitions are the orders of the day. Geometry probably stresses the use of language more than any other mathematical component. The tasks become even more difficult if the teaching is done in a language other than the mother tongue. There is often recognition of the mathematics involved, but not mastery of the language to express that recognition.

*Drawing skills*

Geometry provides learners the opportunity to express their ideas in pictures and diagrams. Some jobs specifically require the expression of ideas visually and geometrically, instead of just proving theorems. A common example is the use of grid paper to assist in the neat and accurate representation of two and three-dimensional figures. Ratio and proportion can then be introduced and the idea of similar figures introduced.

*Logical skills*

It is well recognized that geometry helps students learn to analyse the form of argument and to recognize valid and invalid aspects of it. The propensity to memorise proofs will unfortunately always exist, and this will be at the cost of understanding. Learners often state that they managed geometry by memorizing known popular proofs. This defeats the purpose of geometry, which is often stated to be to develop reasoning ability. Practical examples include using diagrams with certain information and using the known properties of the given figures to deduce extra information.

*Applied skills*

Planar geometry is abundantly used in real life. Working out how many square tiles to use on a given room floor is but one of many practical examples. Calculating the distance from the top of a pole to a given point of the ground when the height of the pole and the distance on the ground from the base of the pole are known is another. Geometry can then be shown to 'make sense', have applications and even be considered to be fun.

### 2.3.3. *Marrying van Hiele and Hoffer*

Applying Hoffer's skills to only the first two levels of Van Hiele's model, results in the following:

On Van Hiele level one- to describe the figure in words and to interpret sentences that describe figures. Drawing would entail making sketches and accurately labelling given parts. Logical skill would make the learner realise the differences and similarities amongst figures. In the applied sense, a learner should be able to recognize and identify geometric shapes in physical objects.

On van Hiele's level 2, a learner should notice properties of a figure and identify a figure as part of a larger one on a visual level. Verbally various properties of figures should be described. The learner should be able to translate verbal information with pictures if drawing ability is assessed. The learner should logically understand that figures can be classified into different types and that properties can be used to distinguish figures. The student in the applied field should recognize geometric properties of physical objects.

## 2.4. Cognitive theories

The representation of a geometrical figure has also been described to have a mental representation in space (Fischbein 1993). Its description is then expanded from merely being a concept to also being an image. Fishbein (1993) argued that geometric reasoning is governed by two factors, the conceptual and figural, and interactions between them are necessary. However tension can exist between the two as far as learners are concerned.

Dorier (nd) quotes Duval (1995), a French psychologist, approached geometry from a cognitive and perceptual viewpoint. He uses an analytic framework when defining geometric drawings, and essentially crystallises out four types of what he terms 'cognitive apprehension'. These are identified as:

- a) Perceptual apprehension: this is what is identified at first glance on viewing a drawing.
- b) Sequential apprehension, which is used in the measurement (using tools like a ruler and compass) and construction of mathematical figures. Here the figures do not depend on perception, but on the technical limits of the instruments used.

- c) Discursive apprehension: all mathematical properties cannot be explained and analysed through perceptual apprehension and must be expanded upon by the spoken medium.
- d) Operative apprehension. The last type involves working on the figure, whether mentally or physically so that insight into the solution of a problem can be found. (Dorier nd: 3)

In the same text, Dorier (nd) quotes Duval (1994) who acknowledges the potential conflict between perceptual apprehension of a drawing and its mathematical perception. The discursive and perceptual apprehension in fact often obscures operative apprehension. He feels that computer-based work may assist in ironing out confusion, a description of which is not relevant to this thesis as very few of the teachers involved in my research have access to computers.

Duval (1998) further expands on this analysis and proposes that geometrical reasoning involved three kinds of cognitive processes. These fulfil specific epistemological functions and are:

- a) Visualisation processes, which includes the visual representation of geometrical statements.
- b) Construction processes, which involves using tools.
- c) Reasoning processes, which especially involve discursive processes for, amongst others, in explaining, or proving concepts, and in the furthering of knowledge.

He points out that these three processes are closely connected and their harmonious interaction is required for proficiency in geometry. However, these three processes can be performed separately. He uses the example that visualisation does not necessarily require construction. In fact sometimes, as when visualisation is incorrect, it can hamper reasoning. Duval, in his attempts to understand geometrical reasoning, indicates that his research shows the following:

- a) The three above named processes must be developed separately.
- b) Research needs to be conducted in the curriculum on differentiating between visualisation processes and reasoning processes.

- c) Only after this differentiation has been analysed and is understood, can co-ordination between the three kinds of processes really take place.

### 2.5. Current research

It is known that the tactile sense is invaluable in the recognition of geometrical shape and space. Some have tried to identify the link between imaginary, memory and visualization (for example, Presmeg 1986). In studying those who use visual methods when attempting to solve mathematical problems that could be solved by both visual and non-visual methods, Presmeg (1986:126) identified five kinds of visual imagery, namely:

- Pictorial (picture-in-the-mind)
- Pattern (relationships depicted spatially)
- Memory (recreating images from experience)
- Kinaesthetic (involving muscular activity)
- Dynamic (moving)

Considering the course according to Van Hiele's theory, I will concentrate on the first three levels:

- The Visual level – 'A learner identifies, names, compares and operates on geometric figures for example triangles, angles, parallel lines, according to their appearance. Construction, drawings or copying of shapes takes place on this level, the verbal description of shapes as well as solving of routine problems by operating on the shapes and not on properties in general.
- The Analysis level - A learner on this level analyses figures in terms of their components and the relationships between these components. The learner can establish the properties of a class of figures empirically, and can use properties to solve problems (Fuys et al. 1988). Examples on this level refer to the congruence of sides, the appropriate language for parts (such as opposite sides, diagonals), as well as the ability to interpret verbal or symbolic statement of rules and to apply them.
- The Ordering /Informal Deduction level - Logical reasoning is developed at this level and precise definitions are understood and accepted. Murray, Olivier & Human (1999) contend that the network of related concepts developed at the analysis level becomes

complete and stable. Some examples of the abilities at this level include the identification of a minimum set of properties that can identify a shape, the ability to justify a conclusion reached by outlining logical relations and the ability to discover new properties by deduction.

The hierarchical nature of the levels has been frequently alluded to (Burger & Shaughnessy, 1986; De Villiers & Njisane 1987; Fuys et al 1988), but Burger and Shaughnessy (1986) have suggested that the levels are not absolutely discreet. Learners can be in transition between levels and interchange them.

### **2.6. In-service courses.**

Research in many schools in the Johannesburg area indicated that teachers were relying on stifled approaches when solving mathematics problems. This involved step-by-step rules and methods (Graven 2000). Graven further indicates that teachers' view school mathematics as 'a bag of facts, rules and skills and that its importance for learners was predominantly in terms of providing access into further education and training' (Graven 2000:158). There is still debate about the issue of teacher development programmes, not whether it is necessary but how it should be structured.

Lester (1996) distinguishes between an educational model and a training model of professional development.

A traditional educational model of professional development typically stresses knowledge, understanding and theory, and the ability to use them to analyse situations and create solutions to problems. It is pitched at a level which is broader than the immediate demand of practice, and ideally develops abilities which give the developing practitioner flexibility and choice, and which give the developing practitioner flexibility and choice, and which is still relevant when practice moves on; it provides principles from which specific abilities can be developed in context. A training model on the other hand aims to enable the practitioner to operate proficiently in the here-and-now situation, and

concerns itself more with immediate skills and competence, which can be updated through further training as demand change

(Lester 1996:1)

It seems easy in theory to merge the two approaches, but there often is underlying tension between the behaviourist-based perspective of the training model, and the more cognitive aspects of the educational model. It has been claimed that the issue of professional development appears to be short of a sound theory of learning though admitting that quite a lot of good is being done. 'Professional development is perceived as a variety of activities in which teachers participate in order to improve their practice' (de Arechaga 2001: 1). Stress is laid on experience and expertise and on the convenience of attending courses and seminars. In Britain the attendance of seminars, conferences and on subscribing to professional journals and publications are also considered important (de Arechaga, 2001). Ball and Wilcox (1989), when reviewing the in-service education of mathematics teachers during a time of curriculum change in the United States (with similar tensions existing in South Africa presently due to Curriculum 2005), concluded that close examination of the content and context of the programmes were required.

In the South African context, work done by Murray Olivier & Human (1999) is enlightening. Referring to their two-day mathematics workshop, they acknowledge that the expectation of achieving 'a paradigm shift in teachers' perceptions about learning and teaching' and 'also equip the teacher to establish and maintain on a daily basis a completely different classroom culture' seemed "unusual and unreasonable" (Murray, Olivier & Human 1999: 34). It has to be borne in mind that the education department is trying to raise teaching standards quickly in a large country with many under qualified (as mentioned in Chapter One) teachers.

Hence all interventions, however trivial or theoretically unproven, need to be explored. Jaworski (1999) acknowledges that the work of Murray et al shows that the courses do change teachers' viewpoints even though the effects might be short-lived. Jaworski and

Woods (1999) indicates that many in-service programmes have positive outcomes, point out further needs, and threaded out important components, which determine their success. They caution that:

There is abundant evidence to suggest that out-of-school workshops, however successful, need to be followed up by support for teachers in their ongoing professional development in schools. It is clear that a major factor is time, which often implies a need for further resources and expense. To achieve effective outcomes, programmes need to have adequate resources allocated to teachers' continued professional development. Obvious as it may seem, the reality, even in the developed world, is that inadequate resources reduce potential for success.

(Jaworski & Woods 1999: 138).

Adler (2002) indicates that teachers left the Inset programmes held at the University of Witwatersrand with more confidence in their mathematical knowledge. However, no direct correlation could be drawn with this increased confidence and the impact it had on their teaching and their students' learning. She identified a multitude of factors, which included schools in impoverished areas, the background of the learners and the motivation of both teacher and learner. Those negatively impacted on learning. The curriculum also tended not to be fully covered in the early years, and then even less work was covered in succeeding years.

There is evidence in South Africa that teachers acquire routines of learner centred practice instead of developing mathematical meaning (Graven 2003). The black teachers attending courses are perceived to have poor mathematics teaching ability and their (frequent) decades of experience is frequently not taken into account (Graven 2003). Adler indicates that the concept of 'bad to good' practices and a 'fix it' approach are problematic and the emphasis on only the new curriculum not the whole answer (Graven 2003: 681).

### 3. THE CONTEXT AND DETAILS OF THE TENDER AND THE COURSE

In this chapter I am going to outline some of the context of the study, with particular regard to the teachers and the education system. Against this backdrop, I will introduce the Western Cape Education Department's (WCED) tender document for Foundation Phase Mathematics content knowledge for which the Schools Development Unit (SDU) at the University of Cape Town (UCT) successfully applied. Having done this, the chapter changes focus to look at the section of the course that became my responsibility- that of Shape and Space in the Geometry section. I give details of the official curriculum and assessment criteria for this topic and then describe the way in which the outcomes were designed for each day.

#### 3.1. The Context of the Study

Complex geopolitical, socio-economic, educational, language and resource factors have to be taken into account to describe the backdrop against which this study appears. For example, 5.3 million out of 18 million children in South Africa were reported starving and 70% of the rural population in the Eastern Cape lives below the poverty line (SAPA 2003). These factors contribute to what can only be regarded as an ongoing crisis in the provision of education.

An example of the present crisis was found in Sunday Times (2003) who reported that in a study done amongst 5 400 Grade 3 Foundation Phase learners in 2001 and 2002 that was accepted by the Education Department:

- Only 30% was scored in numeracy assessment, with 54% being scored for both literacy and life skills;
- 18% enrolled in Grade one did not reach Grade 3 within the minimum three years;
- only 27% of schools surveyed had libraries and only 33% of schools that ordered learning materials received them;
- 25% of Grade 3 teachers have qualifications below Grade 9, a significant amount of teaching time was spent attending meetings, studying and participating in other activities;

- Only one third of teachers started lessons on time.

In addition, the TIMMS studies of 1996 (Beaton et al. 1996; Howie 1997) reflected poorly on South Africa's overall school mathematics standard. Both in primary school and high school mathematics we scored last on an international comparative study.

Numerous areas have been identified and attempts are being made to address them. Unlike in the middle and upper social structures, where teachers are normally equipped with tertiary education, often university degrees and numerous enrichment courses, the situation is vastly different in the lower socio-economic groups and rural areas. Here, besides being under resourced and dealing with overcrowded classrooms, teachers often have inadequate qualifications and especially inadequate support structures to what many consider baffling and bewildering changes to the curricula.

The curricular structure has been designed by the Department of Education with Outcome Based Education (OBE) forming the thrust of Curriculum 2005 (C2005) and now the Revised National Curriculum Statements (RNCS). This can be summarised as having:

active learners, learners are assessed on an on going basis, critical thinking, reasoning, reflection and action...; learner-centred; teacher is facilitator; teacher constantly uses group work and teamwork to consolidate the new approach, learners take responsibility for their learning; pupils motivated by constant feedback and affirmation.

(Department of Education 2001)

This compares to the old approach:

passive; exam driven; rote-learning; ... textbook/ worksheet-based and teacher centred ...; teachers responsible for learning; motivation dependent of the personality of the teacher.

(Ibid)

Curriculum 2005 was implemented in an unstructured manner with teachers ill prepared, ill equipped and demotivated to accept it. It required a radical departure from the chalkboard authoritarian approach to an Outcome Based approach (Jansen 2002).

A frightening statistic reflects that 46% of African teachers, 29% of coloured teachers, 70% of Indian teachers and (only) 1% of white teachers were under qualified in 1994 (Gilmour 2001). Qualified was defined as having matric plus three years training. As far as mathematics is concerned, 41.4% of final year teacher education student at the University of Durban – Westville (UDW) did not study mathematics at secondary school matriculation level (Samuel 2002). Mathematics is a compulsory teaching subject within the teacher education primary school curriculum. At UDW, even though innovative approaches such as Action Research programmes, face-to-face lectures, tutorials and field trips were implemented, the mathematics education course still reflected a low pass rate within the teacher education programme. One of the reasons for this has been postulated to be the level of under-preparedness of the students in secondary school mathematics.

### **3.2. Background to WCED tender document.**

It is crucial that a sound foundation is laid in mathematics for learners in the Foundation Phase. There is the risk of increasing learners' conceptual gaps and poor mathematics content performance unless early diagnosis and remedial action takes place. However, this can only be done with strong intervention by the teachers. Research findings (for example, Rowland 2000) indicate that teachers' mathematics content and pedagogical knowledge is one of the important factors influencing teacher competency and learner performance in all grades. The knowledge of mathematics that teachers bring to their teaching is recognised as a significant influence on how successfully they teach mathematics (Fennema & Franke 1992) yet this is more complex than simply requiring a grasp of mathematics content (Ball 1990; Ma 1999). The role of teachers' 'subject knowledge' is often cited as important and central to the act of teaching and learning (Kerr & Lester 1982; Kruger et al 1990; McNamara 1991; Shulman 1986; Thompson 1984) and that research on teaching and teacher education had ignored questions dealing with the content of lessons taught (Shulman 1986; Van Driel, Veal & Janssen 2001). Ball (2003: 1) argues that teachers need to know how mathematical topics are connected, and that teaching involves 'using tools

and skills for reasoning about mathematics ideas, representations, and solutions, as well as knowing what constitutes adequate proof.

Against this background, the Western Cape Education Department (WCED) in 2002 published an invitation for tenders to be submitted to run a course, Mathematics for Foundation Phase Teachers (See Appendix 2). The aim of the course was to provide Foundation Phase teachers' with mathematics content and pedagogical knowledge.

In the Tender Document the WCED defined the purpose of the mathematics course for Foundation Phase teachers as being to introduce and upgrade teachers to the full understanding and practice of the Foundation Phase Mathematics Learning Area Statement of the Revised National Curriculum Statement. (See Appendix 2).

The WCED stated that the following desired outcomes for the course were for teachers to show:

- a demonstrative knowledge of mathematics content in the Foundation Phase as set out in the NCS;
- the ability to select and design materials and resources appropriate to Foundation Phase learners;
- the ability to develop appropriate learning programmes for each grade;
- the ability to develop appropriate assessment for each grade; and
- the ability to teach mathematics effectively within the scope of the Foundation Phase Learning Outcomes of the RNCS.

(WCED, 2002b: 2)

A Requirement by the WCED was that the course be completed over a period of 5 weeks focusing on the five Learning Outcomes of the RNCS. The WCED provided the outcomes to be achieved within the scope of the following content from the RNCS.

Learning Outcome	Content Focus
1. Numbers, operations and relationships	<ul style="list-style-type: none"> <li>▪ The meaning of different types of numbers</li> <li>▪ Numbers and relative sizes</li> <li>▪ Ways of representation</li> <li>▪ The effect of operating with numbers</li> </ul>
2. Patterns, function, algebra	<ul style="list-style-type: none"> <li>▪ Describing patterns and relationships through the use of symbolic expression, graphs and tables.</li> <li>▪ Identification and analysis of regularities and changes in pattern and relationships to enable predictions and problem solving</li> <li>▪ Overall to lay the foundation for developing algebra in the senior phases</li> </ul>
3. Shape and Space	<ul style="list-style-type: none"> <li>▪ Developing the ability to visualize, interpret, calculate relevant values and justify.</li> <li>▪ Interpret, understand, classify, appreciate and describe the world through 2-D and 3-D objects, their location, movement and relationships</li> </ul>
4. Measurement	<ul style="list-style-type: none"> <li>▪ Direct and indirect estimation</li> <li>▪ Reasonableness of measurements and results</li> </ul>
5. Data Handling	<ul style="list-style-type: none"> <li>▪ Data manipulation, representation and misrepresentation trends and patterns.</li> </ul>

<p>Learning Programme Design (Design to ensure coverage of all aspects of the NCS)</p>	<ul style="list-style-type: none"> <li>▪ Assessment (to inform ongoing planning).27-29</li> <li>▪ Continuous assessment including formative and summative assessment methods.</li> <li>▪ Planning – term plan, year plan</li> </ul>
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(WCED, 2002b: 2)

### 3.3. The Course.

The Schools Development Unit (SDU) is based at the University of Cape Town, and was successful in its tender for this course. The course was run over a period of five consecutive weeks with a contact time of 7 hours per day, on Mondays to Fridays from 8:00am to 4:00pm. The course was held at the Cape Teaching Institute in Kuilsriver. This site was established by the WCED and is ‘dedicated to serving and meeting the ongoing needs of qualified teachers in the classroom and managers in schools’ (WCED 2002b: 1). The location of this Institution is on the campus that is occupied by the WCED.

INSET projects are often described as school-based or institution based (Graven 2003). Research done by Thompson & Holloway (1997) indicated that educational changes tend to be more successful in schools that have good support structures amongst staff members. It is easier from an administration and logistical point of view to provide INSET programmes for a large number of teachers at an institutional venue chosen by the provider of that service.

### 3.4. The Teachers

The selection of teachers for the pilot course as well as the other courses was made by the WCED. The teachers chosen by the WCED to participate in this In-service Course were selected on the basis of the poor mathematics results at their schools. The demographics on class size, resources allocation, specific socio-economic location as well as the discipline and collegial structure of the specific schools were stipulated in the tender. These are important considerations (Adler & Reed 2002, Graven 2003). Similarly the motivation - or lack thereof - of teachers for attending the course could not be established as many were

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simply 'informed' that they 'had' to attend. Graven noted that the 'dilemma of who' is a much debated topic as far as inset is concerned, with the 'who' being prescribed by donors of these projects (Graven 2003: 679).

