Science and Mathematics Education Centre

Mathematics Teacher Learning in the Context of South African Outcomes-Based Education Reforms

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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature:

Date:
ABSTRACT

The new South African national curriculum for the twenty first century adopted an outcomes-based education approach. The new curriculum represents a crucial shift in emphasis from learners concentrating on formal and procedural mathematics (with an absence of meaning) to learners making meaning of mathematics and becoming flexible mathematical thinkers, with problem solving and mathematics investigations as central focus.

This study reports on an action research collaboration between two teachers and myself, a university mathematics educator. It was conducted over a period of three years. The main purpose of our collaboration, and this thesis, was to explore mathematics teacher learning in the context of the OBE-based reforms. The data were gathered through questioning, journal keeping by the two teachers and my participant observations. Using the two teachers’ reflective writings and field notes I analysed the data in two stages - narrative analysis and analysis of narratives. What emerged from the study were several issues clustered around three characteristics of teacher learning - teacher learning as situated, teacher learning as social and teacher learning as distributed. These three overlapping characteristics of teacher learning were used as heuristic devices or convenient organisers for the description, analysis and discussion of the issues that emerged.

This study revealed several overarching propositions that may have applicability beyond its boundaries. The first proposition is that teachers reflect on and revise their personal practical knowledge if exposed to learning experiences that encourage them to attach meaning to and make sense of the underlying concepts of new curriculum reforms. The second proposition is that interactions with literature improve the quality of teacher learning. The third proposition is that teachers are motivated to experiment with new ideas if they observe these ideas being modelled in practice. The fourth proposition is that teachers develop positive perceptions about learning if the expectations of multiple stakeholders (both in their classrooms and beyond the classrooms) are not contradictory. The fifth proposition is that teachers’ listening to learners’ thinking opens opportunities for explorations. The sixth proposition is that
teachers respond to learners’ learning by being more curious about classroom discussions. The seventh proposition is that teachers who play an active role in collaborative working relationships are more likely to revise their pedagogy. The eighth proposition is that true collaborative relationships take time. The last proposition is teachers who are supported are more likely to distribute their knowledge and learning. Some implications of this study are also highlighted in the last chapter.
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Kenny, your support was more than I thought it would be – ever growing, ever loving. Thato, Theto and Thekgo, for your perseverance when I was away, sometimes for months.

Gerty and Joel, you deserve a pat for our collaboration and support. It made and will continue to make a difference in our lives and the mathematics community. To your learners, a big thank you for their classroom participation.

Kwena, we fought and we will continue to fight the academic struggle.

Colin and Dianne Wood-Robinson, I am not sure whether you still remember the interview you once conducted for a Primary INSET/PRESET coordinator position. The question you asked me and the other applicants was: What would be the theme of your first workshop if you get the post? My response to your question turned out to be another milestone in who I am today. Although I thought I was going to help educators grow professionally, after completing the writing of this study I realised I learned to reflect together with the two teachers, Gerty and Joel. We were equals in the learning. Reflective practice through journaling is powerful.

Doctor Mathume Bopape, I will never forget where I come from – meeting you first as my ‘senior phase’ educator; then NOTMO; to Leeds University for an in-service course in mathematics education; to PMP and AMESA; back to Leeds Master’s programme in mathematics education; to Technikon South Africa; to MASTEC; to University of the North; to Curtin University in Perth – the journey continues.

Doctor Kopano Taole, if it had not been for you, my name would still be on the waiting list.

Professor John Wallace, my supervisor, you know how much work was involved in this thesis. It remains for you to write a book on researcher learning. I remember trying to explain with confidence how I attacked literature on teacher learning, not realising that I was using the concept synonymously with professional development.
I insisted that I understood what I was talking about. That was frustrating to you, I think. But, that was the day I learned more. I learned to read and re-read to attach deeper meaning to concepts. The motivation you gave me, not by telling but by listening, will never stop – I will continue writing and publishing. Thank you so much for your patience and critical sharing.
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CHAPTER 1

INTRODUCTION

This chapter gives an overview of what this study is about. I start by describing how the three participants entered into the study: Gerty, a female secondary school teacher; Joel, a male primary school teacher and me, a female university educator. Thereafter I briefly outline my interpretation of the new South African national curriculum. This is followed by the outline of the study. Lastly, I highlight the significance of the study.

Entry into this study

I pursued this study from the year 2000 entering as the mathematics educator of a newly established college of mathematics, science and technology education, abbreviated as MASTEC. The MASTEC initiative was a four-year project which sought to transform the approach to mathematics, science and technology education in the Limpopo Province of South Africa. It was a direct response to the President’s Education Initiative to improve the quality of teaching, building on the national policy for better schooling through institutional development, teacher education and implementation of a new national curriculum. Its pre-service (PRESET) component started operating in 1997 and the in-service (INSET) component (later referred to as MASTEC Schools Project or MSP) started from the beginning of 1998 with a group of 28 schools in the three districts of Limpopo Province. Twenty two (22) of these schools were secondary schools, and one of the participants was Gerty, a female secondary school teacher from Mogodumo district. Of the six primary schools in the project, Joel’s school which is situated in Mankweng district was not selected to take part.

At the beginning of the second year (1999) a further group of primary schools (19) was added to the initial 6 and again Joel’s school was not selected. At the beginning of the third quarter of 1999 Joel visited my office to request that his school be taken on board. I was involved then in the project as the primary PRESET/INSET coordinator. At this time, we (the Project Advisor, Project Manager and I) decided to
informally allow him just to attend workshops. At the beginning of the year 2000 the secondary schools were dropped from the project following a review. The work of the project was re-orientated for its fourth and final year with the focus being on primary schools. At this time, Joel’s school was then formally considered to be part of the MASTEC Schools Project (MSP).

Also in 2000, whilst still the primary PRESET/INSET coordinator, I coordinated and facilitated a two-year Further Diploma in Education (FDE)—Mathematics franchised with Rhodes University and 30 teachers were subsidised by MASTEC Schools Project to register. Gerty and Joel registered for the part-time FDE program (now called Advanced Certificate in Education or ACE) specialising in mathematics. Engaged with the two study teachers as one of their facilitators of the FDE program, I requested them to take part in this study and they agreed. The first FDE module that I facilitated on ‘philosophy of mathematics education’ was designed in such a way that the secondary teachers and the primary teachers were taught at the same time. At the beginning of April 2000 I left MASTEC to take up a lectureship post at University of the North. This did not break ties with Gerty and Joel as I continued coordinating and facilitating the MASTEC/Rhodes FDE.

Gerty and Joel satisfied the requirements of the FDE program at the end of February 2002. In addition, while collaborating with me, they were also attending OBE workshops run by district officials (mostly lecturers from the rationalised Colleges of Education). However, this district-based program was not entirely successful and was supplemented by a new program sponsored by the National Department of Education called Science and Mathematics Education Program (SMEP). University of the North in the Discipline of Mathematics, Science and Technology Education (the discipline in which I was attached) and the University of the North Foundation Year program (UNIFY) took care of that SMEP program, offered during school holidays and weekends. Gerty, excited by our previous and ongoing collaboration, decided to join in to learn more about designing rich mathematics activities and issues of educational policy.
The national curriculum

The new South African national curriculum for the twenty first century brought changes based on an outcomes-based education approach, with constructivist underpinnings (Department of Education, 1997). It reflects a crucial shift in emphasis from learners concentrating on formal and procedural mathematics, with an absence of meaning, to learners making meaning of mathematics and becoming flexible mathematical thinkers with problem solving and mathematics investigations as central focus. According to the new curriculum, classes are to be presented with problems or investigations that will allow learners to explore the topic and develop their own understanding and algorithms.

The type of teachers envisioned are those that will, for example, play the role of instigator, the role of enabler, the role of facilitator, the role of listener, the role of questioner, the role of positive assessor, and the role of participant observer. These kinds of roles are what Pirie (in Frobisher, 1994) discusses as the teacher’s role in a problem-centred classroom. Under this view, there is a need for less exposition teaching, less teacher-talk, more listening to learners and careful selection of tasks to encourage inquiry. The central aim is not only to increase the general knowledge of the learners, but also to develop their skills, critical thinking, attitudes and understanding (Bengu, 1997) The focus is not only on what is learned, but how it is learned - the process of learning becomes just as important as the product. Thus, there is a strong need to ensure the inter-relatedness of the mathematical processes, the mathematical themes and the learning situations, if they are not to be artificially separated into 'topics' to be taught.