WCED selected a total of 50 practising foundation phase teachers from schools with a poor learner performance in mathematics in the nationally administered grade 3 tests. Two Foundation Phase teachers from a school were selected by Education Management District Committees to participate on the Course. All teachers were expected to attend daily sessions from 8:00am to 4:00pm. Before the start of the course, a profile of the teachers mathematics qualification, language preferences, age, and teaching experiences was gathered so as to inform the course design and planning. Of the 50 teachers participating on the course, only 46 completed and returned the questionnaires (See Appendix 1). All the teachers in the sample were female, which is not surprising as generally Foundation Phase teachers are of that gender. The majority of 22 teachers in the sample have Afrikaans as their first language, followed by 17 teachers who had Xhosa while the remaining 7 were English speaking. The language of instruction in their schools showed 50% in English, 46% in Afrikaans, and 30% in Xhosa (more than one language is used in several schools). It is interesting to note that even though Afrikaans is the dominant first language for these teachers and they probably teach in Afrikaans, 70% of the teachers preferred the course materials to be in English compared to 30% for Afrikaans.

The table in Appendix 1, indicates the teachers' highest standard passed in mathematics at school and the highest College qualification in mathematics. Only 17 of the 46 teachers had matriculation level mathematics and only 10 were in possession of M + 4. However, it must be noted that 25 teachers had more than 15 years of teaching experience (See Appendix 1).

Most of the teachers taught at schools in impoverished areas. A large number of the black learners attending these schools live in conditions of impoverishment, poor housing, no or erratic electricity supplies, inadequate sanitation and evident overcrowding. In some of the schools that I have been to, children admitted to attending school to take advantage of feeding schemes to get some food. Extended families in small shacks or houses often result

in school children having to perform household duties and tending to multiple smaller siblings and other family.

What is the point of learning geometry? Is it to train logical thought by studying deductive systems? Is it to develop spatial awareness and ability by empirical study of the environment? Is it to learn a language rich in metaphor?

(Tahta 1980: 3)

### **3.5. Background to Geometry (Shape and Space) Course.**

Ball (2000) refers to three problems that must be bridged to assist teachers in teaching effectively. The first is identifying the content knowledge required and as far as this thesis is concerned, this has been identified by the Revised National Curriculum Statements (RNCS). The second regards understanding of how such knowledge needs to be held, and the third focuses on what it takes to use such knowledge in practice. The course that this thesis is about is an attempt to answer the latter two problems with specific regard to shape and space. However I have added a fourth dimension, which is teachers' content knowledge before embarking on the course. Teachers' subject knowledge is considered paramount to effective teaching (McNamara 1991; Shulman 1986, Thompson 1984). McNamara (1991) further refers to a few studies that show teachers' limited knowledge inhibits what they are able to teach. He also infers that their use of and deployment of techniques and explanations are hampered, as well as their ability to cope with students' difficulties in learning. An outline of the course is given below. It must be emphasised that the course content and structure was decided upon by the SDU and this was approved after initially being commissioned by the WCED.

### **3.6. The Geometry Curriculum.**

The former syllabus for Foundation Phase was centred on only the 4 basic shapes. The biggest change in the geometry content in Foundation Phase was with the introduction of Curriculum 2005. The content of Curriculum 2005 was not overt and was designed according to the Specific Outcomes of which there were two for Geometry.

## For Shape and Space

Specific Outcome	Assessment Criteria
<p>SO7</p> <p>Describe and represent experiences with shape, space, time and motion using all available senses</p> <p>Mathematics enhances and helps to formalise the ability to grasp, visualise and represent the space in which we live. In the real world, space and shape do not exist in isolation from motion and time. Learners should be able to display an understanding of spatial sense and motion in time.</p>	<p>Descriptions of the position of an object in space.</p> <p>Descriptions of changes in shape of an object</p> <p>Descriptions of the orientation of an object</p> <p>Demonstrate an understanding of the interconnectedness between shape, space and time</p>
<p>SO8</p> <p>Analyse natural forms, cultural products and processes as representations of shape, space and time.</p> <p>The mathematical forms, relationships and processes embedded in the natural world and in aesthetic representations are often unrecognised or suppressed. Learners should have access to that mathematical knowledge which aims to unravel, critically analyse and make sense of these forms, relationships and processes.</p>	<p>Recognition of natural forms, cultural products and their value and processes.</p> <p>Representation of natural forms, cultural products and processes in a mathematical form.</p> <p>Generation of ideas through natural forms, cultural products and processes.</p>

(Department of Education 1997)

### 3.7. The Geometry Course.

Whilst the complete mathematics programme for the course addressed the five Learning Outcomes of the RNCS, in this research I will zoom in on the Geometry with a particular focus on Shape and Space in the Learning Outcome 3.

The study and the course on Shape and Space was guided by the requirements of the Assessment Standards of the Revised National Curriculum Statements as shown below:

ASSESSMENT STANDARDS (FOUNDATION PHASE) from RNCS document.

We know this when the learner:

Grade R	(i) Grade 1	Grade 2	Grade 3
Constructs various simple real models of shapes and objects following verbal instructions and instructions from pictures.	Constructs various simple real models of shapes and objects by making use of different construction materials (e.g. clay, stones, boxes, blocks)	Constructs various simple real models of shapes and objects by making use of different construction materials (e.g. clay, stones, boxes, blocks)	Based on pictures, constructs simple real models of shapes and objects by making use of different construction materials (e.g. clay, stones, boxes, blocks)
Matches different real shapes and objects with pictures of the real objects.	Fits together, compares and takes apart shapes and objects following instructions in pictures.	Fits together, compares and takes apart shapes and objects following instructions in pictures.	Fits together, compares and takes apart shapes and objects following instructions from pictures and drawing steps (sequences).
Talks about shapes, using everyday language (e.g. thick, thin, tall, short, big, small, wide, narrow, deep and shallow)	Talks about shapes, using everyday language (e.g. thick, thin, tall, short, big, small, wide, narrow, deep and shallow)	Talks about shapes, using everyday language (e.g. thick, thin, tall, short, big, small, wide, narrow, deep and shallow)	Talks about shapes, using everyday language (e.g. thick, thin, tall, short, big, small, wide, narrow, deep and shallow)
Names objects informally (e.g. balls, boxes, ice-cream cones)	Names objects informally (e.g. balls, boxes, ice-cream cones)	Names objects informally (e.g. balls, boxes, ice-cream cones)	Identifies spheres, cones, pyramids and prisms.
Works concretely to discover and understand that what we see changes as we change our position in space.	Works concretely to discover and understand that what we see changes as we change our position in space.	Works concretely to discover the changes that take place as we look at the same object from different distances and heights.	From pictures or drawings, builds, describes, predicts and tests what he/she will see from different positions.

Physically moves around different positions in space, using his/her own body in the classroom and personal environment.	Discusses changes in viewing position, using everyday language (e.g. front, straight ahead, next to.)	Discusses changes in viewing position, using everyday language (e.g. front, straight ahead, next to, behind)	Discusses changes in viewing position, using everyday language (e.g. front, straight ahead, next to, behind)
	Physically moves around different positions in space, using his/her own body in the classroom and personal	Works in familiar contexts to build up ideas of location.	Draws informal maps of familiar locations in the near environment of the school.
	Uses spatial language that indicates how simple locations can be reached.	Describes position, using 2 directions.	
		Uses spatial language that indicates location to describe how simple locations can be reached.	

My brief encapsulated the empowerment of the teacher in the geometry sub fields of the Foundation Phase Revised National Curriculum (RNCS), Mathematics Learning Area, Learning Outcome 3, being Space and Shape. Yet, deep down, I as a teacher ultimately teach in order to have some impact on society at large. The teacher would be more effective in communicating Shape and Space and the learners would have intricate knowledge of the world around them. They would later utilise that knowledge to be effective engineers, lovers of mathematics able to appreciate nature's own unique creations; ultimately leading to society at large benefiting. We all know however, through our teaching experience, that our concept of our sincerity (of our teaching intentions) in no ways is reflected in the purity of our practice. As Stephen Brookfield so aptly says:

The cultural, psychological and political complexities of learning, and the ways in which power complicates all human relationships (including those between students and teachers) means that teaching can never be innocent.

(Brookfield 1995: 1)

He further expands on the concept of teaching innocently which he defines as ‘thinking that we’re always understanding exactly what it is that we’re doing and what effect we’re having’ (ibid: 1). We feel that our actions embody significance and student consume it readily. We all know that this is a fallacy; sometimes we can only have superficial insight into a topic that often learners are only at a class to fulfil departmental criteria. Even if everyone is considered to be on the same wavelength, vast differences can be triggered by simple tasks such as Dawson (1981) demonstrated when he asked participants of a session to partake imaginary tasks with a lemon. Simple instructions such as ‘imagine a lemon and break it into two pieces’ (Dawson 1981: 57) were given. The lemon being cut at its shortest and longest diameters by different participants resulted in different images. These participants however fitted Gattegno’s definition of geometry as ‘an awareness of imagery’ (Hewitt 1989). I had to however face reality. My teachers had varying qualifications, while my brief was to improve their concept and content of shape and space. We were faced with teachers with virtually no access to computers (or little knowledge of how to use them), and with varying motivation to attend the courses. Some came with a genuine hope to improve their knowledge and teaching skills, some felt it was a break from school, while still others felt they were sent by the education department and came to pass the hours required. I always like to believe that my attempts to empower teachers to teach are based on the concept of the good citizen, where everything is ultimately done in the best interest of the country. An avid believer of ‘teaching through listening’ (Davis 1996). I plan my sessions as being interactive, often letting the class probe the session and still try and cover the set content required.

‘It is by listening by attending to the person’s action and situation, and not just to his or her voice that one comes to know the other’..

(Davis 1996: 36).

Considering the course according to Van Hiele’s theory, I decided to concentrate on the first three levels:

- The Visual level – ‘A learner identifies, names, compares and operates on geometric figures for example triangles, angles, parallel lines, according to their appearance. Construction, drawings or copying of shapes takes place on this level, the verbal

description of shapes as well as solving of routine problems by operating on the shapes and not on properties in general.

- The Analysis level- A learner on this level analyses figures in terms of their components and the relationships between these components. The learner can establish the properties of a class of figures empirically, and can use properties to solve problems (Fuys et al. 1988). Examples on this level refer to the congruence of sides, the appropriate language for parts (such as opposite sides, diagonals), as well as the ability to interpret verbal or symbolic statement of rules and to apply them.
- The Ordering /Informal Deduction level- Logical reasoning is developed at this level, and precise definitions one understood and accepted. Murray (1997) contends that the network of related concepts developed at the analysis level becomes complete and stable. Some examples of the abilities at this level include the identification of a minimum set of properties that can identify a shape, the ability to justify a conclusion reached by outlining logical relations and the ability to discover new properties by deduction.

### **3.8. The Foundation Phase Mathematics course: Shape and Space**

My focus for the shape and space module thus was based on the progression of conceptual development and the sequencing of activities according to the assessment standards in the RNCS. (Department of Education 2001). The design of the course was influenced by the assessment standards (as this was a requirement by WCED), but more importantly by the knowledge and the participation of teachers on the course. Throughout the presentation of the course the planning changed according to the class assessment at the time. The course did not only cover Foundation Phase content as required by WCED, but I extended the geometry to grade 7 level. I strongly believe that for teachers to teach at any level, they need to know more content knowledge than that required at the grade they teach. Throughout the course various teaching methods were used and classroom, assessment management and teaching issues were discussed. Teachers were encouraged to reflect on their own learning as adult learners, their own teaching situations through the use of learners' work, as well as through posters, video clips and micro teaching sessions.

The following principles were incorporated into all aspects of the course done by Schools Development Unit:

- a) **Content of Mathematics.** I've included work from Grade R to Grade 7. In this course the assessment standards were covered but I encouraged teachers to see beyond the immediacy of their grades and to imbue learners with a sense of essential nature of mathematics for the life after the Foundation Phase. The idea was also to give teachers the necessary extension ideas for those learners who are ready to move further with the mathematics.
- b) **Assessment.** Teachers were required to compile a portfolio of work done during the course. This included journal writings, course readings, individual, peer and group assessment (both oral and written work) and resources. The journal was used for self –assessment and reflective writing.
- c) **Strategies.** A variety of strategies was used on the course. This involved making teachers aware of common misconceptions, limitations and strengths of current classroom practices. In these ways, teachers engaged with the conceptual and cognitive tools to help them and their learners make informed choices about which processes and methodologies to use.
- d) **Critical Thinking.** Throughout the course teachers were encouraged to think critically about the work they were doing. Where they needed a better way of working, they had to think about and understand how and why a rule works and why the rule results in a more efficient way of working. They were challenged on why there was a necessity to work systematically.
- e) **Learning Outcome 3 module** examined some of the learning theories about teaching Shape and Space.
- f) **A scope and sequence of the content from Grade R to 9 for this learning outcome** was given to teachers. The process was intended to assist teachers in recognizing the prior knowledge that is essential for developing concepts across the phases.

- g) Teachers also engaged in a scope and sequence of the content for the foundation phase. Teachers analysed texts and how the content has been scoped and sequenced in the learner texts. This process enabled teachers to develop skills of recognising the strengths and weaknesses in the design of learner materials in available texts and how best to use them.
- h) In designing the geometry course, I provided content enrichment in terms of the teachers' own mathematical knowledge for the different learning outcomes. Teacher diversity was recognized in this process in terms of tasks and classroom assessment designed with the teachers on the course.

### **3.9. Focus**

The study of Shape and Space improves the understanding and appreciation of pattern, precision, achievement and beauty in natural cultural forms. It focuses on the properties, relationships, orientations, positions and transformations of 2-D shapes and 3-D objects.

Learning Outcome 3 states: the learner should be able to describe and represent characteristics and relationships between 2-D and 3-D objects in a variety of orientations and positions.

The study of Space and Shape in the Foundation Phase is very practical and hands-on. Learners begin by recognising and describing objects and shapes in the environment that resemble geometrical objects and shapes, cut out and draw sketches, and describe them with appropriate and expanding vocabulary.

### **3.10. Content of the Shape and Space Course**

The Schools Development Unit designed the following course content and pedagogical outcomes. The course content was prescribed by the tender document and guided by RNCS. The activities used to achieve the outcomes were not prescribed so for many of the activities I was able to introduce my own ideas. These were based on my practical exposure to ideas as outlined in Chapter One as well as theories discussed in Chapter Two.

### 3.10.1. Day One: Content Outcomes

a) Identify and name shapes and objects.

The teachers should be able to:

- recognise and provide mathematical names for polygons and polyhedra.

b) Sorting shapes and objects.

The teachers should be able to:

- Sort shapes and objects according to different sets of criteria, for example: the nature of the sides or faces, the number of sides or faces, symmetry, 2-dimensional or 3-dimensional.

c) Describing and draw shapes and objects.

The teachers should be able to:

- Describe shapes and objects by referring to properties of the sides or faces and angles within the shapes.
- Draw 2-dimensional representations of 3-dimensional objects.
- Describe the 3-dimensional object if given its 2-dimensional representation (called a net).
- Describe 3-dimensional objects on a 2-dimensional plane.

### 3.10.2. Pedagogical Outcomes

a) Overview of the curriculum in terms of focus and content for the Foundation Phase and grade 4 and 5 of the Intermediate Phase.

b) Design tasks that are appropriate for the phase and that engage the learners with all of the above content outcomes.

c) Design assessment tasks for the content outcomes.

d) To analyse learners' work and responses to diagnose learners' understanding and how to address particular situations.

- e) To raise classroom or teaching issues as they happen in the sessions, e.g. large class teaching, dominant/silent voices, giving voice to all learners, listening to others, language, classroom culture, etc.

### 3.11. Outcomes for Day 2

#### 3.11.1. Content Outcomes

- a) Describes objects from different positions (perspectives)

The teachers should be able to:

- from pictures or drawings, describe, predict and test what he/she will see from different positions.
- draw and interpret sketches of simple objects from different positions.
- describe changes in the view of an object held in different positions.
- describe positions using 2 directions.
- use spatial language that indicates location to describe how simple locations can be reached.
- draw informal maps of familiar locations.

- b) Recognise and describe different transformations

The teachers should be able to:

- perform rotations(turns), reflections (flips) and translations (slides).
- uses the vocabulary and properties of rotations, reflections and translations to describe the relationships between distinct objects and shapes within patterns.
- create geometric patterns using different transformations.
- use these transformations to investigate the properties of geometric shapes.

#### 3.11.2. Pedagogical Outcomes

- a) Overview of the curriculum in terms of focus and content for the Foundation Phase and grade 4 of the Intermediate Phase.

- b) Design tasks that are appropriate for the phase and that engage the learners with all of the above content outcomes.
- c) Design assessment tasks for the content outcomes.
- d) To analyse learners' work and responses to diagnose learners' understanding and how to address particular situations.

### 3.12. Outcomes for Day 3

#### 3.12.1. Content Outcomes

- a) Recognises and describes line and rotational symmetry

The teachers should be able to:

- make objects, shapes and patterns from geometric objects and shapes that focus on line symmetry.
- draws and completes the pictures around different lines of symmetry (vertical horizontal and lines at an angle in the plane).
- uses symmetry to investigate the properties of geometric shapes and objects.

#### 3.12.2. Pedagogical Outcomes

- a) Overview of the curriculum in terms of focus and content for the Foundation Phase and grade 4 of the Intermediate Phase.
- b) Design tasks that are appropriate for the phase and that engage the learners with all of the above content outcomes.
- c) Design assessment tasks for the content outcomes.

- d) To analyse learners' work and responses to diagnose learners' understanding and how to address particular situations.

### 3.13. Reasons for chosen activities:

The activities chosen were intended to engage teachers where they have to recognise, describe and name, as many objects in the real world in order to assess the teachers' knowledge of different shapes and objects. We used the real world as a starting context as it is the familiar context for all young learners. Starting with 3- dimensional objects in the real world was a teaching strategy for recognising different shapes and objects. Teachers engaged in activities in which they drew representations of the 3-dimensional objects, which they observed in the environment. This translation from 3-D to 2-D provided opportunities to engage with the notion of different dimensions as well as developing drawing, spatial and visual skills.

Teachers were required to design activities that help learners understand that 2-dimensional shapes come from 3-dimensional objects.

#### 3.13.1. Activity Outcomes

- Moving from 3-dimensional objects to 2-dimensional shapes.
- Understanding 2-dimensional shapes come from 3-dimensional objects.
- Linking 2-dimensional shapes with the faces with 3-dimensional objects.
- Comparing 2 and 3 dimensional shapes and objects.

(Collins & Lebeth 2001: 56-57)

The above activity, for example, explores the cylinder and asks learners to draw the circular top ends of cylinders. In a whole-class discussion after an analysis of this activity I asked the teachers to make a prediction about the kind of shape that will produce the cylinder.

Thereafter the teachers engaged with a grade 2 learners' activity in which they explored how to make paper cylinders, cones and boxes. This allowed teachers to see how learners can move from 2-dimensional representations to 3-dimensional objects.

Research by (Clements & Sarama 2000) on children's knowledge of shapes suggest that learners be given the opportunities to learn, which is more important than waiting for learners to reach a particular developmental level.

The instructional tasks, the setting, including the collection of shapes, influences learners' abilities to choose a shape in a collection (Clements & Sarama 2000). They further describe that the basic shapes should not only be taught through examples but learners need elaboration not just pictures. As the teacher, I needed to help my learners develop the language of attributes and description of shapes (Clements & Sarama 2000).

Teachers used tangram activities in which they made predictions about the kinds of shapes that can be made with certain geometric shapes. The research of Clements & Sarama (2000) suggests that young learners will be able to engage with "visual" descriptions and "property" descriptions of shapes at this stage. The research suggests that learners' abstract, manipulable, imagistic knowledge is underestimated and should be provided for so as to develop rich schemas of geometric shape from an early stage. I encouraged teachers to test their predictions by using concrete tangram shapes.

In the process of these activities, teachers were given opportunities to explore the properties of these objects and shapes, for example, the number of faces in a cube, the number of vertices and the number of edges. We made it explicit which assessment standards were being addresses as we engaged with activities at all times.

These activities, for example, explicitly focus on the following assessment standards in the Foundation Phase:

- a) Based on pictures, constructs simple real models of shapes and objects by making use of different construction materials (e.g. clay, stones, boxes, blocks).
- b) Fits together, compares and takes apart shapes and objects following instructions from pictures and drawing steps (sequences).
- c) Talks about shapes, using everyday language (e.g. thick, thin, tall, short, big ,small, wide ,narrow, deep and shallow).
- d) Identifies spheres, cones, pyramids and prisms.

The activities were sequenced to give teachers a sense of how content can be sequenced across the phase. I made explicit when assessment standards were addressed in the Intermediate and Senior Phase to show how content is developed from one phase to another.

Opportunities were created for teachers to analyse learners' work, such as learners' 2-dimensional drawings of objects and their ability to describe shapes.

We reflected on these learners' tasks and addressed the difficulties that were highlighted.

In the assessment task teachers were asked to classify different shapes and objects according to different set of criteria. In our feedback discussion on this task I encouraged teachers to revisit classification tasks across the grades as learners investigated and learned about new properties of shapes. These new properties would now be used as criteria classification.

#### 3.13.2. *Assessment*

- a) Teachers were given an individual task in which they had to provide the least number of transformations to move an equilateral triangle from one position to another on a triangular (equiangular) grid. Teachers were required to describe as many properties of different geometrical shapes in the triangular grid (tiling).
- b) Teachers were given a project in which they create tessellations using a technique known as the “nibble” technique. The technique was demonstrated by showing how two sides of a rectilinear shape can be altered by a translation. Teachers created colourful tessellating pictures using different transformations, which altered all the sides of the original rectilinear shape, but still preserved the area of the shape.

## 4. ASSESSING THE COURSE

In this chapter I give the background to the testing, which was a tender requirement designed to measure the success of the course. I use the opportunity to explore a selection of the various Shape and Space tests, which have been designed over the years. After this I turn to the test, which was administered to the teachers on the course, and analyse both the pre-and the post-tests.

### 4.1. Data Collecting Instrument

An important specification of WCED and condition for In-service Courses for teachers at the Cape Teaching Institute was for the Service Provider (in this case, the SDU) to design and compile an assessment tool for the assessment of Foundation Phase teachers. This was done by means of diagnostic tests at the beginning of the course in mid August 2002 and at the end of the course on 27 September 2002. The analysis of the two tests would then give the researchers an indication of the teachers' performance as well as an idea of the impact of the course. The idea was that the same test should be taken at the start of the course and at the end. The teachers were required to complete a questionnaire on their qualifications, age and language before taking the test. Of the 50 teachers who participated on the pilot course, only 46 of them wrote the tests. This information as well as the Revised National Curriculum Statement (RNCS) was used to inform the standard and the design of the tests and the course.

### 4.2. Designing the tests.

Before starting the task of designing tests, we reviewed the available material. Tests have been developed over the years to measure the geometry competence of students. Most of them incorporate the Van Hiele framework, as this is currently the best-known developed theory. These tests were consulted before the SDU started designing the tests to be used in this project, and are summarized in the following section.

*Cognitive Development and Achievement in Secondary School Geometry Project (CDASSG)*

Usiskin & Senk (1990) working through the (CDASSG Project) developed a test, which has been used to determine Van Hiele levels for a particular group. It also tests the theory in essence. This test consisted of a multiple-choice format, with 25 items. It had to be completed within 35 minutes. Difficulties with this test involve its specialised language, the fact that guessing the multiple-choice format may confuse results, and that no written or verbal responses are allowed that could possibly give insight into the student's comprehension. Its positive points are that it is a short test and has a standard format that is easy to apply and mark (McAuliffe 1999).

*4.2.1. RUMEUS*

The RUMEUS group at the South African Stellenbosch University developed a larger test. This open-ended test consisted of 29 questions totalling 60 items, and was also used to ascertain Van Hiele levels. It covered lines, angles, triangles, polygons, congruency and construction. As far as its reliability and allocations of students on the correct Van Hiele structure was concerned it was considered superior to the CDASSG test (McAuliffe, 1999). Difficulties with this test centred on the variety of responses by students as well as the labour-intensive process of marking. Some of the concept categories were also not always appropriate to the students' prior exposure.

*4.2.2. Mayberry*

This test, which was validated by Van Hiele himself, had tasks designed on all five Van Hiele levels. Seven common geometric concepts (squares, right angles, isosceles triangles, circles, parallel lines, similarity and congruence) are used in the 128 questions comprising of 62 items (Mayberry 1983). The overall test involved two one-hour interviews, with candidates given paper, a pencil, a straight edge and instructions to draw diagrams.

*4.2.3. Revised Mayberry*

A written revision was also developed and this test could be broken up into one-hour segments and concepts, and which takes the students' prior experience and knowledge

into account. The language is generally simpler, with the questions allowing students to make ‘selections and justify their answers’ (McAuliffe 1999: 55). Marking the test also seems simpler. Disadvantages include the ambiguity of some question, the fact that only a limited number of questions at each Van Hiele level appear (leading to incorrect student allocation because of him/her answering that level incorrectly) and that guessing can occur. This test aims to replicate the Mayberry test in a different way as well as to interpret the validity of the test questions. The tests made it possible for a large number of students to be assessed, and was devised in such a way that the aim of each question was made clear (Lawrie 1998: 178).

#### 4.2.4. *Fuys, Geddes, Lovett, Tischler*

The test developed by Fuys et al and his colleagues centred around three modules, which were based on the properties of quadrilaterals, angle relationships for polygons and area of quadrilaterals. It took the Van Hiele levels into account. Assessment took place over 6-8 sessions of 45 minutes each with a detailed protocol followed. Each session was also videotaped, and required individual interviews, which clearly required a labour and time intensive course. This tool, though able to assess a student’s potential, is impractical in the South African context, but has merit in developed countries (Mc Auliffe 1999).

#### 4.2.5. *HSRC and others*

The Human Sciences Research Council (HSRC) had tests developed prior to 1994, but these are considered culturally inappropriate, and outdated in certain aspects (Adler & Reed 2002:45). The mathematics tests were also not geometry specific. The TIMMS test, designed for pupils, also revealed that the teachers undertaking that test often did not fare much better (Adler & Reed 2002).

### 4.3. **The SDU tests in action.**

The CDASSG & RUMEUS tests were specifically targeted at secondary learners, and less so at teachers and were considered inappropriate for Foundation Phase teachers. Similarly the Fuys et al and both forms of the Mayberry tests were designed for pre-service undergraduate teachers. The TIMMS and JET test were also designed for learners, even though some studies indicated that teachers also performed poorly. Also these last two

tests tested general numeracy not geometry specifically. Our task was not to assess the teachers' geometry knowledge and assign it to a Van Hiele level, but to assess it in terms of the RNCS Assessment Standards. The SDU tests were initiated from scratch and took the above into account.

The SDU designed two diagnostic Tests for the participating teachers. This was done before the start of the course and at the end of the course. The diagnostic test was designed according to the content of the RNCS (Revised National Curriculum Statements) and was based on each of the 5 Learning Outcome and Assessment Standards. The test items on each of the different learning outcomes were included and the number of items per learning outcome was weighted according to the RNCS. Each test item was designed according to a set of specific criteria relating to different assessment standards within a learning outcome or across the different learning outcomes.

Due to the large number of test items, the test was divided into two parts. Part 1 focused on Learning Outcome 1: Number, Operations, Relationships and Learning Outcome 2: Patterns, Functions and Algebra. The second test paper was based on the 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> Learning Outcome, i.e. Shape and Space, Measurement and Data Handling. There was no particular order in which the items were listed and the items were mixed to prevent the division of specific learning outcomes. The pre-test was written over the first two days of the course, and the post-test over the last two days of the course. Part 1 of the test which included test items on Learning Outcomes 1 & 2 was written on the first day and Part 2 of the test which included test items focusing of Learning Outcome 3, 4 & 5 was completed on day two. The post-test was written at the end of the 5-week course under the same conditions.

The test did not focus on Foundation Phase mathematics content only but had content ranging from Intermediate Phase to Senior Phase. The purpose of the test was to assess teachers' mathematical content knowledge and see whether it extended beyond the foundation phase. Time constraints were not placed on the test and teachers could comfortably complete the course at their own pace. On average the teachers completed the

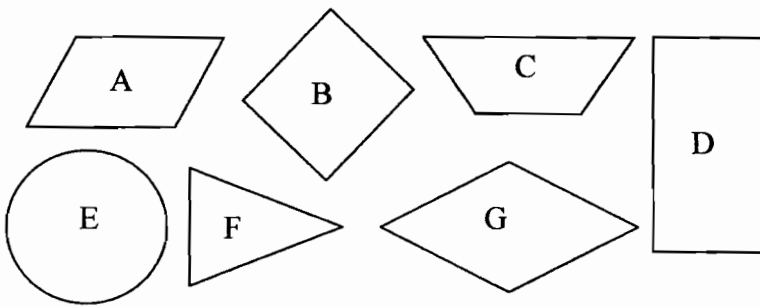
test within 2 ½ hours. A number had been assigned to each teacher for the purpose of confidentiality.

#### 4.4. Pre Test Results

In the review which occurs below, only those items in Test 2 which specifically referred to content on Shape and Space will be covered.

#### Item 4

4. Name the following shapes:



Shape A is a \_\_\_\_\_

Shape B is a \_\_\_\_\_

Shape C is a \_\_\_\_\_

Shape D is a \_\_\_\_\_

Shape E is a \_\_\_\_\_

Shape F is a \_\_\_\_\_

Shape G is a \_\_\_\_\_

The results (see Table 4.1 below) show that the teachers scored the highest in test items 4e, 4d. This indicates that every teacher knows and can identify a circle and a large majority could identify the rectangle. The lowest scores were found to be 4c where not one of the teachers knew the answer required was a trapezium. This question was based on the first Van Hiele level and shows an inadequate grasp of fundamental two dimensional shapes.

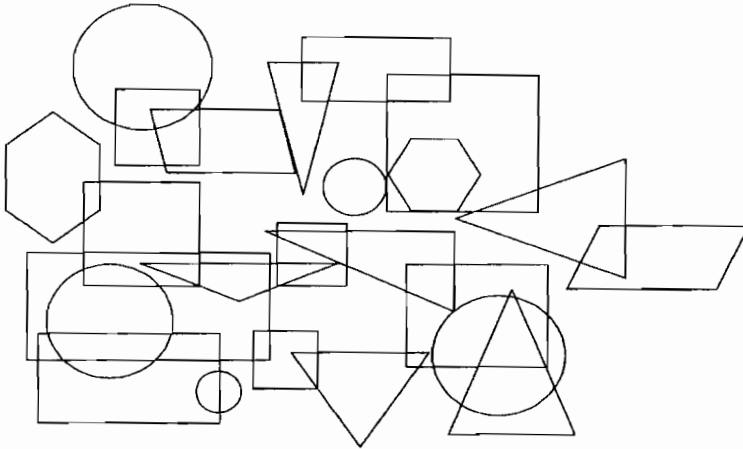
No. of teachers	Q4a	Q4b	Q4c	Q4d	Q4e	Q4f	Q4g
46	18	41	0	45	46	44	4

Table 4.1: Pre-test result of Item 4

## Item 16

16.

Complete the table by counting the shapes.



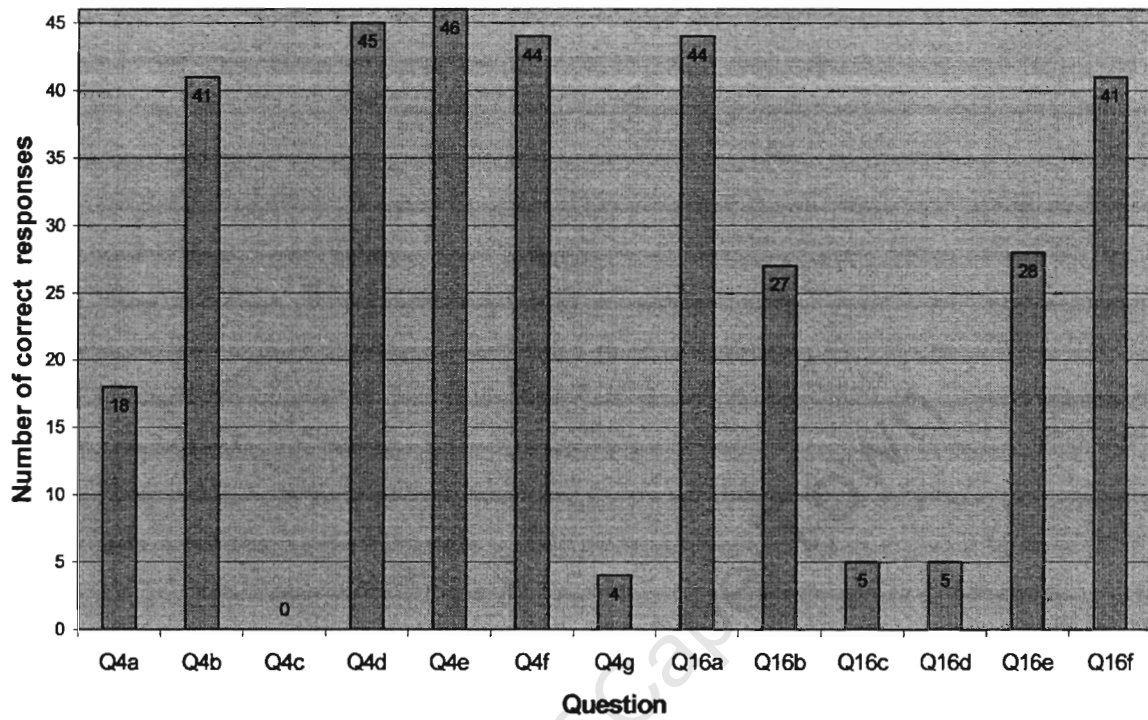
a.	b.	c.	d.	e.	f.
circle	square	triangle	rectangle	parallelogram	hexagon

Teachers had difficulty in counting the shapes and identifying shapes within other shapes. This question is again based on the first Van Hiele level and shows that the teachers have a poor recognition ability of basic geometric shapes.

No. of teachers	16a	16b	16c	16d	16e	16f
46	44	27	5	5	28	41

Table 4.2: Pre-test result of Item 16

## Pre Test Results (Question 4 &amp; 16)

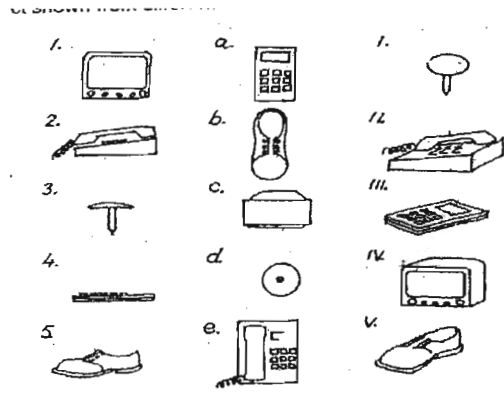


**Figure 4.1: Pre-test result of Items 4 & 16**

The above figure reflects the teachers responses on the two questions on 2D shapes. Only on item 4e where there was 100% correct answers.

Item 6

6.  
Match the same object shown from different views.



In question 6 it seems that for the majority of the teachers were able to answer the question correctly and were able to match the same object shown from different views.

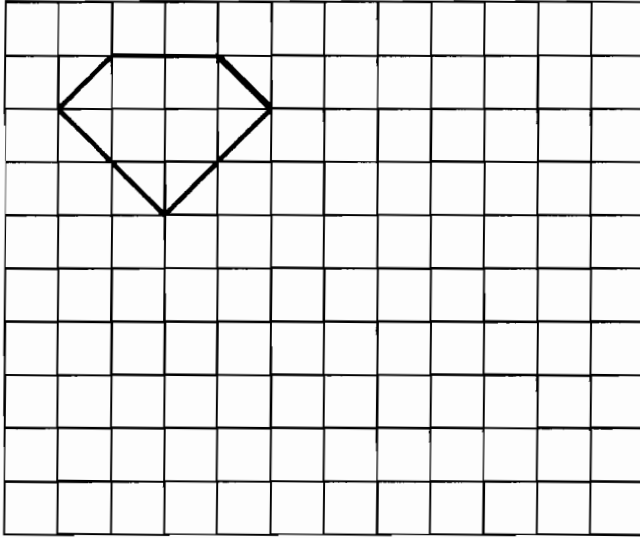
No. of teachers	Q6a	Q6b	Q6c	Q6d	Q6e
46	41	44	43	41	43

Table 4.3: Pre-test result of Item 6

**Item 22**

22.

On the grid paper, draw a rectangle that has the same area as the pentagon.

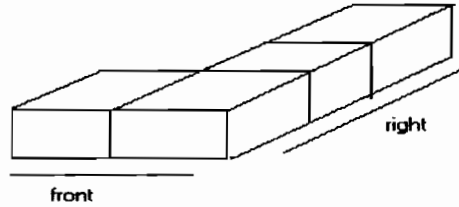


Only 9 teachers of the 46 that wrote the pre-test were able to draw a rectangle that had the same area as the pentagon.

University of Cape Town

**Item 29****29.**

Look at this building of blocks



On the dotted paper, draw each of the following:

- The front view of the building
- The aerial view of the building
- The side view (from the right) of the building
- The side view (from the left) of the building
- The rear view of the building

No. of teachers	Q29	Q29	Q29	Q29	Q29
	a	b	c	d	e
46	30	17	22	6	5

**Table 4.4: Pre-test result of Item 29**

From the above results it is clear that many teachers were unable to draw the side and rear view of the 3D drawing represented.

## Pre Test Results (Question 6,22,29)

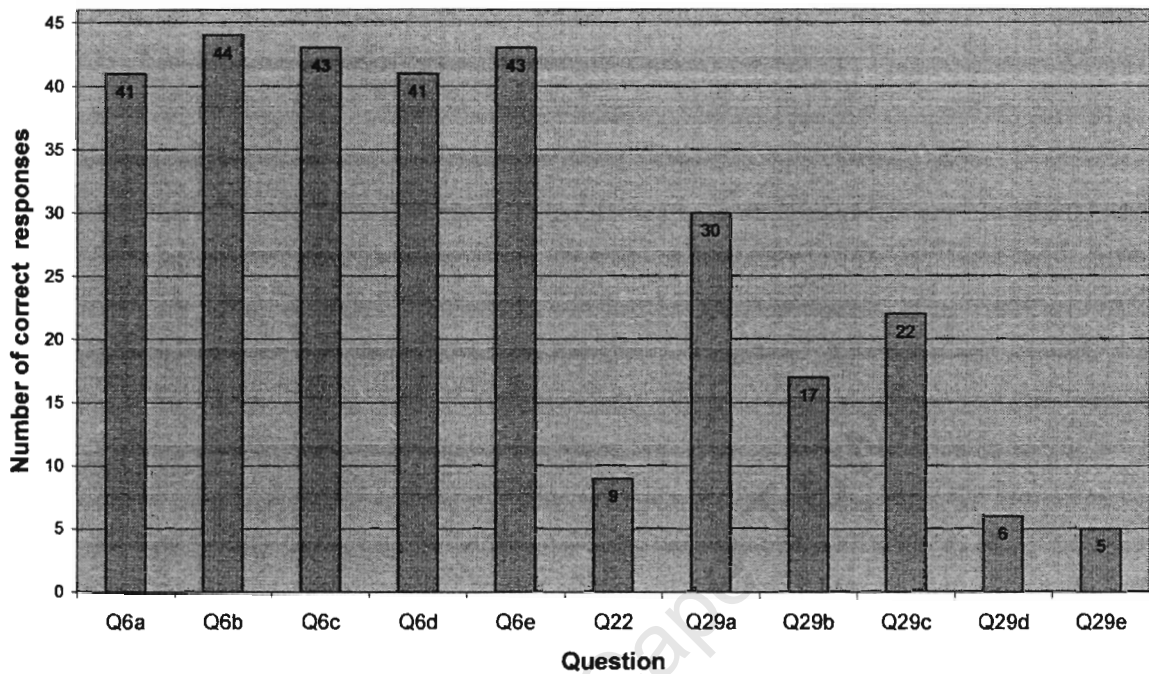


Figure 4.2 Pre test results questions 6, 22, 29

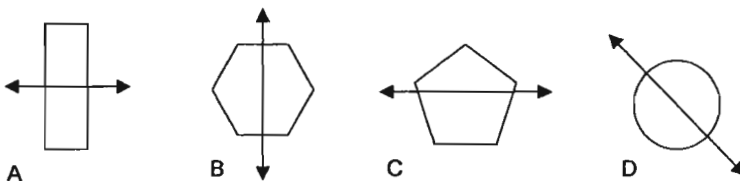
The results show that the teachers were strong with item 6, where the visual picture was presented. However they were weak in their representation of their drawings.