The kind of classroom implied is one with an atmosphere of negotiation, cooperation, involvement, shared control, cohesiveness, investigation, freedom of expressing critical opinions and equity. Hence, one of the major challenges that this curriculum brought is to re-focus mathematics education in a way that will undo the damages inflicted by South Africa's past as well as to empower all the citizens.

From the above, there is no doubt that the kind of teaching envisioned is significantly different from what many of us as teachers have experienced as students in
mathematics classes. Although as teachers we express fears about making mistakes, being criticised, disturbing traditions and making changes, action has to be taken. The caution would seem to be that presenting teachers with a new curriculum, particularly one which demands new approaches and broader subject understanding, whilst not making adequate preparation for its implementation, is a recipe for disaster. It is also important to note that principles that go along with the new teaching approach might be accepted in theory but very often they are not put into practice.

**Outline of this study**

This study explores mathematics teacher learning in the context of the South African OBE-oriented reforms. Guided by this broad purpose, I started with some questions of interest that kept crossing in my mind. These included: What are teachers’ views regarding the characteristics of exemplary teaching in an OBE environment? What are the critical factors for initiating change in mathematics teachers’ instructional practice in the South African OBE context? and What and how do other contextual factors impact on the process of becoming a mathematics teacher in this OBE environment?

Over the period of the study, these early questions of interest were changed and refined, eventually coalescing around the three features of teacher learning which emerged from my literature review. Thus the study is, in many senses, emergent in character.

**Thesis structure**

This thesis is organised into seven additional chapters as follows:

Chapter 2: The literature review addresses four questions: What is the philosophy behind the OBE reform? What are the contexts in which the two study teachers work? What is the nature of teacher learning? and How can teacher learning be enhanced and supported? Following each question, I respond to the literature to draw personal meaning about each question.
Chapter 3: The methodology and methods chapter provides an overview of how the study was conducted. It comments on six sections: study design (including issues of the participants and setting), data gathering techniques, data analysis, access, ethical considerations and quality criteria.

Chapter 4: This chapter presents the case of Gerty. It is designed to highlight Gerty's learning as it unfolded during this study. To organise my description and analysis I use, as a heuristic device or convenient organiser, the three characteristics of teacher learning that I identified in the literature review chapter. These three characteristics are teacher learning as situated, teacher learning as social and teacher learning as distributed. It should be noted that these characteristics overlap. I show how Gerty's learning unfolds in three stages: ideas and instructional practice early in the study, ideas and instructional practice during our collaboration, and ideas and instructional practice at the end of our collaboration.

Chapter 5: This chapter presents the case of the second teacher Joel and it employs a similar format to the previous chapter.

Chapter 6: The discussion chapter highlights issues that emerged from the two case studies of Gerty and Joel. These issues are organised and discussed using the following seven key questions: How is teacher learning situated within the specific and critical outcomes listed in the new South African outcomes-based education (OBE) curriculum? How is teacher learning situated within the constructivist views that are implied by OBE? How is teacher learning situated within the contextual factors experienced by the two study teachers? How is social interaction facilitated in the classroom setting? How is social interaction facilitated when a teacher is engaged with other teachers? How is social interaction facilitated between the teachers and me (as a collaborator)? How is teacher learning distributed across a wider community who employ artefacts or tools that teachers come to share? While recognising that the answers to these questions may overlap and intersect, nonetheless, they provided me with some useful starting points in examining my understanding of the learning of these two teachers.
Chapter 7: This chapter presents nine overarching propositions arising from the two case studies and the discussion.

Chapter 8: The final chapter presents a summary of findings, implications, further research and my reflections.

Significance

Given the large scale of the South African educational reforms and the challenges provided by under-resourcing, it is important to investigate the processes of teacher learning and change, and the impact on classroom practice. While it is hoped that the study will be of wider significance, the three participants (myself included) have undertaken action research to enhance our own learning and learners’ learning, and develop our collaborative skills and reflective practice. Through this study, we have made personal sense of what teacher learning and OBE-oriented reforms entail. We hope that others will find this study informative. What I initially thought were little questions in teaching tended to be big challenges worth pursuing. Questions such as: ‘What really counts most in mathematics teaching?’, ‘If, through teaching mathematics, I want to give the learners in my classroom just one or two important things, what would I give them?’, ‘What is it that causes some learners to be so interested or not interested in mathematics?’, ‘How can I facilitate learning in such a way that all learners become curious and self-critical citizens who are able to participate creatively and critically in their social world?’, and ‘How can I make my teaching of mathematics contribute to the development of reflective and aware learners?’ Each of these questions is connected to the nature of (mathematics) teacher learning. This study could also assist those interested in tracing some if not all of these questions. It is up to the individual reader to identify what she or he regards as deeply important.
CHAPTER 2

LITERATURE REVIEW

This study explores mathematics teacher learning in the context of the South African OBE-oriented reforms. In the first part of the literature review, I address two contextual questions: What is the philosophy behind the OBE reform? and What are the contexts in which the study teachers work? In the second part of the literature review, I examine the theme, teacher learning, focusing on the questions: What is the nature of teacher learning? and How can teacher learning be enhanced and supported?

In this chapter I address each of the four questions in turn drawing on my reading of the appropriate literature. Following each question, I respond to the literature to draw personal meaning about each question. I conclude the chapter by drawing together the arguments to guide my thinking, actions and analysis for the rest of the thesis.

What is the philosophy behind the OBE reform?

The design of the new South African national curriculum has been influenced by the philosophy of progressive learner-centred education, outcomes-based education (OBE) and an integrated approach to what is to be learnt. The central organising concept is outcomes-based education (Lubisi, Wedekind, Parker & Gultig, 1997) which is seen as “in essence ... defining, organising, focusing and directing all aspects of a teaching system in relation to what we want ALL learners to demonstrate successfully when they exit the system...” (Chisholm, et al., 2000, p. 21). Defined simply by Spady (1996), OBE means education is to be based on the outcomes (or learning results) that all learners should be able to demonstrate successfully. Thus values, beliefs, attitudes, and self-concept are not really outcomes in their own right because they are covert (innate) in a person and outcomes require that individuals clearly demonstrate knowledge and competence. Put by Spady, the key elements of genuine outcomes-based models always have clarity of focus (on outcomes of significance), designing back (from ultimate outcomes), high expectations (for high-level performance), expanded opportunity (for learning
success), and success for all clearly in place. Having missing elements doesn’t necessarily make educational practices “bad” – it just makes them different from what OBE is (Spady, 1996).

In South Africa, Spady’s ideas have been adapted to describe the country’s version of outcomes-based education. In the revised National Curriculum Statement for Grade R-9, it is postulated that outcomes-based education:

- Is developmental; it encompasses both what learners learn and are able to do at the end of the learning process.
- Emphasises high expectations of what all learners can achieve.
- Is a learner-centred educational process.
- Though its outcomes at the end of the learning process shapes the learning process itself – the process of learning is thus considered as important as what is learnt.
- Is an activity-based approach to education designed to promote problem-solving and critical thinking. (Department of Education, 2001a)

The Department of Education’s Teacher’s Manual for Grade 7 (n.d.), asserts that OBE is described as what (outcomes) and whether learners are learning well as more important than when and how they learn it. Thus, planning ‘back’ from outcomes is regarded as a central aspect of the methodology. The South African OBE guiding principles relating to curriculum design include: human resource development; learner-centredness; relevance; integration; differentiation, redress and learner support; nation-building and non-discrimination; critical and creative thinking; flexibility; progression; credibility and quality assurance (Lubisi, et al., 1997).