Items numbers 7, 11, 12, 20, 25, 26, 27 were grouped together. These questions dealt with symmetry, transformation and 3D-2D.

### Item 7

7.

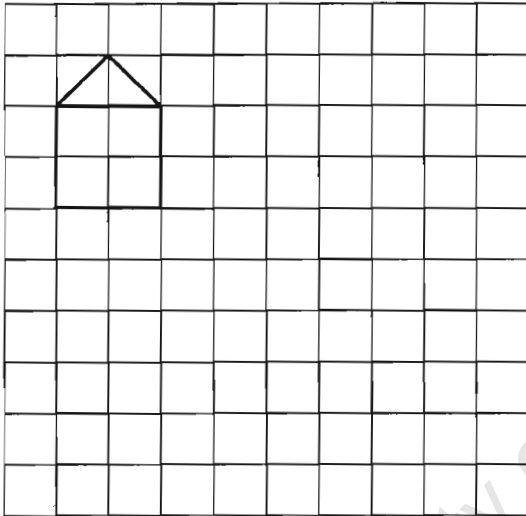
Which of these does not show a line of symmetry?



Question 7, where it was required to indicate the shape that does not indicate a line of symmetry, it is evident that more than half (35 of 46) of the group understood this concept.

**Item 11****11.**

Draw the same shape house bigger on this grid.



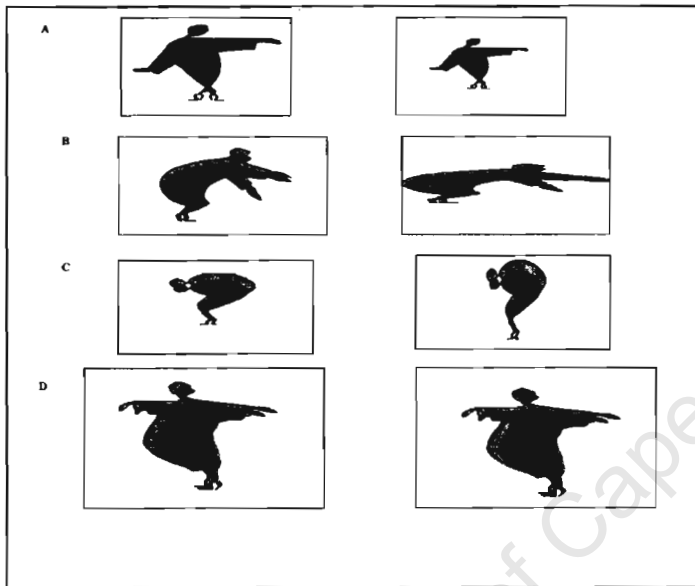
In analysing teachers' drawings, most teachers' concepts of 'bigger' meant twice/double the size of the house. Only 22 of the 46 teachers were able to draw the same shape bigger on the grid provided.

## Item 12

12.

Look carefully at the following pairs of photographs taken by Vusi at an art gallery.

In each case, state whether you consider the figures in the photographs to have the same shape or not and why.



No. of teachers	Q12	Q12	Q12	Q12
	a	b	c	d
46	40	26	32	40

**Table 4.5: Pre-test result of Item 12**

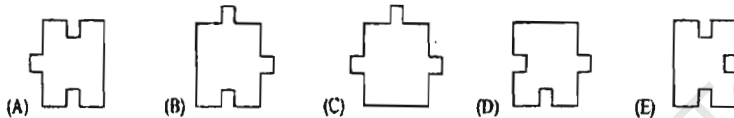
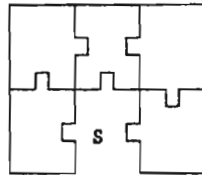
Most teachers faired relatively well with item 12a and 12d.

**Item 20**

20.

Circle the puzzle pieces that will fit into the space marked 's'.

Explain what you did to get your answer

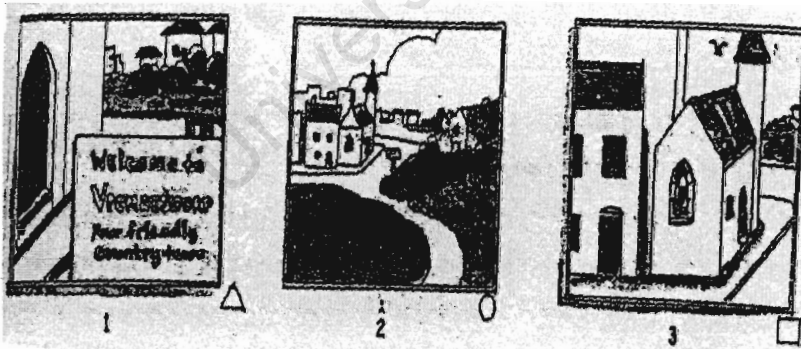


32 teachers responded correctly to the fit of the puzzle pieces that fit into the space marked with the "s".

**Item 25**

25.

Gavin is on a bus going into Vremdesdorp. Below are three photos he took of the town,



Say which photo he took:

First \_\_\_\_\_

Second \_\_\_\_\_

Last \_\_\_\_\_

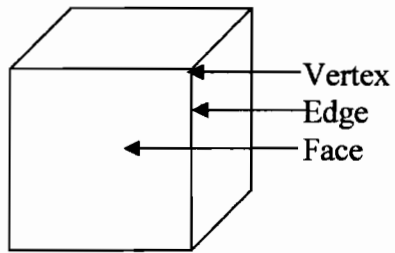
Answer: \_\_\_\_\_

20 of the 46 teachers interpreted the 'correct' answer.

## Item 26

26.

Have a look at this labelled drawing of a cube, then complete the table below



a cube has:

.....faces

.....edges

.....vertices

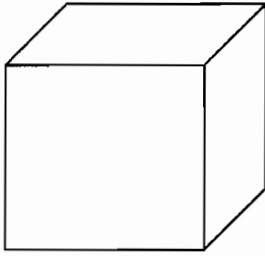
No. of teachers	Q26	Q26	Q26
	a	b	c
46	26	14	18

**Table 4.6: Pre-test result of Item 26**

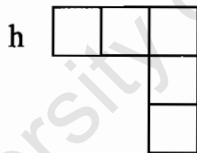
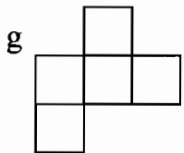
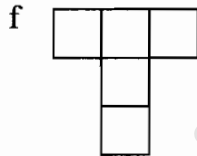
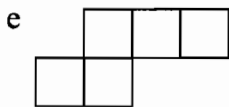
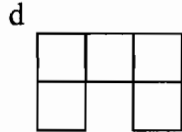
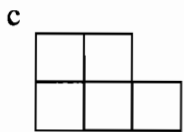
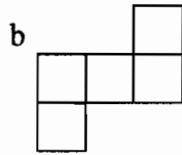
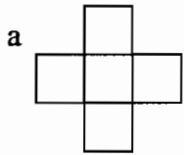
From the 3D drawing presented, teachers were not able to visualise a cube and indicate the correct number of faces, edges and vertices.

Item 27

27. This is a drawing of a cube without a top.

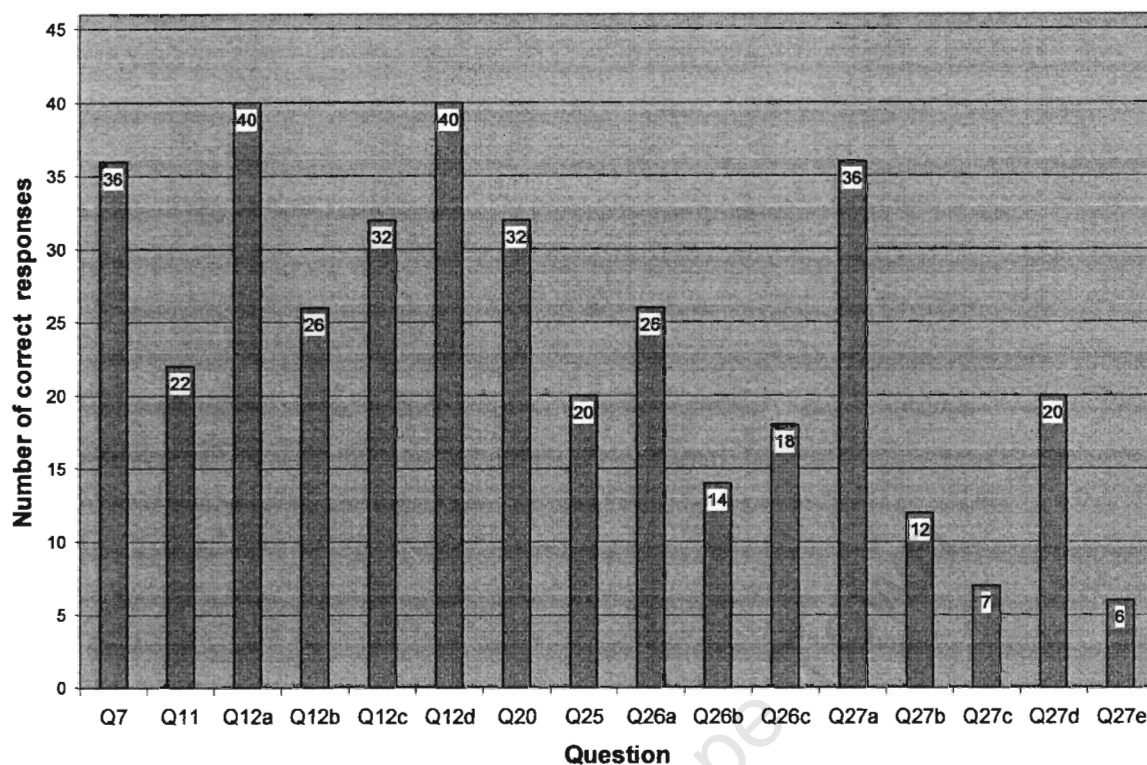


Which of the nets below can be folded to make this



No. of teachers	Q27	Q27	Q27	Q27	Q27
	a	b	c	d	e
46	36	12	7	20	6

Table 4.7: Pre-test result of Item 27



**Figure 4.3: Pre Test Results (Questions 7, 11, 20, 25, 26 & 27)**

Figure 4.3 indicate the results of the group of items referring to visualisation, transformation and two- and three-dimensional figures. Item 27 required teachers to use their visualisation skills, but also requires that teachers study the three-dimensional figure (cube) as well as its two-dimensional net.

From these results I concluded that teachers visualization skills are weak. Item 27 teachers scored low as they couldn't visualize the three-dimensional object by the given nets.

#### 4.5. Lessons learnt from the pre-test results.

The pre-tests were given at the start of the course, which meant that they were able to influence the way in which I decided to offer the course. Some of the major findings were:

- Teachers had great difficulty in identifying two-dimensional shapes other than the ‘4 basic shapes’ evident in the previous syllabus i.e. (square, rectangle circle, triangle) The triangle was always presented as an equilateral triangle therefore many of the teachers could not identify shape 4f in item 4 as a triangle. Given that the square is a shape mostly taught in the foundation phase, it is surprising to note that not all teachers got this item right. In analyzing, I suspect that due to the change in the orientation and position of the square, they saw shape B as something other than a square.
- Teachers had difficulty in identifying line symmetry.
- Teachers could not visualize a three-dimensional object (cube) from a two-dimensional drawing and were not able to describe and classify geometric figures and solids in terms of properties such as faces, vertices and edges.
- Teachers had difficulty in counting when shapes were presented in a puzzle form.
- Teachers had difficulty in drawing a representation of a solid from a particular position or perspective even though dotter paper was provided as a guide.

In revisiting the test items, in particular the second paper, it appeared that some of the test items needed to be refined due to their language or a definition that caused teachers either to give the incorrect response due to misunderstanding. For shape and space the following item comments must be taken into consideration for future testing.

##### **Test Item 4**

It was noted that many teachers provided responses that reflected a visual level of understanding in recognizing two dimensional shapes. Rephrasing the question to read more specifically: ‘Provide the correct mathematical terms for the following 2-D shapes.’ may have resulted in more participants having correct responses.

**Test Item 6**

The question was phrased ambiguously and it was not clear whether the numbers in the answer section referred to the object number or just a number for the question. The answer should have stated, object 1 instead of simply 1.

**Test Item 25**

This question makes assumptions about the zoom function of the camera. Is it not possible that Gavin took both picture 1 and 2 at the same time? It is possible that he used a powerful zoom lens to take picture 1.

**Test Item 26**

Some of the teachers described the shape of the face of the cube instead of the number of faces. The question could read: 'State how many of the following a cube has: .....faces and not simply a cube has ..... Faces.'

**Other issues were:**

- Some of the questions' language was ambiguous and this influenced the rephrasing of the questions in the post-test and the use of language on the course as the majority of the teachers have English as their second language.
- The test did not allow for practical manipulation of concrete objects. Teachers were required to visualize three-dimensional objects from drawings and they were required to sketch representations of solids from different positions. It is important in the Foundation Phase that learners observe and create given and described two – dimensional shapes and three dimensional objects using concrete materials (e.g. building blocks, construction sets, cut-out two -dimensional shapes, straws, clay and so that became an important aspect on the course. The idea was to represent the course practically, for teachers to understand the concepts, knowledge and skills needed and the theory to become meaningful. It was clear that the course had to have a strong practical aspect to it as it would be difficult to 'talk' teachers through various processes.

- Visual representation in the test was concentrated on Grades 2-4 and in the course far more was done in terms of visualisation and perspectives using various concrete/ three-dimensional objects.
- The items on two-dimensional shapes were answered poorly. The course was designed to give teachers a practical, visual, and hands on experience of various shapes in the environment, focus on semi-concrete- sorting of shapes into different categories, and identifies, classifies and knows the properties of the shapes.
- We had to make sure that the content covered in the test would be done during the course and that it satisfied the RNCS requirements. These assessment tasks were done in various ways.
- The test items worked towards achieving the assessment standards in each of the five learning outcomes.

#### 4.6. Post Test results

The post test result reflect that there was a small increase on some of the test items. In fact, on some of the items teachers scores were lower than some of the pre-test items.

##### Item 4

Question	Pre	Post	Difference
Q4a	18	33	15
Q4b	41	30	-11
Q4c	0	15	15
Q4d	45	45	0
Q4e	46	42	-4
Q4f	44	42	-2
Q4g	4	13	9

**Table 4.8: Pre-Post test result of Item 4**

In the analysis of this data, one observes that there is a negative result 4b, 4e, 4f. In item 4c, a significant improvement is noted.

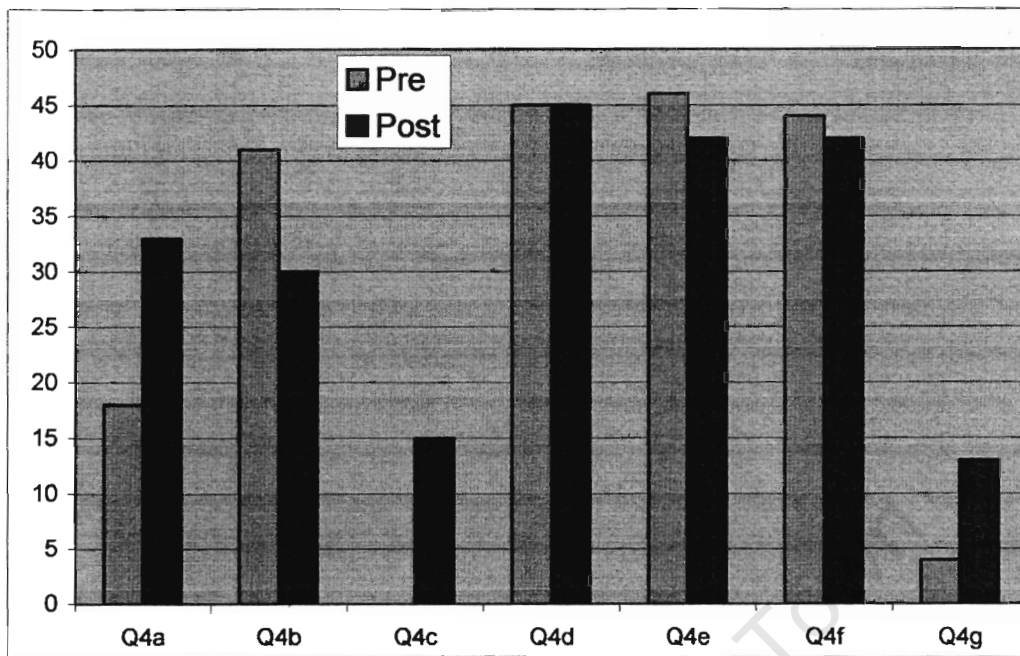


Figure 4.4: Pre-Post test result of Question 4

### Question 16

Question	Pre	Post	Difference
Q16a	44	44	0
Q16b	27	32	5
Q16c	5	7	2
Q16d	5	2	-3
Q16e	28	33	5
Q16f	41	39	-2

Table 4.9: Pre-Post test result of Item 16

From Figure 4.5 one observes that only three questions showed a marginal improvement in the post-test. In questions 16d and 16f there was a deterioration of results in the post-test.

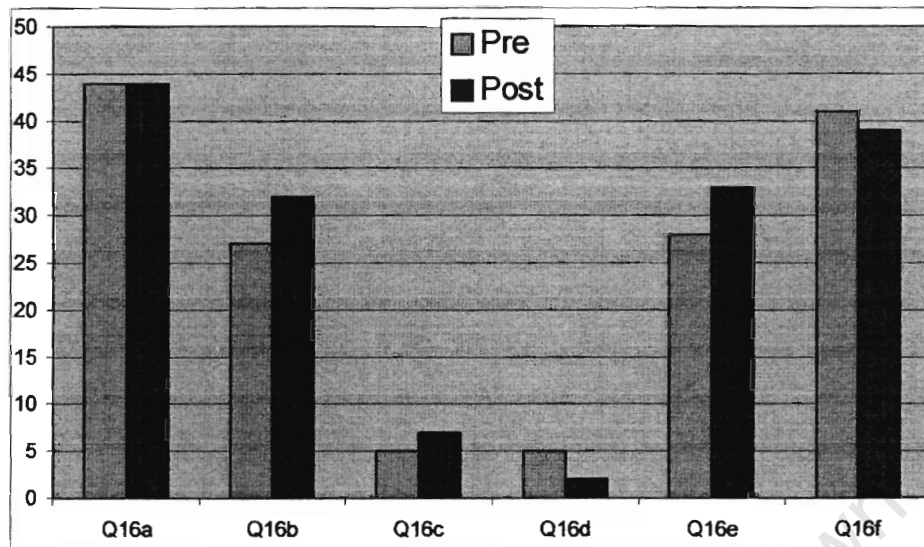


Figure 4.5: Pre-Post Test Results Question 16

### Question 6

Question	Pre	Post	Difference
Q6a	41	46	5
Q6b	44	46	2
Q6c	43	46	3
Q6d	41	44	3
Q6e	43	46	3

Table 4.10: Pre-Post test result of Item 6

It is only Item 6 where all the respondents teachers answered 4 of the 5 questioned correctly in the post-test. However, one should not get excited as the difference range from 2-5. It should be noted that in the pre-test the correct responses was in the number range of 40's.

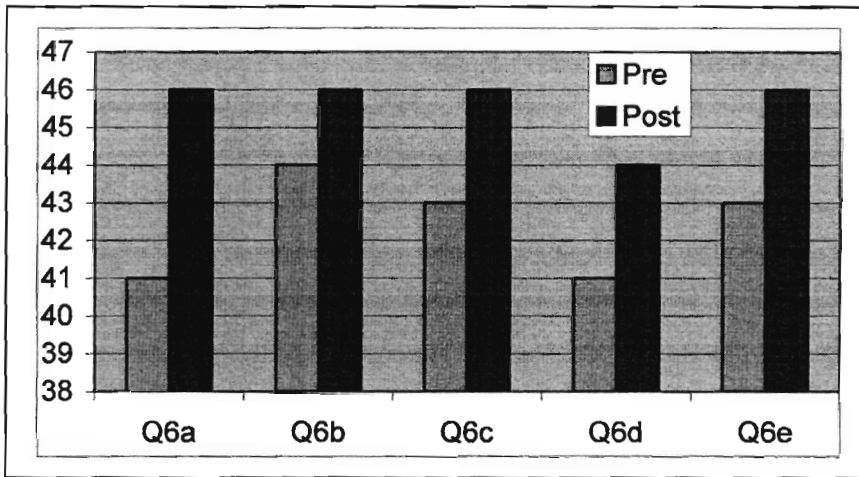


Figure 4.6: Pre-Post test result of Item 6

Question 29

Question	Pre	Post	Difference
Q29a	30	34	4
Q29b	17	22	5
Q29c	22	33	11
Q29d	6	10	4
Q29e	5	5	0

Table 4.11: Pre-Post test result of Item 29

A marginal increase is noted in the first 4 items with the last item (29e) showing no improvement at all.

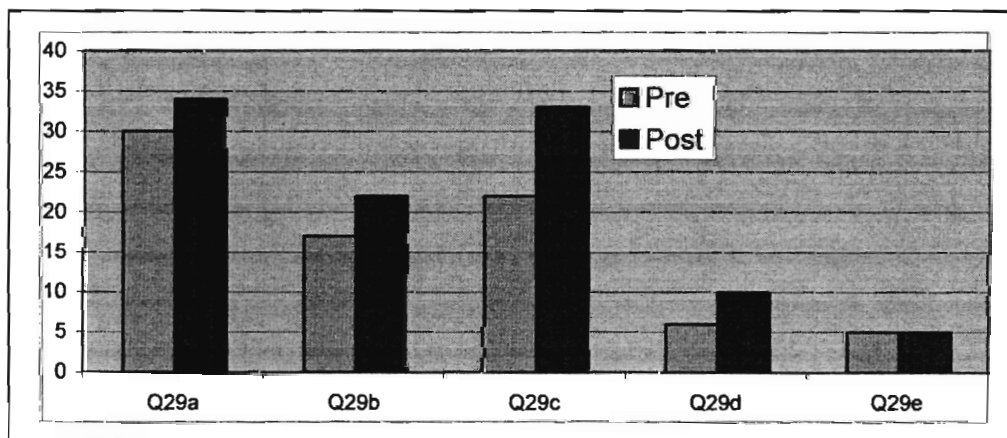


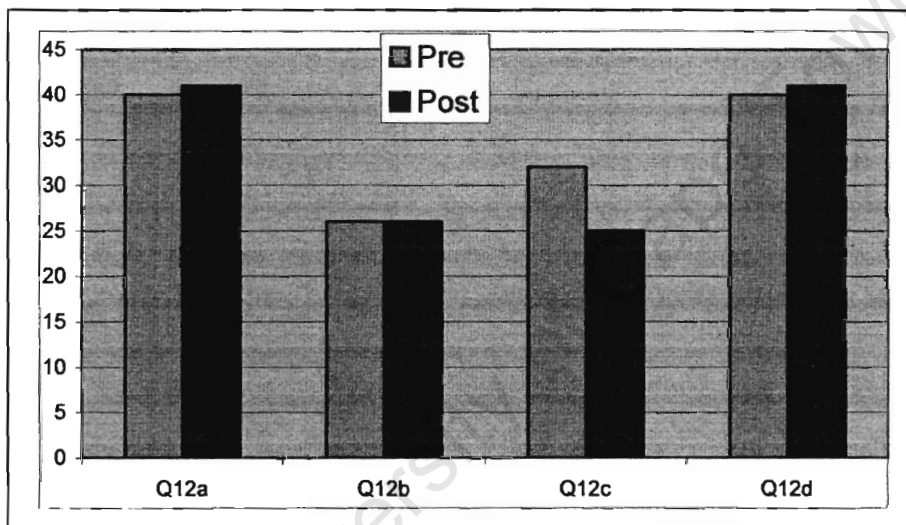
Figure 4.7: Pre-Post test result of Item 29

## Question 12

Question	Pre	Post	Difference
Q12a	40	41	1
Q12b	26	26	0
Q12c	32	25	-7
Q12d	40	41	1

**Table 4.12: Pre-Post test result of Item 12**

The results show that the course had no impact on this particular question and that one item (12c) in particular shows a deterioration in the post-test results.



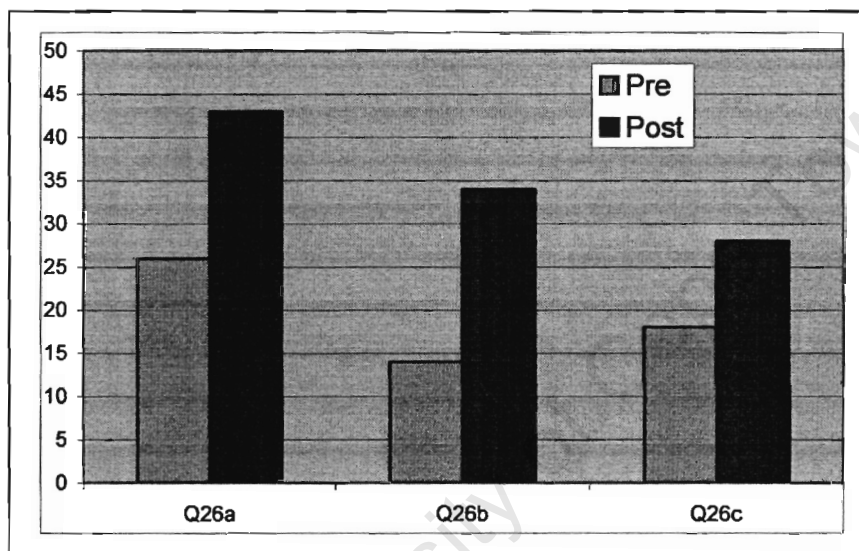
**Figure 4.8: Pre-Post test result of Item 12**

**Question 26**

Question	Pre	Post	Difference
Q26a	26	43	17
Q26b	14	34	20
Q26c	18	28	10

**Table 4.13: Pre-Post test result of Item 26**

This question shows significant improvement in all three items in the post-test.

**Figure 4.9: Pre-Post test result of Item 26**

## Question 27

Question	Pre	Post	Difference
Q27a	36	41	5
Q27b	12	34	22
Q27c	7	29	22
Q27d	20	20	0
Q27e	6	12	6

Table 4.14 : Pre-Post test result of Item 27

Three items in the post-test (27b, 27c & 27e) show a marked improvement in the post-test. Item 27a shows a marginal improvement and 27d shows no improvement at all.

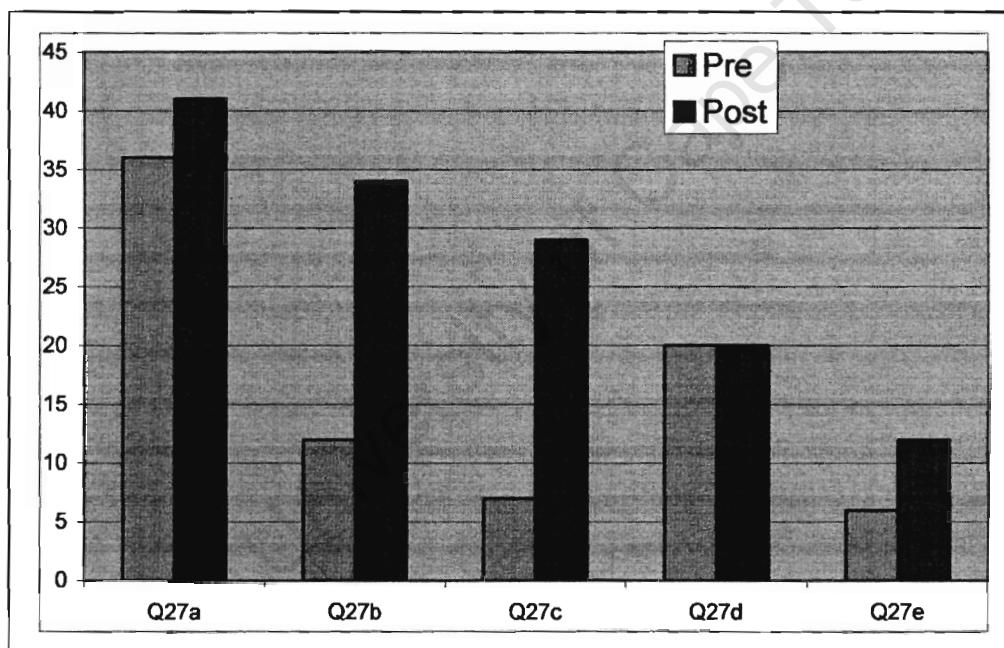


Figure 4.10: Pre-Post test result of Item 27

Question 6 it seems that for the majority of the teachers they were able to answer the question correctly and were able to match the same object shown from different views.

Question 7, where it was required to indicate the shape that does not indicate a line of symmetry, it is evident that less than half of the group understood this concept.

Question 11, Only increased by 4. Most teachers' concepts of 'bigger' meant twice/double the size of the house.

Question 16

Teachers had difficulty in counting the shapes and identifying shapes within other shapes.

On analysis of the Learning Outcome 3, there has been a slight improvement in teachers' content knowledge. Of the 46 teachers who participated, 37 of them have shown an improvement from the pre-test.

#### **4.7. The post-test results show:**

The analysis of the post-test Learning Outcome 3 items indicated the following:

- Even though there has been a marginal improvement on the items of two-dimensional shape, teachers still struggled identifying the different shapes.
- From the post-test it is clear that all the teachers had a good understanding of line symmetry.

They could also all match, describes and recognizes changes in the view of an object held in different positions.

Learning Outcome 3, on Shape and Space post-test show that there has been an improvement in teachers' content knowledge. Of the 46 teachers who participated 37 of them have shown an improvement.

**Teachers Motivation**

Teachers were chosen from five different areas by the WCED to attend the course. Their motivation for attending the course varied widely, with some enthusiastic whilst others were irritated initially. The selection criteria of teachers for the course were not made known to us, and because of the short and intense nature of the interaction, the different attitudes could not be investigated. Only a certificate of attendance was issued to each participant, no-test mark (pre and post) were made available to teachers. Teachers had no idea how they fared in the pre-test and could not evaluate their shortcomings at the beginning of the course. They were informed before the start of the course that the testing was to evaluate the group as a whole, and not individuals specifically and would not have a bearing on their certificate of attendance. There was no real motivation for doing well in the tests and a few teachers indicated this to us.

University of Cape Town

## 5. SOME THOUGHTS ON THE TESTS

### 5.1. Introduction

The pre- and post-test from the previous chapter have been used to determine the success of the in-service course. However, this does not sit easily with me. In this chapter, I want to introduce some additional factors through my personal views and perspectives as I was both researcher and teacher educator on this course.

The focus of this chapter is to show the different ways that the teachers learnt that cannot be demonstrated in the pre and post-tests which generally did not show a large increase on teacher knowledge. This learning experience includes the growing confidence of the teachers as they learned new mathematics, as well as their enthusiasm and excitement, their reflections and stories of how they wanted to take new ideas back to their classrooms.

#### 5.1.1. *The voice of the researcher/teacher educator.*

My story is about what the test did not capture and what learning is not evident in the test. I believe that the learning that took place between the pre and post-test is what I find most useful and necessary to me as a teacher educator. When I talk about my practice and the time spent on the course the moments that immediately come to mind are the times spent teaching, the time spent observing the teachers and the time spent listening to them.

When I talk about the course and my teaching I speak of more than just the pre and post-tests. I speak of how I have seen the teachers struggle to make sense of the content, their frustrations, their delight and wonderment in being exposed to new ideas and sometimes a glimpse of confidence is evident. I speak of my continuous amazement at the stories that teachers tell of their classroom practice and their relief in finding a space and someone who will listen without judging.

In order to illustrate what the test does not show I shall tell the stories of three teachers who captured my attention during the course. The first teacher is Pria, the only Indian teacher on the course. The second teacher that you will meet is Wendy and the third teacher I will refer to as the Paarl lady because I cannot remember her name. I have also used direct quotes from the teachers taken from the course evaluation sheets.

## 5.2. Stories

### 5.2.1. *The Story of Pria*

On the first day on the course I arrived very early so that I could prepare the classroom and my resources by the time the teachers arrived. Pria was one of the first teachers to arrive and we got talking. She thought that I was a teacher on the course, which seemed to be going to start late. I recall her surprised expression when I said I was the teacher for the Shape and Space course. On the course Pria was very much engaged in the activities and was an active member of her group. At the end of the course everyone noticed that Pria was quite emotional and thought something must have happened. She indicated that she was okay and we shouldn't worry. Just before leaving at the end of the course, she approached me and said that she had to thank me and apologize to me. She thanked me for the way I presented the course and exposed the teachers to quite a difficult standard of mathematics. She had previously avoided teaching Shape and Space to her learners (or left it for last) as she had felt that she did not know the difference between two-dimensional and three-dimensional shapes. Because of this, Pria would only teach the four basic shapes to her learners. She related that she will think differently now about teaching Shape and Space to her learners. She had shed tears for the many learners she felt she had harmed by not knowing the content she was supposed to have been teaching. Her apology was that she had first thought of me as a Muslim woman who would not have much to offer. From her experience as she put it, 'Muslim women fit into certain roles' and I didn't fit one of these roles in my position as a teacher of teachers.

### 5.2.2. *The Story of Wendy*

Wendy seemed to believe that she was the Miss Universe of the classroom. Wendy would often throughout the day take out her mirror and makeup and touch up her face much to the amusement of the rest of us. Initially I thought she was beauty with no brains. She made me change my mind midway through the course when she was able to make the connections to previous content. Teachers had made solids from given nets and systematically counted the edges, faces and vertices. The task required teachers to determine the number of edges, vertices and faces of the Five Platonic solids. After Wendy had completed her recording, she excitedly told the rest of the group to look at the relationship between the edges, faces and vertices of the solids. She was focusing on the

duality of the solids without being aware of it. The teachers in her group could not see the relationship between the solids; so she drew their attention to it and showed them what she noticed by drawing arrows to indicate the relationship between two solids. This task ended by teachers viewing a video on the Platonic Solids. The video finished with a question: 'What is the dual of the tetrahedron?' 'Tetrahedron!' she exclaimed, to the gasps and surprise of the rest of the class. She was able to describe the connections and articulate them very confidently. It was as if in that moment everything just made sense to her.

### 5.2.3. *The Story of 'The Paarl Lady'*

I had given the class a task in which they had to identify different shapes in the environment, and then name the shapes as well as where they saw them. On their return back to the class, we discussed the shapes that they had seen. One teacher said she had seen a shape, but could not name it. She could only trace the outline of the shape with the finger in the air and that the shape she saw was found on the roof. She described the shape as looking like a rectangle but that it was not. I asked the class if there was anyone that knew the name of the shape and one responded that it was a trapezium. There was one particular teacher that captured my attention when she said aloud: 'that is a beautiful name!' 'Is dit 'n regtige woord?' (is it a real word?). From that moment in class she was nick-named by the other participants as 'trapezium' simply because she exuded a sheer enjoyment at the discovery of a new name that she liked the sound of.

Throughout the course when she responded somehow or the other the answer had to have a 'trapezium' in it.

In a sorting of 2D-shape activity it was interesting to observe and listen to her. All quadrilaterals she would regard as being 'family' of her trapezium. When questioned why this was so, her response was that they all had 4 sides and 4 corners. This led to an interesting discussion about the nature and properties of various quadrilaterals.

### 5.3. **What is it that these stories show/tell?**

A central theme in all three stories is about making sense of new content knowledge. In each of these stories there were different forms of 'sense making'. For Pria the sense making came at the end of the course and was an emotional moment for her. The sense making was not only on one particular moment but also on the whole course. I believe that

Pria realised through her tears that she no longer is/was the same person/teacher. Teaching for her had taken on a different meaning. She was aware of the fact that returning to school would present new challenges.

Pria's sense making also brings regrets for her. Regrets of the kind of teacher that she had been up to this point. It was an emotional moment watching Pria tell me that she is crying not because of her new learning but rather thinking back to the disservice to the children she has taught before. It was thinking of the content that she did not share with her children that caused Pria's tears to fall. Taylor and Vinjevold (1999) claim that teacher's content knowledge is directly linked to what content is taught;

The PEI research studies strongly suggest that teachers' poor grasp of the knowledge structure of mathematics, science and geography *acts as a major inhibition to teaching and learning* these subjects, and that this is a general problem in South African schools.

(Taylor and Vinjevold 1999:142, my emphasis)

I believe that Pria knew at this moment that it was her fear of mathematics that almost imprisoned Pria the person and Pria the teacher. The course forced Pria to confront her fear of not knowing sufficient content knowledge and the fear of then teaching it. Previously she would simply have avoided teaching shape and space, now hopefully she would be more confident.

Wendy's sense making came in the middle of the course and for her it was centred on her own learning. This was not about Wendy the teacher, but about Wendy as the learner of mathematics.

The Paarl lady is an example of a teacher who explicitly and publicly made known her new found knowledge and use every opportunity to use it whether appropriate or not. I was surprised that the teacher could not recognise and name shapes which foundation phase content required.

#### 5.4. What the tests do not show.

What the test results do not reveal is the complexity of the relationship between content knowledge and teachers' confidence. As a teacher educator I believe that one needs to acknowledge, hear and respect the experience that teachers bring to a course. While supporting teachers in their classroom I have seen many successful maths lessons where resources are non-existent and there are 50 learners in the room. The content knowledge of the teachers was not strong yet they were confident of their pedagogical knowledge, belief and practices. I have also seen teachers who are confident in their content knowledge yet their maths lessons were not successful. I am therefore saying that even though the results show an increase in content knowledge the teachers might lack the confidence to put their new learning into practice. However I cannot deny that teachers' pedagogical skills will/can be improved if the mathematical content knowledge of the teachers is secure.

As a teacher educator I value the interaction that I have with the teachers during the course and it brings illuminating moments. So watching them grapple with the content, tear into bite-able bits so that they can understand; dismiss the content by saying: "As Foundation Phase teachers do we need to know this kind of mathematics", cannot be shown in the test. This kind of experience is only evident during the course as teachers work with the content.