The National Curriculum Statement does not list the facts to be learnt in a narrow syllabus format. Nor does it specify teaching method. It is the responsibility of schools and teachers to develop and detail learning programmes of activities (Department of Education, 2001a). However the National Curriculum Statement states that, in mathematics as a learning area, access is a human right in itself, and is not value- or culture-free (Department of Education, 2001a). In teaching
mathematics, teachers have to incorporate contexts that can build awareness of human rights, and social, economic and environmental issues relevant and appropriate to learners' realities (Department of Education, 2001a). Mathematics, according to departmental documents, is defined as:

the construction of knowledge that deals with qualitative and quantitative relationships of space and time. It is a human activity that deals with patterns, problem-solving, logical thinking, etc., in an attempt to understand the world and make use of that understanding. This understanding is expressed, developed and contested through language, symbols and social interaction. (Lubisi, et al., 1997, p.2)

This definition suggests that mathematical knowledge should not be absolute, superhuman, remote and inaccessible. Embedded in the definition is the social nature of mathematics with emphasis on both mathematical processes and products. Mathematics is seen as an extension of natural language and, as a language, is acquired and developed through social interaction.

Alongside the critical mathematics outcomes, the new curriculum represents a crucial shift in emphasis from learners concentrating on formal and procedural mathematics (with an absence of meaning) to learners making meaning of mathematics and becoming flexible mathematical thinkers, with problem solving and mathematics investigations as central focus. There is a warning in the Report of the Review Committee on Curriculum 2005 (Chisholm, et al., 2000) that theme or activity-directed lesson development is simply not a reliable guide to systematic coverage of content in concept-driven learning areas. When the content required for higher level skills is omitted, and then the omission becomes critical.

A close analysis of both the critical outcomes and the specific outcomes of mathematics outlined in the curriculum documents could tempt one to say that in South Africa mathematics was not for everyone but for a few super-intelligent beings with mathematical minds (Ernest, 1996), mostly males. For example, a commonly used series of primary school textbooks, Understanding Mathematics 5, selects boys rather than girls as already competent student-pedagogues (Davis, 1997).
found that the illustrations of activities show that boys teach most of the time, animals (dogs and birds) sometimes teach, and that girls never teach. This textbook is still used in the final year at primary school.

A question that could be tempting to ask is: Is it possible and proper to address and thus redress the wrongs of the past within the framework of mathematics education? The African National Congress (ANC) has made a policy commitment to "redress and access" (A Policy Framework for Education and Training, 1994, p.3) for all who wish to study mathematics. The new education system is aimed at equality for all. Mathematics teachers are therefore directly challenged to provide the necessary reconstruction processes, to use the learning of mathematics as a means of redressing imbalances within the current society. It is expected that individuals should be empowered to carry out mathematical calculations and analysis, but, more importantly, to interpret these and to act on this interpretation.

Mathematics anxiety, feelings of failure and the inability to effectively use mathematical skills to interpret reality are products of the construction of school mathematics as a high status, inaccessible knowledge area in South Africa (Adler, 1991). Thus one of the recent challenges in reforming mathematics teaching includes instructional practice that will combat elitism, racism and sexism. There is a push to democratise knowledge so that it will contribute towards the development of equal opportunities and choice. Two essential aspects of such democratisation are that education must be accessible to all the people of South Africa, and education must be relevant to the economic, social and political activities of its participants.

Given the absolutist ideology that mathematics is only for some, there is a complex interplay of factors in the democratisation of mathematics (Adler, 1991). According to Adler democratisation includes attacking authoritarianism and implies questioning the curriculum, including what is taught (and thus valued as mathematical knowledge), and how this is taught and then assessed. Carolus (1993) also concludes that:

... to build an education system, that will be accessible to every single woman and man in this country, that education needs to be equitable and possible for everybody.
it needs to be an important vehicle which will enskill, empower our people to become meaningful participants in a society which is democratic, non-racial and non-sexist (p.10).

In South Africa, there is an expectation that teaching should contribute towards the wider development of different cultures. This idea replaces the previous notions of a single dominant class with a need for "cultural collaboration" instead of "cultural invasion" (Slammert, 1991, p.74). The use of culture in teaching is thus included, for it influences the way people see things, perceive things and understand concepts. One of the innovations associated with a fallibilist view of mathematics is a reconceptualised view of the nature of mathematics. Mathematics is associated with sets of social practices, each with its history, persons, institutions and social locations, symbolic forms, purposes and power relations (Ernest, 1996). Mathematics is thus cultural knowledge, like the rest of human knowledge (Ernest, 1999). As Fasheh (1982) puts it:

If culture determines the way we see a camel, and the number of colours that exist, and how accurate our perception of a certain concept is, may it not also determine the way we think, the way we prove things, the meaning of contradiction, and the logic we use?!... Teaching math in a way detached from cultural aspects, and in a purely abstract, symbolic and meaningless way is not only useless, but also very harmful to the student, to society, to math itself and to future generations. (p.6)

Fasheh stressed that it should not be understood from the above that mathematics should or could be taught within one culture separate from other cultures. Advances in thought in one culture, he suggested, should be understood and welcomed by other cultures. But these advances should be "translated" to fit the "borrowing" culture (Fasheh, 1982, p.6). In other words, what Fasheh is emphasising here is that it is acceptable to import ideas and that should be encouraged, but the meanings and implications of these ideas should be "locally made". He also pointed out that "not only local and cultural meanings should be encouraged, but also personal feelings and interpretations" (Fasheh, 1982, p.6). What he seems to be emphasising here is the role of context in mathematics teaching.
The central aim of the new South African curriculum (C2005) is not only to increase the general knowledge of the learners, but also to develop their skills, critical thinking, attitudes and understanding (Bengu, 1997). The focus is not only on what learners learn, but how they learn – the process of learning becomes just as important as what is learned. According to C2005, there is a strong need to ensure the inter-relatedness of the mathematical processes, the mathematical themes and the learning situations if they are not to be artificially separated into new ‘topics’ to be taught. There should be the promotion of both conceptual coherence and integration (Chisholm, et al., 2000, p. 21). Implicit in all of these is that the success of outcomes-based education depends centrally on the quality of the teachers – their content knowledge, their facility with different teaching strategies, and their access to learning programmes and textbooks.

**My response**

My interpretation of the principles guiding the new South African OBE-based curriculum convinces me that the philosophy underpinning the curriculum reform reflects a constructivist perspective of learning. It is clear to me that the OBE approach to teaching has shifted its focus from teacher-centred to learner-centred. The process of learning is as important as what is learned (product). In mathematics, in particular, I could say that the emphasis is placed on construction of knowledge and development of skills: pattern investigations, problem solving, logical thinking, investigations, critical thinking, communication, reasoning, and mathematical connections. Emphasis is also placed on the practice of mathematics and the human side of mathematics. When mathematics is defined as a human activity, I interpret that as implying that it is taken as a language developed by humans to describe their observations of the world. Thus mathematics is viewed as the outcome of social processes and has both a “front and a back” (Hersh, in Ernest, 1996). Access to mathematics is recognised as a human right in itself, and is not value or culture free. To generate and warrant knowledge, skills, critical thinking, attitudes and understanding as implied in the curriculum documents, I conclude that indirectly what is proposed is a social constructivist or problem-solving philosophy of mathematics.
In describing the reform, the designers seemed to understand that constructivism does not correspond entirely with particular teaching methods, for example, discovery learning or problem solving. Use of a variety of different teaching and learning strategies is encouraged and by this the designers hoped to accommodate and allow learners more time and space to construct and negotiate their knowledge. My understanding of the teachers’ role is that there will need to be less exposition teaching, less teacher-talk, more listening to pupils, and careful selection of tasks to encourage inquiry. I see the need for teachers to move towards more open pedagogical styles in which the teacher becomes a helper in the task of building up the learner’s own mathematical knowledge and this, I would argue, requires a major shift in the teacher’s view of what is appropriate and possible.

What are the contexts in which the two study teachers work?