The test also does not

- show how teachers have made sense of the content. As a mathematics teacher educator this is what I am interested in. The sense making was done over a period of five weeks. This was an intense time of struggle and personal and professional reflection.
- show the physical, emotional times when the teachers finally understand new content taught to them. This was often demonstrated on the course when teachers would say: "Ah! Now I understand. I was confused and didn't know but now it is clear". The test also does not show how the teachers thought of themselves as learners of mathematics.
- reveal the conscious shift in teachers viewing themselves as professionals and their learning. The test obviously cannot show how the identity of the teacher was

changed during the five weeks on the course. Pria is for me an example of a changing identity.

- show how teachers dealt with the fear of mathematics. This was evident in the conversations that were had in groups and the distorted faces of the teachers when the outcomes of the session for the day were stated. The teachers also told stories of a maths teacher that lurked in the background and still caused anxiety throughout their professional lives. As mathematics learners on the course they were still trapped as little children scared of their teacher.

### **5.5 Report back by teachers on the course**

The report prepared by the Schools Development Unit to the Western Cape Education Department clearly states that 95% of teachers felt that their mathematical knowledge improved for the different learning outcomes (Western Cape Education Department 2002a). All 48 respondents were positive about the Shape and Space course. Only six teachers indicated that they need further support in the Shape and Space course that was presented. They indicated that this support include short courses, school based and classroom support. There was a strong indication that most teachers did not feel confident enough after one course to offer support to their colleagues at their respective schools.

### **Course Evaluation**

Each teacher was asked to evaluate the course. Evaluation forms were designed to cover the entire course, with Shape and Space having specific questions. Anonymity for the respondents was assured by no questions being posed that would identify them. Forty eight of the 50 course participants responded to the questionnaire which is included in its entirety as Appendix 3 and Appendix 4.

The three questions pertaining specifically to the Shape and Space course were for participants to:

- state their shift in their own content knowledge (Space and Shape).
- give an example of how the new content knowledge that they have acquired will influence their teaching in the Foundation Phase.
- indicate the categories they need further support.

The following are the Teacher Evaluation of Shape and Space Course for Foundation Phase Content

**Shift in your own content knowledge.**

- *Very helpful – changing of positions of shapes*
- *Het meer breek betekenis van vorms*
- *I have learnt more about hexagons and pentagons*
- *New shapes- shapes viewed in different light- significance of shape*
- *Wonderful techniques were given from grade R to grade 3*
- *I knew only the circle, triangle, and square*
- *Different shapes*
- *Different shapes. Pentagons. Tessellation and symmetry.*
- *Polyhedra*
- *Different kinds of shape and symmetry*
- *Naming different triangles. Different kinds of gons. Folding of shapes.*
- *2D and 3D shape and objects*
- *I have a more clear idea of 2D and 3D and presenting it*
- *A lot! Shapes were just things I talked with no emphasis about. Now I know how important they are.*
- *Constructions. Clay constructions. Tetrahedron*
- *The edge, vertex, face. As well as names of certain shapes: rhombus*
- *All the names of 3D objects.*
- *Polyhedra*
- *I have a better knowledge of how to work with shape and space and some names of shapes I didn't know.*

**Give an example of how the new content knowledge that you have acquired will influence your teaching in the Foundation Phase**

- *The 2D and 3D was very interesting. I can now use that not just the 2D flat shapes. I can go a little bit in detail.*
- *The different ways to introduce shape and space –the different movements why it stays the same shape*

- *Shape and space will make a difference*
- *Relevance of forming a solid foundation and how it influences learners ability in geometry later in life*
- *Practical lessons are important*
- *Giving the child a broader knowledge of shapes e.g. hexagon.*
- *Practical- do things they will understand better*
- *Give the nets let the learners build*
- *Let learners learn many kinds of shapes*
- *Learners have to make patterns with symmetry*
- *I will do a lot more exercises, with this outcome as I have neglected this outcome. Transforming and tessellations*
- *I will be able to demonstrate and let learners experience the different contents*
- *Make use of more 3D objects*
- *Different shapes e.g. soccerball pentagon*
- *Polygons*
- *Ek is nou meer sensitief vir die kind se vermoens en beperkinge en sal dus beter in staat wees om dit effektief oor te dra. (I am more sensitive now to the child's ability and limitations so I'll be in a position to convey more effectively)*
- *Constructions- very practical*
- *I don't have to show them about familiar shapes. They can be taught how to count the faces.*

### **Teacher Confidence**

All the teachers felt more confident in dealing with Shape and Space after the course. They expressed that the new acquired content gave them more confidence to take risks in their teaching. Correlations clearly exists between our teachers responses and those elucidated by Adler, Slonimsky & Reed (2002). They elicited responses such as 'learned so much' and from 'all the course' (ibid:146). They caution that an impact on the subsequent teaching by the teachers and their learners learning cannot be assumed. They however

agree with researches who are investigating the positive link between teachers' learning and an increasing sense of professional self-confidence.

### 5.5. Conclusion

The stories of the three teachers show the human side to learning and teaching mathematics and that what teachers know cannot always be measured by a test. I acknowledge that the process of learning mathematics cannot be captured and measured in the pre and post-tests format.

The purpose of the Foundation Phase course was to increase teachers' content knowledge. The success of the course and my competence as a teacher educator could be measured by comparing the results of the test. The assumption made by the WCED I believe is that if teachers have sufficient content knowledge this would be translated into effective and good practice.

Based on my interpretation of the course I think that the course assumes the following, in its form and focus on content:

- Teachers' conceptual knowledge is significantly improved through subject focused in-service training.
- Improved teacher knowledge leads to improved students' learning.

(Taylor & Vinjevd 1999: 155-156)

The use of pre and post-tests attempts to fix the situation. In attempting to do this we lose out on the complexities of how teachers make sense and meaning on a mathematics in-service course. We lose out on how the in-service worker has used trust, communication and motivation to encourage teachers to participate in their professional development.

Allowing the teachers the opportunity to discuss problems, share ideas and their fears, struggle to solve a problem, is an attempt to place the teachers at the centre of their own professional development. Relying and reading the test results is only telling part of a story. I prefer to tell a story that recognises that teachers are 'knowers', and that they want to be life long learners.

There remains a challenge for me. This is well articulated by Adler, Slonimsky & Reed (2002: 136) when they say that the task for in-service is to characterise and articulate 'subject knowledge for teaching' and how its acquisition for teaching lies in the co-ordination of subject, pedagogic and contextual knowledge. They refer to teachers' conceptual knowledge-in-practice and suggest that a focus on teachers' conceptual knowledge alone is not the route to improvement in teaching practice.

University of Cape Town

## 6. CONCLUSIONS AND IMPLICATIONS FOR PRACTICE.

The final chapter of the inquiry draws together the aims of the study, test results (chapter 4), the analysis of the data and concluding remarks. Recommendations are made for teacher educators and this is based on how the research has informed the teacher educator.

### 6.1. Purpose of the study

The purpose of the study was to analyse a pre and post - test that was conducted with Foundation Phase Primary teachers participating on a mathematics education in-service course.

The research aims that were developed are:

- Comparing the results of a pre and post test of Foundation Phase teachers.
- Demonstrating that one cannot rely only on the results of the tests.
- Show that the classroom situation/the time between the pre-test and the post test needs to be considered together with the test results.
- Acknowledge the experience/assumptions/voice that I bring to the construction of the test and the teacher on the course.

### 6.2. Summary of Findings

#### 6.2.1. *Was there a shift in teachers' content knowledge?*

The post-test results show that there has been a marginal improvement of teachers' knowledge of Learning Outcome 3- Shape and Space. It is therefore possible to say from the test results that the course did not have a great impact on teacher content knowledge even though there is evidence of success on some of the items as shown in chapter 4. Teachers started on a very rudimentary level and most were only on the first Van Hiele level. Although a general statement can be made that there has been an improvement in teachers' knowledge of Shape and Space, a closer inspection of the test results reveal that teachers' were quite weak in areas such as identifying 2-D shape, perspective drawings and transformation. The test results show that teachers' content level was at the recognition stage of Van Hiele level 1.

The pre-test tells me that there are insufficient items of mapping and symmetry. The post-test only show that there has been a marginal increase in most teachers' content knowledge in those spheres. My concern is that I do not know what it is that teachers will take to their classrooms from the course. The question I ask is: does the shift in teachers' content knowledge guarantee a change in their practice? My experience of supporting teachers in their classrooms has shown that courses quite often do not impact on the pedagogical practices of teachers. Teaching is complex and one needs to consider the social world of the primary school, where the primary school is situated, the number of learners in the classroom, access to resources and collegiality among staff members, to name but a few factors. One also needs to consider the teacher as an individual and how self directed they are in their own professional development.

### **6.3. What I've learnt about Foundation Phase Geometry?**

I have learnt on this course that I cannot assume that teachers know basic shape and space. I have learnt that teachers have not been exposed to a fundamental shape like a trapezium and that the answer to the malaise in mathematics cannot be approached with a shotgun attitude of crash courses. Mastery of the first Van Hiele level is essential before subsequent insight into further properties can be elucidated. The previous (and in some cases persistent) lack of knowledge does not bode well for a vast amount of students.

### **6.4. What has the course and the research taught me about this group of teachers?**

The course confirmed my assumption that teachers' content knowledge of Shape and Space is limited. Some teachers bring rich teaching experiences to the course and they are willing to learn new content knowledge so that they could implement the new curriculum. It also taught me that teachers do reflect on their practice. This particular group of teachers was very conscious and aware of the habits they have formed in their teaching lives. I also found that this particular group of teachers were willing to share stories of 'how I used to teach'. They also told stories of how they intended changing their practice and implementing new ideas and the new content gained. Writing the maths pre-test brought to the surface their old fears of mathematics, as they knew they were being judged by the

course facilitators. Teachers were very aware in a shameful way of what they did not know.

### **6.5. Implications for teacher educators**

Valuable lessons can be learnt from this report for teacher educators. Firstly teacher educators need to ask the question: 'What does it mean to know mathematics for teaching?' (Ball nd). As teacher educators we need to take into account what teachers bring to these kinds of courses and we need to develop ways of challenging, changing, and extending what they know, believe and what they care about.

### **6.6. The usefulness of the quantitative data to a mathematics in-service worker.**

It provides the worker with evidence of how the teachers performed on the course. It allows a mathematics in-service worker to describe the shift in teachers' content knowledge and how successful the in-service course had been. It allows you to use the test results to plan and conceptualise future in-service courses.

The challenge for teacher educators is to reconceptualise and articulate what we understand by teachers' content knowledge and how can this be developed on in-service programmes. Adler (2002) says that teacher educators should begin to characterise and articulate 'subject knowledge for teaching' and how its acquisition by the teacher lies in the co-ordination of subject, pedagogic and contextual knowledge. As teacher educators we also need to examine what values are embedded in our teacher education curricula. (Gudmundsdottir, nd)

The model of delivery shows a shift in thinking on or about doing in-service work. Criticism was heavily given about the way the education department had given teachers training during the implementation of Curriculum 2005. The main problems experienced by teachers revolved around the 'training being too abstract and insufficiently focused on what the theory meant in practice' (Chisholm et al 2000: 57). This course comes with a new model of helping teachers understand and implement the content suggested by the Revised National Curriculum Statements. For the first time a pre and post-test is done on

every course. There is a conscious effort from WCED to track teachers' content knowledge and the success of the course.

Researchers such as Graven (2003) have concluded that such courses are generally far too short to be effective. This inset model, is still the major form of inset provision in South Africa (Chisholm et al 2000). A clear discordance exists between the quantitative data obtained and the (admittedly) subjective responses of the teachers. The marginal improvement in the test results do not resonate with the overwhelming positive response to the Shape and Space course. Tools, which do not presently exist, need to be developed to somehow take these factors, together with other aspects such as teacher's motivation into account and form a universal assessment on the success of a particular course. The ultimate aim is for teachers to teach more effectively. If subjective confidence alone is a measure of such ability, it should be further explored. This can be done by further courses with testing a few months later and in class assessment through in-service school-based visits. The overriding impression of Graven (2003) was that the content, methodology and techniques taught at these courses were not transferred to the classroom situation. My study however did not focus solely on suddenly providing competent teachers over a short period, nor how to effectively achieve it. It centred on ascertaining their content knowledge and whether the course influenced it.

### **6.7. Conclusion**

A constructivist perspective holds that children's learning of content is a combination of interaction between what they are taught and what they bring to any learning situation. Similarly adult learners' learning of subject matter is a product of an interaction between what they are taught and what they bring to any learning situation. This view is based on evidence from cognitive research that learners' prior knowledge and beliefs affect the ways in which they make sense of new ideas and problems (Anderson, 1984; Davis, 1983; Schoenfeld, 1983). South Africa has unique needs as far as mathematics teaching is concerned. Effective teaching requires that a teacher be well grounded in content and pedagogy, an environment conducive to learning (adequate resources, well-fed learners, secure school), a well structured clear curriculum and education department that has constant positive interactions with all its individual components. Most of the above is

lacking in our country. Unfortunately a holistic approach is lacking when the problems are confronted, and approaches such as short “refresher” courses are the present order of the day.

The evaluation reports, teachers’ comments and the teacher educator observations show that during the course there was an increase in teacher confidence. The analysis shows that there was a marginal increase in teachers’ knowledge and understanding of shape and space.

The course is so content driven that it focuses/highlight teachers weaknesses/strengths in the mathematics.

Will teachers leave the course with the acknowledgement of their weakness but also recognition and respect for their strengths? Have the teachers left the course with initial thoughts on how to organise and make sense of their own professional development? Returning to their classrooms requires them to alter their own professional development.

Connelly and Clandinin state that

If you understand what makes up the curriculum of the person most important to you, namely, yourself, you will better understand the difficulties, whys, and wherefores of the curriculum of your students. There is no better way to study curriculum than to study ourselves.

Connelly & Clandinin (1992: 92).

## REFERENCES

- Adler, J. (1996). Lave and Wenger's social practice theory and teaching and learning school mathematics. In Puig, L. & Gutierrez, A. (Eds). *Proceeding of the Twentieth Conference of the International Group for the Psychology of Mathematics Education* University of Valencia, Spain, 2, 3-10.
- Adler, J. (2002). Inset and mathematics teachers' conceptual knowledge-in-practice. In Malcolm, C. & Lubisi, C. (Eds). *Proceedings of the 10th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education Conference*, Durban, January, (2), 1-8.
- Adler, J. (2003). Mathematical knowledge for teaching: Structural and conceptual issues in a formal degree programme. In Jaffer, S. & Burgess, L. (Eds). *Proceedings of the Ninth National Congress of the Association for Mathematics Education of South Africa*, UCT Baxter Theatre Complex and Rustenburg Girls' Junior School, 1, 95-104.
- Adler, J. and Reed, Y. (Eds). (2002). *Challenges of teacher development: An investigation of take-up in South Africa*. Pretoria: Van Schaik.
- Adler, J. Slonimsky, L. & Reed, Y. (2002). Subject-focused INSET and teachers' conceptual knowledge-in-practice. In Adler, J. & Reed, Y. (Eds) *Challenges of Teacher Development*. Van Schaik publishers, Pretoria, 135-152.
- Anderson, R.C. (1984). Some reflections on the acquisition of knowledge. *Educational Researcher*, 13 (9), 5-10.
- Ball, D.L (1990). Teaching Mathematics for Understanding: What do teachers need to know about subject matter knowledge? In Kennedy, M. M. (Ed.). *Teaching Academic Subjects to Diverse Learners*. New York, 63-68.
- Ball, D.L (1993). With an Eye on Mathematical Horizon: Dilemmas of Teaching Elementary School Mathematics. *The Elementary School Journal*, 93 (4), 373-397.

Ball, D.L. (2000). Bridging Practices – intertwining content and pedagogy in teaching and learning to teach. *Journal of Teacher Education*, 51 (3), 241-247.

Ball, D.L. (2003). *What Mathematical Knowledge is Needed for Teaching Mathematics?* Remarks prepared for the Secretary's Summit on Mathematics, Department of Education, U.S. Retrieved 3 September 2004 from:  
[http://66.102.9.104/search?q=cache:S9JJj-yNcDUJ:www.icme-organisers.dk/tsg15/Guimaraes\\_et\\_al.pdf+Ball,D.L.+2003](http://66.102.9.104/search?q=cache:S9JJj-yNcDUJ:www.icme-organisers.dk/tsg15/Guimaraes_et_al.pdf+Ball,D.L.+2003)

Ball, D.L. (n.d). *Unlearning to Teach Mathematics*. Retrieved: 4 August 20, 2003 from:  
<http://ncrtl.msu.edu/http/papers/htm>

Ball, D.L. & Cohen, D.K. (1999). 'Developing practice, developing practitioners: towards a practice-based theory of professional education' In Darling-Hammond, L. & Sykes, G. (Eds) *Teaching as the learning profession*. San Francisco: Jossey-Bass.

Ball, D. & McDiarmid, G. (1989). *The subject matter preparation of teachers*. East Lansing,MI: National Center for Research on Teacher Learning. (ERIC Document Reproduction Service No. ED 310 084)

Ball, D.L. & McDiarmid, G.W. (n.d). *The Subject Matter Preparation of Teachers*. Retrieved: 4 August 20, 2003 from: <http://ncrtl.msu.edu/http/papers/htm>

Ball, D. & Mosenthal, J. (1992). Constructing new forms of teaching: Subject matter knowledge in in-service teacher education. *Journal of Teacher Education*, 43, 347-356.

Ball, D.L. & Wilcox, S.K. (1989). *Inservice Teacher Education in Mathematics: Examining the interaction of context and content*. Retrieved: September 23, 2003 from:  
<http://ncrtl.msu.edu/http/rreports/ht>

- Barba, R. & Rubba, P. (1992). A comparison of preservice and in-service earth and space science teachers' general mental abilities, content knowledge, and problem-solving skills. *Journal of Research in Science Teaching*, 30(5), 1021-1035.
- Beaton, A.E., Mullis, I.V.S., Martin, M.O., Gonzales, E.J., Kelly, D.I., & Smith, T.A. (1996). *Mathematics Achievement in the Middle School Years: IEA's TIMSS*. Chestnut Hill, MA: Boston College.
- Breen, C. (2003). Dilemmas Of Change: Seeing the Complex Rather than the Complicated? In Putsoa, B., Dlamini, B. & Kelly, V. (Eds) *Proceedings of the 11th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education Conference*, University of Swaziland, 684-689.
- Brodie, K. (1999). How to Change? Strengths and weaknesses within changing practices among mathematics teachers enrolled on a Further Diploma course. In Kuiper, J. (ed) *Proceedings of the 7th Annual Conference of the Southern African Association for Research in Mathematics, Science Education Conference*, Harare, Zimbabwe, January, 67-75.
- Brodie, K. (2001). Changing practices, changing knowledge: towards mathematics pedagogical content knowledge in South Africa. *Proceeding of the Seventh National Congress Of The Association For Mathematics Education Of South Africa* University of Witwatersrand.
- Brookfield, S. (1995). *The Getting of Wisdom: What Critically Reflective Teaching is and Why it's Important. Becoming a Critically Reflective Teacher* San Francisco, Jossey-Bass.
- Burger, W.F. & Shaughnessy, J. (1986). Characterising the Van Hiele levels of development in geometry. *Journal for Research in Mathematics Education*, 17, 31-48.
- Clements, D.H. & Sarama, J. (2000). Young children's ideas about geometric shapes. *Teaching Children Mathematics*, (6), 482-487.