Some statistics on the education system in South Africa drawn from Edusource (1993, 1994) reveals that although 98% of white teachers are properly qualified (with at least Grade 12 plus 3 years of professional teacher training), only 37% of African teachers are similarly qualified. Of the remaining 63% of African teachers, 12% have no professional qualification and 51% are under-qualified, having either less than Grade 12 or less than 3 years training (Edusource, 1993). A report published by Edusource in 1997 found that most mathematics and science educators were not qualified to teach these subjects (in Department of Education, 2001b). Although 85% of mathematics educators were professionally qualified as educators, only 50% had specialised in mathematics in their training. An estimated 8 000 mathematics educators needed to be targeted for in-service training to address the lack of subject knowledge (Department of Education, 2001b). These large numbers of under qualified teachers cope valiantly in under-resourced and overcrowded schools and inevitably rely on their own authoritarian and transmission-type learning experiences to inform their teaching. Also, the National Education Policy Investigation NEPI (1993, p.237) reveals that the majority of South Africa’s teachers have been trained in racially segregated colleges of education, most of which are "academically isolated, small, poorly equipped and ineffective in the provision of quality teacher education".
The 1995/1996 Limpopo Province (then called Northern Province and it is where this research study has taken place) Needs Survey revealed that nearly half the schools in the province were still under-resourced (Hartley, Visser & Sheppard, 1998). Some of the resources investigated are described in the graphs below:

![Graph showing conditions of learning resources in primary and secondary schools in Limpopo Province.](image)

**Figure 1: Conditions of learning resources in primary and secondary schools in the Limpopo Province (Hartley, Visser, & Sheppard, 1998)**

Figure 1 shows that 27% of the schools were without any cupboards/cabinets in the classrooms, 54% were inadequately provided with such furniture, while only 19% of the schools had an adequate provision of cupboards/cabinets for the classrooms. With regard to desks and chairs for educators, 13% of the schools had none (teachers then have to use one or more of the learners' desks) and in 43% of the schools provision was inadequate, while 44% of schools had an adequate supply. The situation with regard to desks and chairs for learners was virtually the same: 14% of the schools had none, 43% had an inadequate supply while 43% reported an adequate provision. The two resources in fair supply at the time of the survey were textbooks (47% of schools reported an adequate provision, 50% an inadequate provision, 3% had none) and stationery (46% had adequate supplies, 47% had inadequate supplies, and 7% had none). Of the schools that reported having none of these resources, 115 had no textbooks and 260 had no stationery. The other resources investigated were in extremely poor supply with 95% of the schools in the Limpopo Province lacking media equipment, 91% lacking media collections, and 73% lacking materials. Of the
through unequal learning resources and educational facilities allocation. We are all aware that you cannot teach without making use of resources of one kind or another. Whether it is a highly structured piece of equipment, a textbook or simply the classroom in which you work, all are resources and the way that a teacher and the children make use of them has implications for the style of teaching and the quality of learning that takes place (Goodwin, 1987).

Johnson, Monk and Hodges (2000, p. 180) comparing the conditions in South African schools commented that “the bricks and mortar of the places in which the curriculum is to be delivered cannot be transformed as easily as one can change the ink on a draft of a curriculum document”. Comparatively speaking the schools that were previously white only, known as ‘Model C’, are quite different from schools that were (and still are) historically disadvantaged. They have good facilities and resources. Curriculum reform under these types of conditions becomes an even more complex endeavour because it has many facets including (a) the development of teaching materials, (b) the identification of appropriate instructional approaches, (c) the implementation of processes by which these new materials and approaches will be introduced into practice and sustained, and (d) the appropriate attention to the social context in which it all occurs (Anderson, 1992).

My response

Mathematics requires thorough or proper planning of rich activities before presentation. For quality learning, I think school contexts should include a comfortable working room (office or proper staff room), working surface (desks and chairs), cabinets for storage purposes, relevant textbooks for reference purposes, sufficient time and direct social influence (through students, other staff members or even parents). In many parts of Limpopo Province, because of no or insufficient learning resources and basic facilities such as those hinted above, educational reforms are more challenging, if not demanding, to teachers. The learning climate, I claim, strongly influences such things as self-esteem, motivation, discipline, and expression, as well as achievement. This works the same way for both teachers and learners.
The classroom contexts that offer both teachers and learners opportunities for a range of teaching and learning styles are also necessary. I include factors such as, class sizes (manageable versus overcrowded classrooms), desk spaces, space to move around the room, sufficient learning materials and writing materials such as exercise books, pens, pencils and mathematical instruments. If factors such as these are not catered for, I think, that would hamper knowledge construction because certain skills (e.g. experimenting, fruitful discussions) cannot be fully attained in an overcrowded classroom for example. I maintain it is hard to work in an uncomfortable physical environment of the classroom, something that as teachers we have no greater control over. In the majority of schools I have observed, you would still find a hard floor and corrugated roof without a ceiling (the roof itself in certain cases does leak).

The statistics drawn from Edusource 1993, 1994, and 1997 reveals that in South African schools one would find a combination of teachers with different subject content knowledge (ranging from weak to strong) and different pedagogical content knowledge depending on where they received their training. Many teachers of mathematics have no formal training in the subject. In the South African context the teacher's environment is also constituted by curricula that require acts of interpretation. This demand to interpret the curricula becomes the added constraint on the teacher. That is, the constraint on the teacher becomes more interpretative rather than physical.

What is the nature of teacher learning?

Current reform in mathematics teaching, as outlined in the new OBE curriculum documents, call for radical changes in teachers' knowledge and beliefs about subject matter, teaching, children, and learning. Teachers are challenged to examine and expand their mathematical and pedagogical understandings and thus revisit what Van Driel, Beijaard and Verloop (2001) referred to as "practical knowledge".

Over the years, in the context of the classroom, teachers construct "personal practical knowledge – the integrated set of knowledge, conceptions, beliefs, and values" – which greatly influences their practice and how they respond to educational change (Van Driel et al., 2001, p. 141). Rarely do teachers make that knowledge explicit to
themselves or others (Davis, 2002). As it is constructed by teachers in the context of their work, it consists of teachers' knowledge and beliefs about their own teaching practice and thus integrates experiential knowledge, formal knowledge, and personal beliefs (Van Driel, et al., 2001). Therefore, the implementation of reforms raises the need for new learning about teaching and can be seen as essentially a matter of teacher learning (Ball & Cohen, 1999; Putnam & Borko, 2000). This is because many of the ideas central to these efforts are foreign to teachers and thus do not form part of their practical knowledge.

Many researchers (Ball & Cohen, 1999; Eick, Ware & Williams, 2003; Lave & Wenger, 1991; Putnam & Borko, 2000; Wallace, 2003) stress the importance of learning in context or learning in practice. They conclude that learning cannot be separated from the context in which it takes place (Anderson & Helms, 2001; Wallace, 2003). Putnam and Borko (2000, p.4), comparing the cognitive theories and situative theorists, point out that situative theorists posit that “the physical and social contexts in which an activity takes place are an integral part of the activity, and that the activity is an integral part of the learning that takes place within it”. They conclude that how a person learns a particular set of knowledge and skills, and the situation in which a person learns, are fundamental to what is learned. Learning about teaching is situated therefore in particular classrooms (Wallace, 2003, p.10). Teaching, according to Ball and Cohen (1999), “occurs in particulars – particular students interacting with particular teachers over particular ideas in particular circumstances”. Much of the knowledge for teaching cannot be learned out of context and later applied in classrooms (Eick, et al., 2003). Since such knowledge is situated in practice, it must be learned in practice (Ball & Cohen, 1999). Teachers cannot build upon, nor enact understanding of such work as proposed in new curriculum reforms unless they have experienced and know how to learn in the contexts of their work.

Feldman (2000) proposes a model that connects teachers' beliefs, reasoning, and knowledge with changes in their instruction. He suggests that certain conditions need to be met for teachers to change the theories that guide their teaching. First, in the same way that a learner must become dissatisfied with his/her understanding, a teacher must become discontented with a practical theory because he/she recognizes
it as “ineffective, unsuccessful, or because it leads to dissonance or dilemmas in practice” (p. 612). Those dilemmas are often due to the teacher’s perception or belief that something is “morally, ethically, or politically wrong” in his/her practice (p. 612). A new practical theory must appear sensible for it to be accommodated by the teacher. Explaining this, Feldman points out that a new practical theory “should be comprehensible and reasonable in particular situations and consonant with the teacher’s technical and normative goals so that the actions or goals that emerge from it make sense” (p. 612, emphasis in original). It should be understandable, sensible, and beneficial in particular situations and be in tune with the teacher’s goals. Also, the new concept should have the potential to be extended, to open up new areas of inquiry (p. 613). Finally, he suggests that for a new practical theory to be accepted, it should be “illuminating or enlightening” (p. 613) in the sense of providing new understanding of practice situations. For the teachers, this new understanding, which can arise from the particularities of one situation, can be used to modify the new practical theory to the particularities of different situations.