- Chisholm, L., Volmink, J., Potensa, E., Muller, J., Vinjevold, P., Malan, B., Ndhlovu, T., Mohomed, H., Lubisi, C., Ngozi, L., Mphahlele, L. (2000). *A South African Curriculum for the Twenty First Century*. Report of the Review Committee of Curriculum 2005 Presented to the Minister of Education, Professor Kader Asmal, Pretoria 31 May 2000.
- Cohen, D.K. & Ball, D.L. (2001). *Making Change: Instruction And Its Improvement*. Phi delta Kappan, 83 (1), 73-77.
- Collins, H. & Lebethe, A. (2001). *Maths for All Grade 1, Learners Activity Book*. Cape Town, MacMillan,, 56-57.
- Connelly, F.M. & Clandinin, D.J. (1992). Understanding teacher development. In Hargreaves, A. & Fullan, M.G. (Eds). *Classroom-based Teacher Development*, Teachers College Press, Columbia New York, (6), 92.
- Darling-Hammond, L. (1998). Teachers and teaching: testing policy hypothesis from a National Commission Report. *Educational Researcher*, 27 (1), 5-15.
- Davis, B.A. (1994). *Mathematics Teaching: Moving from Telling to Listening*. Journal of Curriculum Supervision, 9 (3), 267-283.  
<http://www.atl.ualberta.ca/po/articles/template>.
- Davis, B.A. (1996). *Teaching Mathematics: Towards a Sound Alternative*. New York Garland Publishing INC.
- Davis, R. (1983). Diagnosis and evaluation in mathematics education. In Smith, D. (Ed). *Essential knowledge for beginning educators*, Washington, D.C.: American Association of College for Teacher Education.
- Dawson, S (1981). Words Triggered by Images: Images Triggered by Words. (based on a presentation made at the 1981 conference of the Canadian Mathematics Education Study Group).

de Arechaga, G.M. (2001). *Teacher Development Awareness, reflection and sharing*. The weekly column Article 69, August 2001, Retrieved on 22 September 2003, from:

<http://www.eltnewsletter.com/back/August2001/art692001>

Department of Education (1997). *Curriculum 2005: Lifelong Learning for the 21<sup>st</sup> Century*. Pretoria, South Africa.

Department of Education (2001). *Revised National Curriculum Statement: Overview*. Pretoria, Department of Education (DoE), Pretoria.

Department of Education (2002). *Revised National Curriculum Statement Grades R-9 (Schools) Mathematics*. Pretoria, Department of Education (DoE), Pretoria.

De Villiers, M.D. & Njisane, R.M. (1987). The development of geometric thinking among black high school pupils in Kwazulu (Republic of South Africa). In Bergeron, J. C., Herscovics, N. & Kieren, C. (Eds). *Proceedings of the 11<sup>th</sup> Conference of International Group for the Psychology of Mathematics Education*, Montreal, Canada, 3, 117-123.

Dorier, J. L. (nd). *Geometric Thinking Thematic Working Group 7*. European Mathematics Education. Retrieved on August 2004-08-30 <http://www.dm.inipi.it/~didattica/CERME3/>

Duval, R. (1998). Geometry from a cognitive point of view. Mammana, C.; Villani, V. (Eds.), *Perspectives on the teaching of geometry for the 21st century*. (New ICMI Study Series n. 5). Dordrecht, Holland: Kluwer, 37-52.

Ensor, P., Dunne, T., Galant, J., Gumedze, F., Jaffer, S., Reeves, C., Tawodzera, G., (2002). Teachers, Textbooks and Pedagogy: Studying Maths for All in primary classrooms. In Malcolm, C. & Lubisi, C. (Eds) *Proceedings of 10th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*, University of Durban, KwaZulu-Natal, 30-37.

- Fennema, E. & Franke, M. L. (1992). Teachers' knowledge and its impact. In Grouws, D. A. (Ed). *Handbook of Research on Mathematics Teaching and Learning*. New York: MacMillan, 147-164.
- Fischbein, E. (1993). The theory of figural concepts. *Educational Studies in Mathematics*, 24, 139-162.
- Frith, V., Bowie, L., Gray, K. & Prince, R. (2003). Mathematical Literacy of students entering First Year at a South African university. In Jaffer, S. & Burgess, L. (Eds). *Proceedings of the Ninth National Congress of the Association for Mathematics Education in South Africa*, 1, 186-193.
- Fuys, D., Geddes, D., Lovett, C., Tischler, R. (1988). *The Van Hiele model of thinking in geometry among adolescents*. Monograph Series Reston, VA: The National Council of Teachers of Mathematics.
- Gilmour, J.D. (2001). Intention or in tension? Recent Education reforms in South Africa. *International Journal of Educational Development*, 21 (1), 5-20.
- Graven, M. (2000). What Changes in Mathematics Teacher Identities are demanded by current Curriculum change in South Africa? In Mahlomaholo, S. (Ed). *Proceedings of the 8<sup>th</sup> Annual Conference of the Southern African Association for Research in Mathematics and Science Education*, University of Port Elizabeth, 158-161.
- Graven, M. (2003). Dilemmas on the Design of Mathematics Inset. In Putsoa, B., Dlamini, B. & Kelly, V. (Eds) *Proceedings of the 11th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*, University of Swaziland, 675 – 683.
- Gudmundsdottir, S. (nd). *Values in Pedagogical content knowledge*. Retrieved from the World Wide Web on the 23/09/2003 at <http://www.geocities.com/tgzaiza/pck6.htm>

- Hewitt, D. (1989). Asking Pupils to work Geometrically. *Mathematics Teaching* 126, 50-55.
- Hoffer, A. (1983). Van Hiele -based research. In Lesch, R. (Ed) *Acquisition of mathematics concepts and processes*, New York, NY Academic Press, 205-227.
- Howie, S. (1997). *Mathematics and science performance in the middle school years in South Africa: A summary report on the performance of South African students in the Third International Mathematics and Science Study (TIMSS)*. Pretoria: Human Sciences Research Council.
- Huang, H.M.E (1998). *Investigating of Teachers' Mathematical Conceptions and Pedagogical Content Knowledge in Mathematics*, Department of Elementary Education, Taipei Municipal Teachers College, Taiwan Retrieved: September 23, 2003 from: <http://www.geocities.com/tgzaiza/pck1.htm>
- Jansen, J.D. (2002). Political symbolism as policy craft: Explaining non-reform in South African Education after Apartheid. *Journal Education Policy* 17 (2).
- Jaworski, B. (1999). The Plurality of Knowledge Growth. In Jaworski, B., Wood, T. & Dawson, S. (Eds). *Mathematics Teaching In Mathematics Teacher Education: Critical International Perspectives*. London: Falmer Press, 180-207.
- Jaworski, B. & Wood, T. (1999). Themes and Issues in Inservice Programmes. In Jaworski, B., Wood, T. & Dawson, S. (Eds). *Mathematics Teaching In Mathematics Teacher Education: Critical International Perspectives*. London: Falmer Press, 125-147.
- Kennedy, M. (1990). *Trends and issues in teachers' subject matter knowledge*. East Lansing, MI: National Center for Research on Teaching Learning. (ERIC Document Reproduction Service No. ED 322 100).

Kennedy, M. (1991). Some Surprising Findings on How Teachers Learn to Teach. *Educational Leadership*, 49(3), 14-17.

Kennedy, M. (1998). Education reform and subject knowledge. *Journal of Research in Science Teaching*, 35(3), 15-263.

Kerr, D.R. & Lester, F.K. (1982). A new look at the professional training of secondary school mathematics teachers. *Journal of Education for Teaching*, 15(1), 53-56.

Kruger, C., Summers, M. & Palacio, D. (1990). INSET for Primary Science in the National Curriculum in England and Wales: Are the real needs of teachers perceived? *Journal of Education for Teaching*, 16(2), 133-146.

Lawrie, C. (1998). An Alternative Assessment: The Guitierrez, Jaime and Fortuny technique. In Olivier, A. (Ed) *Proceedings of Psychology of Mathematics Education, Stellenbosch, South Africa*.

Lee, O. (1995). Subject matter knowledge, classroom management, and instructional practices in middle school science classrooms. *Journal of Research in Science Teaching*, 32, 423-440.

Lester, S. (1996). *Overcoming the Education - Training Divide: the case of professional development Redland Papers*. Autumn 1996 1-8 from <http://www.devmts.demon.co.uk/divide.htm>

Long, C. (2003). Mathematics knowledge for teaching: How do we recognise this? In Jaffer, S & Burgess, L. (Eds) *Proceedings of the Ninth National Congress of the Association for Mathematics Education of South Africa*, UCT Baxter Theatre Complex and Rustenburg Girls' Junior School, 1, 194-204.

- Ma, L. (1999). *Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States*. Mahwah, Lawrence Erlbaum Associates.
- Malati (1999). *Mathematics learning and teaching initiative, Geometry Primary materials*. Cape Town, South Africa.
- Mayberry, J. (1983). The Van Hiele levels of geometric thought in undergraduate pre-service teachers. *Journal for Research in Mathematics Education*, 14 (1), 58-69.
- Mc Auliffe, S. (1999). An analysis of the Impact of a Geometry Course on Pre-Service teachers understanding of Geometry. Master of Education dissertation, Faculty of Education, University of Cape Town.
- McNamara, D. (1991). Subject knowledge and its Application: problems and possibilities for teacher educators *Journal of Education for Teaching* 17(2), 113-127.
- Mullens, J. (1996). The contribution of training and subject matter knowledge to teaching effectiveness: A multilevel analysis of longitudinal evidence from Belize. *Comparative Education Review*, 40(2), 139-57.
- Murray, J.C. (1997). The Van Hiele theory, Paper presented at the MALATI/ EMSCEP Geometry thinkshop, University of Stellenbosch, South Africa
- Murray, H., Olivier, A. & Human, P. (1999). Teachers' Mathematical Experiences as Links to Children's Needs. In Jaworski, B., Wood, T. & Dawson, S. (Eds). *Mathematics Teacher Education: Critical International Perspectives*. London: Falmer Press, 33-41.
- Nieuwoudt, H.D. & van der Sandt, S. (2003). How well are mathematics teachers conceptually prepared to teach for learning? A case study of grade 7 geometry. In Jaffer, S & Burgess, L. (Eds). *Proceedings of the Ninth National Congress of the Association for Mathematics Education in South Africa*, 1, 224-235.

Presmeg, N.C. (1986). Visualization and Mathematical Giftedness, *Educational Studies in Mathematics*, 17, 297-311.

Reynolds, A. (1995). The knowledge base for beginning teachers: Education professionals' expectations versus research findings on learning to teach. *Elementary School Journal*, 95(3), 199-221.

Rowland, T. (2000). Primary Teacher Trainees' Mathematics Subject Knowledge and Classroom Performance. In Rowland, T and Morgan, C. (Eds). *Research in Mathematics Education*. London: BSRLM, 2, 3-18.

SAPA- South African Press Association, (2003) in Cape Argus, 24/09/03, 6.

Samuel, M. (2002). Working in the rain: Pressures and Priorities for teacher education curriculum in design in South Africa: a case study of the University of Durban Westville. *International Journal of Educational Development*, 22 (3-4), 397-410.

Schoenfeld, A. (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognitions as driving forces in intellectual performance. *Cognitive Science*, 7, 329-363.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.

Standard VIII. (nd). *Knowledge of Content*. Retrieved 24 October 2003, from <http://www.uky.edu/Education/OFE/Standard>

Stoddart, T., Connell, M., Stofflett, R., and Peck, D. (1993). Reconstructing elementary teacher candidates' understanding of mathematics and science content. *Teacher and Teacher Education*, 9, 229-241.

- Sunday Times 2003/06/ 13, Numeracy and Literacy, Grade 3 report, 20.
- Tahta, D. (1980). About Geometry. *For the Learning of Mathematics*, (1)1, 2-9.
- Tahta, D. (1989). Is there a Geometric Imperative? *Mathematics Teaching* 129, 20-29.
- Taylor, N. & Vinjevold, P. (Eds) (1999). *Getting Learning Right*. Report of the President's Education Initiative Research Project. The Joint Education Trust. S.A.
- Thompson, A.G. (1984). The Relationship of Teachers' Conceptions of Mathematics And Mathematics Teaching To Instructional Practice. *Educational Studies in Mathematics* 15, 105-127.
- Thomson J. & Hollaway, D. (1997). Staff Development Procedures and a Culture of Collaboration in a Primary School. *Teacher Development* 1(2).
- Usiskin, Z. & Senk, S. (1990). Evaluating a Test of Van Hiele levels: A Response to Crowley and Wilson. *Journal for Research in Mathematics Education*, 20 (3), 242-245.
- Van Driel, J.H., Veal, W.R. & Janssen, F.J.J.M. (2001). Pedagogical content knowledge: an integrative component within the knowledge base for teaching. *Teaching and Teacher Education*, 17(8), 979-986.
- Western Cape Education Department (2002a). *Mathematics Course 2002: For Foundation Phase Teachers (Grade R to 3) Pilot Report*, Schools Development Unit, University of Cape Town.
- Western Cape Education Department (2002b) *Specifications for In-Service Courses for Teachers to be presented at the Cape Teaching Institute*. Directorate: Human Resource Development.
- Wilson, D. (1994). The Transference Relation in Teaching. In *Chreods* 8: 33-41.

**APPENDICES**

<b>Appendix</b>	<b>Title</b>
1.	Analysis of a Questionnaire.
2.	WCED Tender Specifications: Ref: 9/1/1/1/72
3	Teacher Questions, issues, comments and suggestions.
4.	Evaluation of Mathematics Course for Foundation Phase Teachers.

University of Cape Town

APPENDIX 1

ANALYSIS OF A QUESTIONNAIRE GIVEN TO THE PARTICIPANTS ON THE FOUNDATION PHASE COURSE IN MATHEMATICS 19 AUGUST TO 27 SEPTEMBER 2002, BEFORE THE COMMENCEMENT OF THE COURSE

There are 50 participants on the course. 46 Questionnaires were returned.

Language of instruction in your school	English	Afrikaans	Xhosa
	23 50%	21 46%	14 30%
Your home language	17 36%	22 49%	15 33%
	32 70%	14 30%	

Does your school have computer facilities?	Yes	No
	40 87%	6 13%

Highest standard passed In mathematics in school	6	7	8	9	10	School attended The respondents went to a total of 27 Schools. Not a significant statistic.
	5	7	17	3	17	
	10,8%	15,2%	36,9%	6,5%	36,9%	
Highest College qualification in mathematics	None	M+1	M+2	M+3	M+4	Institution where you qualified
	2	8	4	20	10	
	4,3%	17,4%	8,6%	43,4%	21,7	See Below

Name of the course in which you qualified:.....

HDE	DE III	PP	BA	B.Tech.	Remedial
16 34,8%	25 54,3%	3 6,5%	1 2%	1 2%	1 2%

Your present age	26-30	31-35	36-40	41-45	46-50	51-55	
	3 6,5%	11 23,9%	12 26,1%	10 21,7%	8 17,4%	2 4,3%	
Teaching experience in completed years	0-5	6-10	11-15	16-20	21-25	26-30	31-35
	3 6,5%	9 19,5%	9 19,5%	9 19,5%	8 17,4%	7 15,2%	1 2%

Good Hope	Hewat	Bellville	CTCE	Zonnebloem	Roggebaai	Wesley
7 15,2%	6 13%	6 13%	5 10,8%	5 10,8%	5 10,8%	4 8,6%
WCCE	UWC	Battswood	Boland	Cape College	Pentech	
2 4,3%	2 4,3%	1 2%	1 2%	1 2%	1 2%	

Wes-Kaap Onderwysdepartement

Western Cape Education Department

ISebe leMfundo leNtshona Koloni

DIRECTORATE: HUMAN RESOURCE  
DEVELOPMENTSPECIFICATIONS FOR IN-SERVICE COURSES FOR TEACHERS TO BE PRESENTED AT  
THE CAPE TEACHING INSTITUTE

CONDITIONS OF TENDER	DETAILS OF OFFER								
<p style="text-align: center;"><b>1. <u>BACKGROUND</u></b></p> <p>The WCED has established the Cape Teaching Institute which is dedicated to serving and meeting the ongoing needs of qualified teachers in the classroom and managers in schools. The location of this Institution is on the campus that is occupied by the Western Cape College of Education in Kuils Rivier. Tenders are required from expert service providers in the field of Teacher Education to offer courses at the Institution that are run under the auspices of the WCED.</p>									
<p style="text-align: center;"><b>2. <u>NAME OF THE INTENDED COURSE</u></b></p> <p>MATHEMATICS COURSE FOR FOUNDATION PHASE TEACHERS (GRADES R TO 3)</p>									
<p style="text-align: center;"><b>3. <u>TARGET GROUP</u></b></p> <p>Participants will be practicing Foundation Phase teachers recommended by the EMDCs.</p>									
<p style="text-align: center;"><b>4. <u>NUMBER AND DURATION OF THE COURSES</u></b></p> <p>Each course will be <u>5 weeks</u> in duration. The sessions will be run during the school terms. In 2003, <u>7</u> courses will be offered. The following are the dates for the courses:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">20 January – 21 February.</td> <td style="width: 50%;">24 February – 28 March. (DB)</td> </tr> <tr> <td>14 April – 16 May</td> <td>26 May – 27 June (DB)</td> </tr> <tr> <td>22 July – 22 August</td> <td>25 Aug – 26 Sept. (DB)</td> </tr> <tr> <td>6 Oct – 7 November. (DB)</td> <td></td> </tr> </table> <p>Participants will be expected to attend daily sessions starting at 08h00 and ending at 16h00 with appropriate breaks for lunch and tea. The expected input and involvement for the course is 7 hours each day (weekdays only).</p>	20 January – 21 February.	24 February – 28 March. (DB)	14 April – 16 May	26 May – 27 June (DB)	22 July – 22 August	25 Aug – 26 Sept. (DB)	6 Oct – 7 November. (DB)		
20 January – 21 February.	24 February – 28 March. (DB)								
14 April – 16 May	26 May – 27 June (DB)								
22 July – 22 August	25 Aug – 26 Sept. (DB)								
6 Oct – 7 November. (DB)									

CONDITIONS OF TENDER		DETAILS OF OFFER
<p style="text-align: center;"><b>5. <u>PURPOSE OF THE COURSE</u></b></p> <p>To introduce and upgrade teachers to the full understanding and practice of the Foundation Phase Mathematics Learning Area Statement of the Revised National Curriculum Statement (NCS).</p>		
<p style="text-align: center;"><b>6. <u>THE DESIRED OUTCOMES</u></b></p> <p>In the first instance an existing course needs to be adapted to ensure that the outcomes below are achieved and, thereafter, delivered. The existing course will be provided at the briefing session. The overall design needs to ensure the following outcomes for the participants:</p> <ul style="list-style-type: none"> <li>• A demonstrative <u>knowledge of mathematics content</u> in the Foundation Phase as set out in the NCS</li> <li>• The ability to develop appropriate <u>year-long work schemes</u> for each grade which include progression, integration and continuity from Grade R to Grade 4.</li> <li>• The ability to <u>teach mathematics effectively</u> within the scope of the Foundation Phase Mathematics Learning Outcomes of the NCS.</li> <li>• The ability to <u>select and design materials and resources</u> appropriate to Foundation Phase learners.</li> <li>• The ability to <u>assess mathematics effectively</u> within the scope of the Foundation Phase Learning Outcomes and Assessment standards.</li> </ul>		
<p style="text-align: center;"><b>7. <u>THE ABOVE OUTCOMES TO BE ACHIEVED WITHIN THE SCOPE OF THE FOLLOWING CONTENT</u></b></p>		
7.1 Learning Outcomes and Assessment Standards	Focus	Details of offer
7.1.1 Numbers, Operations and Relationships	<ul style="list-style-type: none"> <li>○ The meaning of different types of numbers.</li> <li>○ The relation of numbers to each other.</li> <li>○ Numbers and relative sizes.</li> <li>○ Ways of representation.</li> <li>○ The effect of operating with numbers.</li> </ul>	
7.1.2. Patterns, Functions and Algebra	<ul style="list-style-type: none"> <li>○ Describing patterns and relationships through the use of symbolic expressions, graphs and tables.</li> <li>○ Identification and analysis of regularities and changes in pattern and relationships to enable predictions and problem solving.</li> <li>○ Overall to lay the foundation for developing algebra in the senior phases.</li> </ul>	
7.1.3. Space and Shape	<ul style="list-style-type: none"> <li>○ Developing the ability to visualise, interpret, calculate relevant values, reason and justify.</li> <li>○ Interpret, understand, classify, appreciate and describe the World through 2-D and 3-D objects, their location, movement and relationships.</li> </ul>	
7.1.4. Measurement	<ul style="list-style-type: none"> <li>○ Direct and indirect estimation.</li> <li>○ Reasonableness of measurements and results.</li> </ul>	
7.1.5. Data Handling	<ul style="list-style-type: none"> <li>○ Data manipulation, representation and interpretation, including trends and patterns.</li> </ul>	
7.2 Planning	<ul style="list-style-type: none"> <li>○ Develop a year-long mathematics programme for their Grade that allows for progression and integration within and between Grades and that</li> </ul>	

<b>8. TENDER OFFER TO INCLUDE THE FOLLOWING:</b>	
<ul style="list-style-type: none"> <li>• Course outline which is a proposed amendment of the existing course.</li> <li>• Weighting of the time allocated to the various content components.</li> <li>• Intended mode of delivery by means of a separate proposal document. The service provider must indicate capacity to deliver courses in the main languages of the Western Cape.</li> <li>• Compilation of an assessment tool for assessment of participants</li> <li>• Compilation of an assessment tool for evaluation of each course</li> <li>• Itemised budget of total costs involved as well as unit cost per course</li> <li>• Tender to exclude printing of material</li> </ul>	
<b>9. CRITERIA FOR THE SELECTION OF THE SERVICE PROVIDER INCLUDE THE FOLLOWING:</b>	
<ul style="list-style-type: none"> <li>• Proven experience and knowledge in the field of Teacher Education and Training. CV's of individual course developers and presenters required.</li> <li>• A thorough knowledge of the National Curriculum Statement.</li> <li>• Experience and training in the Foundation Phase sector. CV's of course developers and presenters required.</li> <li>• Experience of a range of Foundation Phase classrooms.</li> <li>• Appropriate Curriculum Vitae of presenters.</li> </ul>	

**PAYMENT FOR SERVICES:**

- 20% on the acceptance of an approved course outline (December 2002)
- On the completion of each course (21 February; 28 March; 16 May; 27 June; 22 August; 22 September; 7 November 2003).