A focus on the situative perspective suggests the importance of authentic activities in classrooms (Putnam & Borko, 2000; Wallace, 2003). According to Brown and colleagues (in Putnam & Borko, 2000), authentic activities are defined as the “ordinary practices of a culture” (p. 4), that is, activities that are similar to what actual practitioners do. Putnam and Borko (2000, pp. 4-5) conclude that authentic classroom activities are those activities that “foster the kinds of thinking and problem-solving skills that are important in out-of-school settings, whether or not the activities themselves mirror what practitioners do”. In this case the kinds of thinking and problem-solving skills fostered by an activity are considered to be the key criterion for authenticity (Putnam & Borko, 2000).

Other researchers (Anderson & Helms, 2001; Anderson & Mitchener, 1994) posit that new learning is socially constructed within a community of practice. Putnam and Borko (2000) talk of sociocentric view of knowledge and learning (“holds that what we take as knowledge and how we think and express ideas are the products of the interactions of groups of people over time”, p. 5) and discourse communities that are seen to provide the cognitive tools (ideas, theories, and concepts). Put simply by Wallace (2003, p. 10) “when people learn, they learn about knowledge, skills and
situations at the same time” and that mostly happens when they interact with other people over time. Thus learning requires active involvement in constructing meaning, negotiation of meaning with the learning community, making connections with past personal understandings (practical knowledge) – modifying these prior conceptions if they are not accurate – and building understandings within a learning community or context using the tools available to them (Anderson et al., in Davis, 2002).

Learning, as put by Putnam and Borko (2000), is not a unidirectional phenomenon – all involved benefit in one way or the other. Learning about teaching, too, is social (Wallace, 2003, p. 10). Engagement in teaching in itself opens up a dialogue or healthy discussion. And a dialogue or discussion enables participants to come to a shared understanding of the subject being discussed and helps develop new insights into teaching and learning, which are in turn shared across community members (Wallace, 2003). Reaching a shared understanding does not necessarily mean that the interacting individuals end up with identical conceptual structures. Rather, as Steffe and Thompson (2000, p. 205) argue, it means that “their conceptual structures are sufficiently compatible for successful reciprocal assimilation”. In dialogue, actors are empowered to rethink the way they see the world and judge their practice (Bullough & Gitlin, 1991). Creating rich opportunities for teachers to engage in, and to shape, such healthy and rigorous discussion within communities is therefore a critical component of teacher learning (Wallace, 2003, p. 10).

Recent researchers consciously use holistic and systemic approaches to teacher learning (Ball & Cohen, 1999; Eick, et al., 2003; Wallace, 2003) - holistic in the sense of giving simultaneous attention to all of the many elements that are part of the picture and systemic in that attention is given to the many interactions among the various elements and the influence they have on each other. Holistic and systemic perspectives suggest a need for teachers to be linked with a wider discourse beyond their local circle of colleagues, whether through subject matter organisations, study groups, university-school partnerships, or other groups or networks (Ball & Cohen, 1999). Learning about teaching is therefore distributed (Wallace, 2003, p. 11). Rather than residing exclusively with the individual learning is “stretched over” (Lave, in Wallace, 2003) the individual, other people and various tools. Under this conception,
the work of teaching is distributed across groups of individuals (teachers, students, colleagues, formal school leaders, other colleagues and educators beyond their local circles, researchers) who employ tools (curriculum documents, teaching materials, timetables) to achieve certain goals and outcomes (Wallace, 2003).

A distributed perspective encourages a shift from the pattern in which teachers focus exclusively on their own work or the work of those close by, with little external contribution, challenge, or support. It, therefore, suggests that learning about teaching involves the teacher (or teacher leader) and the other members of the educational organisation or community (classroom, school and/or system) interacting with the various artefacts such as physical and symbolic tools used by that organisation or community (Wallace, 2003, p. 11).

A focus on "what and how learners learn" calls for a focus on "what and how teachers learn" because learners and teachers are in most cases in interaction with each other. For both teachers and students, learning is "a risky business that is most likely to take place in a safe environment" (Wallace & Louden, 1994, p. 333). In order to teach in the ways the new curriculum reforms suggest, teachers must be actively learning as they teach.

Teacher learning is "the process of acquiring new ideas, changing or deleting old ones, and gleaning new knowledge and skills" (Davis, 2002, p. 5). Wallace (2003) concluded that teacher learning is both simple and complex. Simply stated, teacher learning is about "building and sustaining knowledge of classroom practice across various discourse communities. It includes principles such as a focus on instruction, collegiality, community, shared expertise, respect for teacher knowledge, the evolution of teacher knowledge, local management and organisational learning" (Wallace, 2003, p. 13). Putting these principles into practice, Wallace stressed, is a different story. The complexity of teacher learning is brought by the fact that it is about individuals and their relationships with others, and it takes place within an environment rich with dilemmas – of practice, of leadership and of school reform. Thus "teacher learning is situated in teachers’ practices, is social in nature and is distributed across communities and tools" (Wallace, 2003, p. 12). Teacher learning,
according to Louden (1991), proceeds slowly and hesitantly by the expansion of horizons of understanding, rather than through sudden leaps of insight.

My response

What I learned is that teacher learning is situated, is social and is distributed. Learning about teaching should be situated on authentic activities. What do these authentic activities refer to in our South African context? The national curriculum statement in South Africa is based on the vision of a lifelong teacher who is critical and responsible, professionally competent, and open to views and opinions held by learners who may differ from his/her own (Department of Education, 2001a). With this vision in mind, in this study I opt to combine the two definitions of ‘authentic activities’ highlighted in Putnam and Borko’s (2000) text. That is, ‘authentic activities are what actual practitioners do’ and activities are authentic if they serve the intended outcomes. For teachers, I acknowledge that authentic activities would normally and naturally be situated in and around the classroom, but these are not limited to their own classroom or schools. They cross to other settings (other schools or non-school settings) depending on the nature of the activity and the goals of learning.

My position on the social nature of teacher learning is underpinned by what I understand by social interaction as used in constructivism theory. It is similar to Steffe and Thompson’s position on what it means by “intersubjective construction of knowledge in social interaction” (2000, p. 205). I believe that when two individuals are in social interaction, intersubjective knowledge is established whenever (a) each individual reciprocally assimilates the language and actions of the other, (b) the reciprocal process of assimilation continues until no accommodation of the conceptual structures involved in the reciprocal assimilations are necessary for successful assimilation, and (c) the individuals reach a state of mutual agreement about the meaning of the results of their interactions. By reaching mutual agreement it does not mean that the interacting individuals end up with identical conceptual structures. Rather, what it means is only that their conceptual structures are sufficiently compatible for successful reciprocal assimilation.
It seems that an attempt to access (because full access appears to be difficult) and to understand teachers’ practical knowledge promises to be a relevant idea in educational reform. However, it has been argued that, to understand the complex process of teaching, it is necessary to understand the knowledge teachers build and use in action. In mathematics, to learn to teach as we were taught is hard enough. To learn to teach in the ways envisioned in the new OBE curriculum, as is the case in South Africa, is harder still because for many teachers, it requires new acquisition of knowledge and development of practice that is different from what they experienced as students. I claim that new acquisition of knowledge and development of practice as implied by the OBE oriented reform would demand a broader view by teachers of the reform process. That is suggestive of a teacher who can stretch over to reach a wider community. For it is in wider communities that I think we can learn more. It is in discourse communities that we get to know how other people see things and that contributes to revisions of our different thinking about mathematics and the process of learning it. Thus, the notion of teacher learning as distributed also makes sense. Few teachers, I suspect, possess the mathematical tools or mental images to accomplish necessary shifts in their teaching. What I think needs consideration is a balance between activities that incorporate ideas of distributed cognition and those that stress individual competence.

**How can teacher learning be enhanced and supported?**

New demands relating to educational reform require learning opportunities for teachers that are more powerful than simply reading and talking about new pedagogical ideas (Ball & Cohen, 1999). The reforms themselves are not prescriptive. In mathematics, teachers are challenged to build on new mathematical knowledge and develop conceptual understanding and relevant mathematical skills. Teachers, according to Darling-Hammond (1998) and Remillard (2000), learn best by studying, engaging in mathematical activities themselves, reflecting, by collaborating with other teachers, by looking closely at students and their work, and by sharing what they see. This kind of learning cannot occur in in-service centres divorced from practice or in school classrooms divorced from knowledge about how to interpret practice (Darling-Hammond, 1998). The best way to improve both teaching and teacher learning would be to create the capacity for much better
learning about teaching as a part of teaching (Ball & Cohen, 1999). The use of teacher’s knowledge to teach (such as knowledge of subject content, of pedagogy as well as knowledge of learners) depends on knowledge that cannot be learned entirely in advance or outside practice (Davis, 2002).

Several actions can support teacher learning and the teacher change process. Teachers should first address pre-existing knowledge and beliefs about teaching, learning, learners and subject matter (Davis, 2002), in other words, revisit their practical knowledge (Van Driel, et al., 2001) or their practical theories (Feldman, 2000). As they make their beliefs explicit, they should be provided with contexts to examine, critique, and weave new ideas into their existing constructs. Teachers make numerous decisions each day that are within their practical domain. If we want teachers to change their practice, which is what is called for in the current reform efforts, then they must accept new practical theories that are consonant with the reforms. Using the conceptual change model as a metaphor, Feldman (2000) suggested that teachers may accept new practical theories, consonant with reform, if they are discontent with their old practical theories and they find the new ones sensible, beneficial, and enlightening. One way teachers could make sense out of these new theories is when they are introduced to disequilibrium (Ball & Cohen, 1999; Edwards & Hensien, 1999), an approach in which teachers are stimulated to reconsider their ideas about the nature of mathematics teaching and learning and reconstruct more powerful ones. Again, teachers should see these new theories being practised or modelled rather than being preached. This does not imply that teachers would find transforming their practice easy if they have seen new theories being modelled.

There is evidence that the kind of learning that leads to fundamental change in teaching occurs over a long period of time, and requires extensive support and multiple opportunities to experiment and reflect (Johnson, et al., 2000; Remillard, 2000). Teachers must be given continued opportunities to deepen and expand both their subject content knowledge (Davis, 2002) and their pedagogical content knowledge (Johnson, et al., 2000; Van Driel, et al., 2001). Pedagogical content knowledge, according to Van Driel, Beijaard and Verloop (2001), refers to a transformation of the subject matter knowledge, used by teachers in the
communication process with learners. Johnson, et al., (2000) see pedagogical content knowledge as summing up that combination of subject knowledge, pedagogical skills and viewpoints of what it is to be a better teacher. Without necessary skills that allow integration of the two (subject content knowledge and pedagogical content knowledge), it is hard for teachers to learn strategies and techniques needed to respond to students' thinking about the subject in ways that facilitate their learning. Anderson and Mitchener (1994) realised that a much deeper understanding of the discipline and its practices is imperative for good teaching. It is, therefore, important that teachers learn content, as well as pedagogy, through engagement in learning activity that "mirrors" the kind of experiences that reformers hope teachers would provide their students.

Research indicates that teacher learning must take place within school and classroom settings (Anderson & Mitchener, 1994; Eick, et al., 2003; Johnson, et al., 2000; Tang, 2002). This situated perspective suggests that teachers need to engage in authentic activities. For teachers, according to Wallace (2003), authentic activities normally and naturally would be situated in and around the classroom. He is of the opinion that authentic activities for teachers would be situated also in other schools and non-school settings and that depend on the nature of the activity and the goals of the learning (Wallace, 2003). Thus teachers need the opportunity to participate in rigorous and critical debate within discourse communities and develop facility with the various tools used in that community. Wallace (2003) argues that while authentic activities are most often associated with the classroom and the school, it is difficult for teachers to break out of routine ways of teaching and schools do not always value or support critical and reflective practice. Clark (2003) captures some hidden challenges of teaching and learning transformation brought by the South African school environment (for example, learners' behaviour, frequent interruptions in the daily programme, an ongoing 'crisis of authority' that results in absenteeism from class by both learners and teachers). Although in certain cases it becomes more challenging to face and manage the innovations, as is the case with the teacher Nomzamo in Clark's (2003) study, making strong links to personal learning and the classroom context are important for teacher change in beliefs and practice. And, this is true for both novice and experienced teachers (Davis, 2002). Clark (2003) argues that the most critical element for change is a teacher's own conceptions of learning
and he suggests that teachers must “revise their conception of learning in ways largely unanticipated by the social fabric of classrooms” (p. 74).

Finally, support from research and professional development teams is critical as teachers begin to incorporate new approaches (Anderson & Mitchener, 1994). Wallace (2003, p.11) writes: “The more sophisticated cognitive, cultural and language tools of practice are often to be found in discourse communities outside the school – for example, in professional associations, universities, and district and central offices. Moreover, organisational learning and learning across the profession are more likely to proceed if teachers engage in communities beyond the four walls of the classroom”. Importantly, teachers must have ample time and support for reflection, interactions with other teachers, and further learning opportunities.

In sum, as teachers are asked to revise their teaching, the following elements appear to be key in the development of new understandings and practice. Reform efforts must (1) enable teachers to reflect upon and make explicit their personal practical knowledge, including beliefs, attitudes, and concerns; (2) consider teachers’ knowledge and practices as the starting point of change; (3) provide teachers with a mix of settings for learning (classroom, in school, out of school); (4) provide teachers opportunities to see these reform-based strategies and approaches modelled and to reflect upon these models; (5) provide teachers foci for learning (theory, practice, tools). These will enable teachers to design inquiry-based instructions and practise these approaches in the context of supportive classroom environments where feedback is provided; (6) provide teachers with a mix of collaborative communities’ settings (with other educators in classroom, schools, profession, experienced professionals as mentors and guides, system) and (7) powerful strategies advocated especially related to achieving lasting changes in teachers’ practical knowledge seem to be learning in networks, peer coaching, collaborative action research, and the use of cases. It seems that teachers’ practical knowledge is an important component of a reform project, and that changes in this knowledge should be monitored throughout the project (Anderson & Mitchener, 1994; Davis, 2002; Lin, 2002; Putnam & Borko, 2000; Van Driel, et al., 2001; Wallace, 2003; Wallace & Louden, 1994).
In this study, the participating teachers and I have tried to recognise and incorporate multiple learning contexts in our work. However, we have focused our energies on some particular situated learning activities. These activities are informed by literatures from several fields including action research and/or teacher as researcher, reflective practice and collaboration. Although these activities are interrelated, I try to address the nature of each.

The principal feature of an action research approach is change (action) or collaboration between researchers and researched. Action researchers are concerned to improve a situation through active intervention and in collaboration with the parties involved (Hitchcock & Hughes, 1995; Zeichner, 1994). Action research promotes inquiry, reflection, problem solving that result in action or change, continuous learning, revitalizes teachers’ practice, and motivates teachers by improving their self-confidence as professionals (Levin & Rock, 2003). It is argued that action research is underpinned by a democratic principle (Noffke & Brennan, 1991). Its 'democratic' epistemology emphasises that everybody is a producer of knowledge, thus changes which are made are likely to be maintained and even extended. Action researchers can use a variety of research techniques and both quantitative and qualitative data (Hitchcock & Hughes, 1995). The collection and analysis of data in classroom action research thus confronts the teacher with the actuality, rather than the rationalization, of the teaching and this alone can shift perceptions dramatically (Street, 1986). Whatever happens, the teacher will gain an insight into how his/her mathematics teaching is being received by the learners and this is the first step to improving it.

Critical action research involves a cyclical approach: questioning, planning, reflecting, acting, observing, reflecting, re-planning, and often questioning further (Levin & Rock, 2003). The expectation is that this will develop the teacher's self-awareness and analytical powers, as it has been stated by Street (1986) that the theories which teachers hold affect the way they teach mathematics. The testing out of theories will help the teachers to challenge the theories and practices of others, thus also helping to make teachers more critical of the activities suggested in published schemes and develop their ability to appraise and use the more valuable ones. Cochran-Smith and Lytle (in Zeichner, 1994) have argued that teacher research
has fundamentally transformed the nature of instruction in the classrooms of teacher researchers. They concluded that when teachers redefine their own relationships to knowledge about teaching and learning, they reconstruct their classrooms and begin to offer different invitations to their students to learn and know. A view of teaching as research is connected to a view of learning as constructive, meaning-centred, and social. At its best, action research can break through the barriers of individualism and isolation (Noffke & Brennan, 1991).