Tender offers must be submitted on the official tender document and deposited into the tender box on the ground floor of:

**THE WESTERN CAPE EDUCATION DEPARTMENT**  
**GRAND CENTRAL TOWERS, PLEIN STREET, CAPE TOWN**

**BRIEFING SESSION TO BE HELD AT A DATE TO BE ANNOUNCED.**

APPENDIX 3

**TEACHERS QUESTIONS, ISSUES, COMMENTS AND SUGGESTIONS**

<b>Foundation Phase Mathematics Course:</b>	
Where do you get the worksheets from? Are they available to the public?	
Will a course similar to this one be presented to the Intermediate Phase and the Senior Phase? Most courses stop at the Foundation Phase.	
Notes – will we get the notes and worksheets in Afrikaans? We will appreciate it.	✓
Is it not possible to get the revised NCS policy in Afrikaans?	
Do you want us to keep a journal on our everyday experiences? What are the questions?	
Can we focus on the critical outcomes and discuss and analyze it?	
The room that we are using is too small. A bigger room would allow us to move around a bit more.	
<b><u>The classroom and school environment:</u></b>	
Big classes are a problem: <ul style="list-style-type: none"> <li>• It makes practical activities difficult.</li> <li>• It is difficult to understand individual problems</li> <li>• How can one do problem solving with such a large class?</li> <li>• Is the ratio of 50:1 realistic?</li> <li>• It is difficult to accommodate 50+ learners in your class, when the class is built to hold 35 learners.</li> </ul>	<ul style="list-style-type: none"> <li>✓ ✓ ✓ ✓ ✓</li> <li>✓ ✓ ✓ ✓</li> </ul> <ul style="list-style-type: none"> <li>✓</li> </ul>
Payment of teachers Aids for larger classes. 50+ learners?	
I don't know exactly how to assess the learners using the levels.	
Observation during contact time – recording of this is time consuming.	
Administration: <ul style="list-style-type: none"> <li>• When and how do I do administration?</li> <li>• Lots of planning (insufficient time because of extra-mural activities)</li> </ul>	<ul style="list-style-type: none"> <li>✓ ✓</li> </ul>
OBE methods confused our learners and we don't have requirements for OBE.	
Parental involvement <ul style="list-style-type: none"> <li>• Parents don't want to involve themselves in their child's work even if you have a problem with their child. If you invite the parent to come and see you, they won't come.</li> <li>• How can I encourage the parents to be part of the child's education?</li> </ul>	<ul style="list-style-type: none"> <li>✓ ✓ ✓ ✓</li> </ul>
Homework is meaningless to our learners and their parents, even if you put them into detention.	
Absenteeism of learners	
Attitude: <ul style="list-style-type: none"> <li>• Teacher – teacher</li> <li>• Parent – teacher</li> <li>• Learner – teacher</li> </ul>	
Environment:	

APPENDIX 3

<ul style="list-style-type: none"> <li>• Not safe, crime</li> <li>• Not hygienic</li> </ul>	✓ ✓
Hours: <ul style="list-style-type: none"> <li>• The Foundation Phase educators are expected to teach in the higher grades so that the Grade 4 – 7 educators can have free time.</li> <li>• Lack of leave – longer hours – 3.30 to be increased to 5.00? “Burnt out syndrome.”</li> </ul>	
Relief teachers: <ul style="list-style-type: none"> <li>• Is it possible to have them when educators on the staff are ill for 1 – 10 days? We only qualify for substitute if the educator is ill for more than 14 days.</li> <li>• Schools that cannot pay ‘helpers’ – what are the other alternatives? Parents <b>refuse</b> to volunteer.</li> </ul>	
I have got a combined Grade 2 and 3 class. How do I cater for all my learners needs?	
<p><b>Learning, social and emotional issues:</b></p>	
<ul style="list-style-type: none"> <li>• How can you deal with a case whereby a child tells you that he can’t understand a problem and that he does not want to do it? He is not interested.</li> <li>• How do you deal with the learner who is frustrated because he has been trying to solve problems for that period and could not get them right?</li> </ul>	✓
Special needs: <ul style="list-style-type: none"> <li>• How do you accommodate the learner with special needs in the mathematics lessons? They struggle to think/reason when doing problems and sometimes their work is not really their own but merely a copy of other children’s work/answers.</li> <li>• Some learners take a long time to complete one task.</li> <li>• What do I do if some children have not completed a task and I want to move onto the next task?</li> <li>• How do I deal with my slow learners who don’t understand, even if I have tried my best to explain to them?</li> <li>• I have a class of 45 pupils. My ‘good’ learners are about 15. The rest are very slow. How do I make the 30 interested in mathematics when they get frustrated if they cannot solve a problem?</li> <li>• Learners who write numbers upside down or back-to-front. Some confuse the symbols: x and +.</li> <li>• Some of the learners have got a problem and I try to refer them to the psychologist/social worker. The process is too slow and you won’t find any solution or report back.</li> <li>• What must I do as the educator if the learner knows nothing at the end of the year – because there is a circular that says that no learner is supposed to fail the class? What is the solution? This learner is not under-age and he was doing the same in the previous grade,</li> </ul>	✓ ✓ ✓       ✓ ✓

APPENDIX 3

<p>Grade One. He took a long time to know his name.</p> <ul style="list-style-type: none"> <li>• Copying with older learners who have mathematics problems. They forge previous class reports and claim to be in the next grade. There is a lack of mathematics foundation skills.</li> <li>• What is it that cause some learners who have learning problems, not to have a problem with mathematics?</li> </ul>	
<p>Children copy and it is said that we should let them copy because they gain something from copying? Do we discourage/encourage copying?</p>	
<p>What do I do with the learners who complete their work quickly?</p>	<p>✓ ✓</p>
<p>Language:</p> <ul style="list-style-type: none"> <li>• It is required that we teach our Foundation Phase learners in their mother tongue but I feel in some learning areas e.g. mathematics, our learners (Blacks) know more of the second language vocabulary (English). Even if they go to the outside world (the workplace) the vocabulary that we have taught them is no longer there. Why should we waste time on this language issue?</li> <li>• The materials and activities available are in English so I have to write the translations on the board, by myself – so the learners can understand what is expected of them.</li> <li>• If you can, please try to have materials that have Xhosa on them.</li> <li>• <b>Try to develop all the material that can be used with the learners in English, Xhosa and Afrikaans.</b></li> <li>• My learners are Afrikaans speaking.</li> </ul>	
<p>Some learners are struggling in terms of finance. They don't have enough materials to work with and it makes it difficult for an educator to move easily and do the job quickly.</p>	
<p>How do I help a child's thinking progress from concrete to abstract?</p>	
<p>The child says the correct answer but writes the wrong one down.</p>	
<p>How do I get children who are scared of mathematics to become interested in it?</p>	<p>✓ ✓ ✓ ✓</p>
<p>How can I encourage children with no confidence to take part in the classroom?</p>	
<p>Most of the learners come to school without eating food. In the classroom he got only one or two loaves (slices??) because of the shortage of bread.</p>	<p>✓</p>
<p>Learners who do not make it in winter because they cannot go to school very early at 8, which is when it is too dark. They are unable to walk long distances in the dark. They miss the first and sometimes second periods, especially the Foundation Phase learners.</p>	
<p><b>Mathematics:</b></p>	
<p>How can I make my Grade R class more mathematically friendly?</p>	
<p>Mathematics is like 'potjiekos' a mixture of so many skills and facets. I really do feel lost at times.</p>	
<p>I am more confident with certain skills than others and would find</p>	

APPENDIX 3

myself concentrating on that only.	
In my classroom I have found that I have spent a lot of time on mathematics and it is not affecting the children's work.	
<p><u>Number:</u></p> <ul style="list-style-type: none"> <li>• How do I make numbers fun and enjoyable?</li> </ul> <p><u>Problem solving:</u></p> <ul style="list-style-type: none"> <li>• How can you do problem solving with a Grade One class with 45 pupils?</li> <li>• Learners don't like word sums. What is the cause of that?</li> <li>• The problem solving that we did, how does it affect our children in the rural areas – not stimulated?</li> <li>• How can the children solve the problem if they can't read it?</li> <li>• What worries me: word-building in Xhosa in my classroom, so that they can read word sums or problems.</li> <li>• How much time can one devote to problem solving?</li> <li>• Wording – how to put it in a way that learner's can understand.</li> <li>• Is there interaction or not? When do I get involved with a learner who is struggling and help him to solve the problem?</li> <li>• At what stage do children need to do problems – following a specific method, for in the Intermediate Phase they will be tested on it and get marks?</li> <li>• Learners cannot reason – problem solving.</li> <li>• How to structure word problems to suit the different grades?</li> <li>• How to formulate different types of questions which could lead to different types of thinking?</li> </ul> <p><u>Counting:</u></p> <ul style="list-style-type: none"> <li>• Some of the learners struggle to count on from a given number. I want to know how I can help them?</li> <li>• The child counts to 9 but points to 7 or 8.</li> </ul> <p><u>Fractions:</u></p> <ul style="list-style-type: none"> <li>• I feel my lack of experience with regards to fractions is really frustrating.</li> </ul>	<p>✓ ✓ ✓ ✓ ✓</p> <p>✓</p>
<b><u>Comments and suggestions made by the teachers – at the end of the course:</u></b>	
A further course/ follow up programmes so that teachers can share whether they were able to apply what they have learnt on the course, in their classes.	<p>✓ ✓ ✓ ✓ ✓</p> <p>✓</p>
Have each phase represented on a course like this.	
More courses	<p>✓ ✓ ✓ ✓ ✓</p> <p>✓ ✓ ✓ ✓ ✓</p> <p>✓ ✓</p>
Forming cluster/support groups (on a monthly basis).	<p>✓ ✓</p>
Courses specifically designed for this important part of the new curriculum.	

APPENDIX 3

Teachers will <u>not</u> benefit from any courses, which are held after school – “Burnt out” and “tired” teachers will not be able to get the most out of any lectures held after school.	
More courses for Foundation Phase educators in the other two learning areas.	✓ ✓ ✓ ✓
Would like a literacy course too.	✓
Wish this course could be given to other teachers. (All the teachers in the Foundation Phase should attend this course because first hand experience is the best.)	✓ ✓ ✓ ✓ ✓ ✓
Would like something like this to be extended to the whole of the Western Cape.	✓
Send the same group of teachers on a Literacy course.	
Quarterly school visits to assist us/school-based and classroom support. School-based so that all the other teachers can do this course.	✓ ✓
More remedial lessons for maths would be wonderful.	
The course was tiring.	
Have an evaluation system that is able to test whether what has been learnt on the course is being successfully applied in the classroom	
Have an evaluation mechanism to determine whether the work learnt on the course is being implemented.	✓
Student numbers for the baseline tests.	
Requested more help with planning and assessment.	✓ ✓ ✓
More about time management in large classes.	
The course was too long – rather aim for 3 weeks/ 4 weeks (from 8 – 3)	✓ ✓ ✓ ✓
Allocate 3 days for each learning outcome.	
Must be given more time – not only six weeks.	
Because of the fullness of the school’s programme, I think school-based support would also impact negatively on schools.	
The quality of the certificates could have been better.	
It would be better if all the presenters were familiar with the Foundation Phase.	✓
I would like the course presenters to stick to the Foundation Phase and include Grade 4 and a little of Grade 6. That way the course would be more beneficial for us and less time consuming.	
Timing of the course is good. But I think you have left out the subject advisors and the deputy principals of the foundation phase.	
Did not have to worry about my learners at school. I could focus all my attention on the course.	
We would like contact numbers so that we can phone if we need help. Would like more support from the presenters in future.	✓
The course was an eye opener. Not only the subjects and content but also that children need to learn in their mother tongue.	
Something needs to be done about our large classes.	

APPENDIX 3

Choose a venue in the area.	
It cost a lot of money to attend this course because I am from out of town. Had to pay for petrol and accommodation.	
Die feit dat van ons so ver moes reis om die kursus by te woon het ook nie 'n positiewe uitwerking of families nie.	
Next time arrange transport money of the venue is still Kuilsriver.	✓
This course has been the most excellent well organised and educational sound one that I have teen to in the last 30 years of teaching.	

University of Cape Town

## Evaluation of Mathematics Course for Foundation Phase Teachers

### A. CONTENT

#### 1. Shift in your own content knowledge.

Indicate whether there has been an improvement in your mathematical content knowledge required for the different learning outcomes.	Yes	No	Specify what new content you have learnt.
Numbers , operations and relationships			
Patterns , functions, algebra			
Space and Shape			
Measurement			
Data Handling			

#### 2. Do you think your new content knowledge has given you new insight into the different learning outcomes ?

Numbers , operations, relationships	Yes	No
Patterns, Functions, algebra	Yes	No
Space and Shape	Yes	No
Measurement	Yes	No
Data Handling	Yes	No

APPENDIX 4

3. Give an example of how the new content knowledge that you have acquired will influence your teaching in the Foundation Phase.

<b>Numbers , operations and Relationships</b>
<b>Patterns, functions, algebra</b>
<b>Space and Shape</b>
<b>Measurement</b>
<b>Data Handling</b>
<b>Learning programme design (Planning ; Assessment; Classroom Practice/Methodology)</b>
<b>Cognition</b>

APPENDIX 4

4. What content do you feel was omitted in the different mathematics learning outcomes?

Course Outcome	
Numbers , operations and Relationships	
Patterns, functions, Algebra	
Space and Shape	
Measurement	
Data Handling	

5. Has this course enabled you to understand and implement the Mathematics Learning Outcome as stated in the NCS for the Foundation Phase? Give an example for each of the following categories:

Content	Yes	No	
Assessment	Yes	No	
Planning	Yes	No	
Classroom Practice / Methodology	Yes	No	
Cognition	Yes	No	

APPENDIX 4

**B. TIME**

6. Time allocated to the content delivered. Tick the appropriate box.

Course Outcome	Sufficient time	Needed more time	Too much time
Numbers , operations and Relationships			
Patterns, functions, Algebra			
Space and Shape			
Measurement			
Data Handling			
Learning Programme design			
Cognition			

7. If you were to design this course for teachers, how much time would you allocate to the different categories? Express this as a percentage. (Remember your total must be 100%).

Content	
Assessment	
Planning	
Classroom Practice / Methodology	

**C. PRESENTATION**

8. Indicate how much time was allocated to the various kinds of interaction in the course. Indicate the time allocated as a percentage of the total time for the different learning outcomes. (Note that the sum of the three kinds of interaction must total 100%).

Course Outcome	Nature of interaction		
	Discussion with colleagues in groups	Posing questions to the whole class by participants	Posing questions to the lecturer on a one-to-one basis
Numbers , operations and Relationships			
Patterns, functions, Algebra			
Space and Shape			
Measurement			
Data Handling			
Learning Programme design			
Cognition			

9. Which of the interactions mentioned in Question 8 do you feel could have been allocated more time? Tick in the appropriate box.

Course Outcome	Nature of interaction		
	Discussion with colleagues in groups	Posing questions to the whole class by participants	Posing questions to the lecturer on a one-to-one basis
Numbers , operations and Relationships			
Patterns, functions, Algebra			
Space and Shape			
Measurement			
Data Handling			
Learning Programme design			
Cognition			

APPENDIX 4

**D. PRESENTERS**

10. Rate the presenters in each of the following categories:

Please tick in the appropriate block.(Note : G- Good ; S – Satisfactory;  
U- Unsatisfactory)

Course Outcome	Presenter/s	Knowledge of Mathematics Content			Knowledge of NCS & Methodology		
		G	S	U	G	S	U
Numbers Operations and Relationships	Hanlie						
	Cally						
	Shaheeda						
	Yusuf						
Patterns; Functions;Algebra	Rolene						
Space and Shape	Hanlie						
	Gabeba						
	Cally						
	Agatha						
Measurement	Cally						
Data Handling	Agatha						
	Gabeba						
Planning	Lydia						
	Jaamiah						
Cognition	Lydia						

APPENDIX 4

10. Did the presenters offer you situations that challenged your mathematical knowledge? (Please tick in the appropriate block).

Learning Outcome	Presenter /s	Yes	No
Numbers , operations and Relationships	Hanlie		
	Cally		
	Shaheeda		
	Yusuf		
Patterns, functions, Algebra	Rolene		
Space and Shape	Hanlie		
	Gabeba		
	Agatha		
	Cally		
Measurement	Cally		
Data Handling			

11. Did you find these mathematical challenges useful for the teaching of mathematics at the foundation phase? Explain.

12. Did you receive the following on the course:

Learning Outcome	Course Notes		Teaching resources	
	Yes	No	Yes	No
Numbers , operations and Relationships				
Patterns, functions, Algebra				
Space and Shape				
Measurement				
Data Handling				
Planning				
Cognition				

13. Do you think that the course notes and teaching resources were useful?  
Give an example.

**D. FOLLOW UP**

14. In which of the following categories do you need further support?  
(Tick in the appropriate block).

<b>Numbers, operations and relationships</b>	
<b>Patterns, functions , algebra</b>	
<b>Space and Shape</b>	
<b>Measurement</b>	
<b>Data Handling</b>	
<b>Assessment</b>	
<b>Planning</b>	
<b>Methodology</b>	
<b>Cognition</b>	

15. How would you like the to have the support offered?

For example; More courses or School-based and Classroom support.

Comment.

APPENDIX 4

**E. MANAGEMENT and ADMINISTRATION**

**16. Did you find the support staff (Sharon Stevens) helpful?**

**Comment.**

**17. What other comments would you like to make about the course?**

University of Cape Town

**THANK YOU**