Reflective practice is a term that carries diverse meaning (Loughran, 2002). According to Loughran, for some reflection simply means thinking about something, whereas for others it is a well-defined and crafted practice that carries very specific meaning and associated action. The seeking of an action to follow the thinking process is important to the definition of reflection (Sengor, 1999). For reflection to lead to valuable learning outcomes Loughran (2002) believes it must be effective reflective practice. Effective reflective practice involves "careful consideration of both 'seeing' and 'action' to enhance the possibilities of learning through experience" (Loughran, 2002, p. 37). Ball and Cohen (1999) talk of learning in and from practice and try to differentiate the two. Relating to this, reflection can happen in the midst of experience "reflection-in-action" or outside an experience "reflection-on-action" (Rodgers, 2002, p. 234). At its core, reflective practice is about self-awareness (Kelleher, 2002). Ghaye and Ghaye (in Harada, 2001, p. 13) maintain that reflective practice is about "developing self-knowledge, the ability to see through teaching situations and understand the meaning of what is happening". Engaging in the process of reflection is about admitting that practice can always be improved in some way. It seems, then, that reflection and change go hand in hand.

The process of change necessitates that teachers reflect on their practice, compare their practice with some form of idealised practice, and begin to change as they move toward that idealised practice (Edwards & Hensien, 1999). One cannot be truly reflective unless one is willing to take risks and act (Goodman, 1991). Edwards and Hensien further maintain that "reflective practice is enhanced when the teacher's efforts to reflect and reform are based on a foundation of collaborative support" (p.191). Rodgers (2002, p. 235) presents the following four-phase reflective cycle that might be useful in teacher learning: "presence in experience: learning to see;
description of experience: learning to describe and differentiate; analysis of experience: learning to think from multiple perspectives and form multiple explanations; and experimentation: learning to take intelligent action." Although there is a certain linearity to these phases, she maintains that one may move both forward and backward through the process, especially between description and analysis.

Teachers are social beings who derive meaning from being with other people, young people in particular. Thus teacher learning does not take place in a vacuum. True collaborative cultures are "deep, personal and enduring and are absolutely central to teachers’ daily work" (Wallace, 1999, p. 67). According to Wallace and Louden, (1994, p. 323) "personal qualities, underscored by mutual trust and respect for knowledge, form the basis for successful relationships in teaching, operating in different ways, for different purposes, for different people". They are of the opinion that teacher collaboration, as an instrument of change, will only be successful when it attends to teachers’ socially derived knowledge (which is seen as tacit, biographical, and experiential). They maintain that qualities such as emergence, trust, and fair exchange are important in collaboration that is focused towards educational change.

*My response*

It appears to me that contexts, needs, talents and commitments differ, but one constant is that schools cannot improve without people working together. Teaching has a complex and a context-specific nature. Hence, learning about teaching, I claim, is a complex or a complicated process. In the context of curriculum reform, there is no doubt that the process of teacher learning requires more powerful learning opportunities. A situated perspective suggests the importance of authentic activities; socially constructed learning within a community of practice and development of facility with the various artefacts or tools in that community. Along with the situated perspective, teachers need to be provided with continued opportunities to deepen and expand both their subject content knowledge and their pedagogical content knowledge. This would require engagement in authentic activities that mirror the kind of experiences that we hope teachers would provide their learners. Often it is not always possible to provide powerful learning experiences for teachers in settings
divorced from practice or in settings divorced from knowledge about how to interpret practice. A mix of settings (in classrooms, in schools, out of schools) seems to be important or essential for powerful learning.

Social construction of learning by definition suggests participation in discourse communities. These discourse communities appear to play central roles in shaping the way teachers view their world and go about their work. My reading of the literature highlights the role of discourse communities in supporting teachers learning to teach in new ways and the importance of reflective dialogue on how to improve lesson presentations and teaching for optimal student learning. It would seem that teachers reflect more deeply on their practice as they team plan and co-teach. Even if this is the case, the existing cultures and discourse communities in some schools often do not always value or support critical and reflective practice. Thus, a mix of communities in schools and out of schools that strives for joint production of knowledge, skills, attitudes and values seems promising for teacher learning.

My reading of the literature, it would seem, reveals that the most appropriate continuing professional development site depends on the specific goals for teachers’ learning. That in itself suggests that different projects would continue emphasising different goals. Thus the work of continuing professional development appears to be as uncertain as practice itself. This tempts me to opt for multiple learning contexts as this could combine different learning experiences. Multiple learning contexts could offer teachers various opportunities to confront research and theory directly, to engage in continued reflective processes, and to engage in collaborative communities for mutual support.

Concluding thoughts

In the preceding literature review, I have started by addressing two contextual questions to give an overview of the conditions under which this study was undertaken. In addressing the first question, I tried to outline the OBE philosophy and included the challenges brought by the new OBE curriculum in my country. Thereafter, I looked at the emerging challenges to mathematics teaching. To address
the second question, I focused on the conditions of learning resources and availability of educational facilities in primary and secondary schools in the Limpopo Province where this study has taken place.

The core of this study lies in the last two questions on teacher learning. Looking at the nature of teacher learning, I highlighted the importance of personal practical knowledge which, using Van Driel, et al., (2001), could simply be defined as an integrated set of knowledge, conceptions, beliefs, and values. This knowledge, I learned, integrates experiential knowledge, formal knowledge, and personal beliefs. Thus, it appears teachers’ practical knowledge can be traced to their biography and experience. It would seem various strategies may be applied to challenge teachers to deconstruct and reconstruct their practical knowledge in the course of a reform. Drawing on the literature, I concluded that teacher learning is situated, is social in nature and is distributed across communities and tools. This leads me to the questions: In what contexts are teacher’s knowledge and learning situated? and What kinds of social engagements provide the proper context for teacher learning to take place?

In my review of the literature on the last question, “How can teacher learning be enhanced and supported?” I conclude that several actions can enhance and support teacher learning and the teacher change process. These actions include addressing pre-existing knowledge and beliefs about teaching, learning, learners, and subject matter; being introduced to disequilibrium; engaging in authentic activities; participating in rigorous and critical debate within discourse communities that also transcend own classrooms; exposure to a mix of learning settings. taking opportunities to see these reform-based strategies and approaches modelled and to reflect upon these models; having foci for learning.

My attempt to make sense of the literature leads me to the view that teacher learning is a complex field with multiple entry points. Central to it are the following three characteristics: situated, social and distributed. In this study, I have used these three characteristics as heuristic devices or as ways of organising the presentation of my data, and my analysis and discussion.
In this study I adopt a social constructivist view of knowledge, in which I see knowledge as the product of social interaction via reflections within collaborative partnerships. Underpinned by this social constructivist view, my study was designed in such a way that the teachers direct or own the process. Also, opportunities were created for the teachers to revise their practical knowledge and make sense in tune with their goals. Successful implementation, I am convinced, requires active and on-going support, and the level of support needed is sometimes unpredictable. Support and its partner, collaboration, are essential to the process of reform.
CHAPTER 3

METHODOLOGY AND METHODS

This chapter gives an overview of how this study was conducted. It covers study design, data gathering techniques, data analysis, access, ethical considerations and quality criteria. Under study design I describe the methodology, the participants and the setting. The section on data gathering describes techniques of questioning, journal keeping and participant observation. Under data analysis I describe the tools of narrative analysis and analysis of narratives featured in this study. This is followed by sections on access and ethics. Finally, I address issues of quality criteria.

Study design

Qualitative research

This study explores mathematics teacher learning in the context of the South African OBE-based reforms. This is a complex and idiosyncratic topic, best approached through qualitative research. Erickson (1998, p. 1155) summarises the appropriateness of qualitative research in education as follows:

Qualitative research in education is especially appropriate when we want:

- detailed information about implementation;
- to identify the nuances of subjective understanding that motivate various participants in a setting;
- to identify and understand change over time.

In this study it has been my intention to understand the teachers’ learning experiences by describing the communications which occurred between the participants. My description and analysis of data used ideas and issues which emerged as the study progressed. The qualitative approach attends to the socially constructed nature of reality, the relationships between me and the two study teachers, and the situational factors that shaped our work (Denzin & Lincoln, 1994).
Two key features guiding the qualitative approach were action research and case study.

**Action research collaboration**

Action research takes 'change' as its focus and encourages participants of different kinds to research collaboratively their shared frustrations and challenges (Bishop, 1998; Hitchcock & Hughes, 1995; Levin & Rock, 2003). Action research motivates teachers by improving their self-confidence as professionals (Levin & Rock, 2003). I used this technique because I did not want to impose activities on the teachers. Equality of partnership was also central. Hence, the action research in this study was underpinned by a democratic principle (Noffke & Brennan, 1991), by reflection and by collaboration. As seen by Bishop, “the approach is only action research when it is collaborative” (1998, p. 39). The action research collaboration in this study took different forms:

- Team planning of term activities;
- Lessons facilitated by me and observed by the teachers;
- Lessons facilitated by the teachers and observed by me;
- Lessons we facilitated together; and
- Reflective sessions following each lesson facilitated as part of the collaborative.

**Case study approach**

I chose a case study approach because it allows for rich and deep description and explicitness about contextual factors (Tang, 2002). Case study can capture the multifacetedness and complexities of teacher learning and help me to probe how teachers, in the particular social circumstances, interpret or make sense of their everyday interactions (Borko, Davinroy, Bliem & Cumbo, 2000). This methodology enables “through the richness of singular experiences, opportunities to consider the complexities of teaching and learning by embedding them within the details of everyday life in school” (Borko, *et al.*, 2000, p. 278).
Participants and setting

The two study teachers, Gerty and Joel, were working in ‘village’ schools. We first met when their schools participated in the mathematics, science and technology education (MASTEC) schools project. I worked in that project as the primary pre-service and in-service coordinator. In the year 2000, when I began this study, I met them as students in the Further Diploma in (Mathematics) Education (FDE) program, where I was the coordinator and facilitator. The first module on ‘philosophy of mathematics education’ that I facilitated and they attended was designed to enhance mathematics teachers’ development. The other three modules in which I also played a role as the facilitator (teaching mathematics; classroom management and workshops; and research in mathematics education) were designed around more individual in-school support than whole FDE group meetings. It was during those in-school supports that I began to build a close relationship with the two study teachers. This took place towards the end of 2000 and for the whole of 2001. Access to their schools for the purpose of this study was negotiated at that time when I was also operating as the coordinator and the facilitator of the FDE program. I was also known as the ex-MASTEC primary pre-service and in-service coordinator.

Data gathering techniques

Questioning: Year 2000

The first set of data were collected in the first semester of year 2000 while the two study teachers were still in their first year of the Further Diploma in Education program. During that time our relationship was still more of a formal interactive type (lecturer and teacher). As part of the FDE course I asked the teachers to address the following questions (in writing):

- Which philosophy best reflects how I have been teaching mathematics?
- Which philosophy best reflects the intentions of OBE curriculum as projected through critical outcomes and specific outcomes of Mathematics, Mathematical Literacy and Mathematical Sciences?
- What are the perceived roles of an OBE mathematics teacher?
What are the things that need to be changed in how I have been teaching mathematics?

The teachers' answers to these questions provided the common point of departure for this study.

**Journal keeping: Years 2001 – 2002**

In the following year, 2001, I worked alongside the teachers in their schools. Joel, the male primary school teacher, revealed his interest in facilitating workshops with other teachers in his district. Thus, he directed our collaboration to focus on 'the role of reflections' on his work both in his classroom setting and in workshop settings when he interacted with other teachers. Journal keeping became the tool he used to capture his reflections on our collaboration.

Gerty, on the other hand, decided to attend another science and mathematics program (SMEP) that I also facilitated at the University of the North. Together with the other teachers, she was asked to decide on an action research plan in July 2001. During the following year, 2002, she implemented her action research plan with my collaborative support. This support included classroom observations. Her action research plan was guided by the following outline provided to all the SMEP participants at the beginning of 2002:

- Give the same planned learning activities to learning groups in the Grade you are facilitating.
- Keep records of the learners' endeavours in the form of a journal that will contain entries of their procedures, strategies, and processes they followed while carrying out the activities.
- Every time reflect on the whole process (inclusion is expected of your analysis of learners’ responses to the activities).
- Refer to Part 4 of your plan and assess their activities’ workings using your decisions (that is, guided by your address of the question “how you will assess learners”; part 4).
- Is your assessment of their work in line with your Part 2 and decisions in Part 4 of your plan, that is, is your assessment addressing your intended outcome and in line with the suggested instructional approach(es)? Confirm. (evidence required)
- Reflect on the whole process and results of activities you have given learners to carry out and suggest improvements if they could be made.

SMEP participants were also asked to submit a report and a journal of their implementation activities on 12 October 2002:

- A report on the whole process/procedure (the report that was to be based on a practical exercise carried out with a group of learners).
- Journal (with entries of the activities’ reflections and learners’ samples based on the plan)

Gerty’s report and her journal, thus, also formed an important data source for the study.

**Participant observation**

Typically, my support involved classroom observation followed by a reflection session after each lesson. Each teacher was visited two days a week for two successive terms and the visits later varied (sometimes once a week and that mostly depended on whether they needed me). I met with each of the two study teachers for two days at the beginning of the third term for planning. Gerty observed my SMEP facilitation because of her involvement in the program. Her attendance was scheduled for four weeks spread during holidays in 2001 and two weekends (Saturdays and Sundays) in each of the 9 months in 2002. Joel, a primary school teacher, attended as the participant observer my Year 1 Advanced Certificate in Mathematics Education program (ACEM) class for two successive weeks during July holidays in 2002. My mutual support ranged from help with lesson planning, demonstration lessons, co-teaching, post-lesson discussions or reflections, advice on activities, and demonstrations on how to use some mathematics equipment.
Through participant observation I was able to constantly check my interpretations during the data collection and analysis. Our close collaboration and freedom to participate helped us to verify our joint constructions. Guba and Lincoln (1989, p. 239) wrote: “If the evaluator wants to establish that the multiple realities he or she presents are those that stakeholders have provided, the most certain test is verifying those multiple constructions with those who provided them”. The constructions were assisted by my own field notes and the two study teachers’ personal journal writings.

**Data analysis**

The data analysis occurred in two different stages. The first stage fits well with what Polkinghorne (1995) referred to as narrative analysis. In narrative analysis the search is for data that will reveal uniqueness of the individual case or bounded system and provide an understanding of its idiosyncrasy and particular complexity (Polkinghorne, 1995). I entered this study with extensive knowledge of the OBE-oriented curriculum documents. That knowledge helped me orient the study within a broader context. At first I tried not to impose my ideas and I thought my analysis would be grounded in the data alone. Therefore, my initial analysis of data attempted to identify emerging themes from each case study. However, after reading more widely about teacher learning, I found that my analysis was being guided by three characteristics of teacher learning from the literature (for example; Putnam & Borko, 2000; Wallace, 2003). The literature on teacher learning, thus, offered me new insights into my own experience (Colvin, 1994). Chambers says: “in literature we find the best expression of the human imagination, and the most useful means by which we come to grips with our ideas about ourselves and what we are.” (in Colvin, 1994, p. 682).

The themes that emerged from my initial analysis of the two case studies were then refined and matched to the three characteristics of teacher learning. I found myself using these three characteristics as heuristic devices or convenient organisers for my analysis. I then represented the case studies of each teacher so that the themes used to describe the learning process unfolded in three stages: ideas and instructional practices early in the study, ideas and instructional practices during our collaboration, and ideas and instructional practices at the end of our collaboration. I also included
several mini vignettes at various points to illustrate particular learning episodes. Narrative analysis as put by Polkinghorne (1995, p.15) is "the procedure through which the researcher organises the data elements into a coherent developmental account". He further sees narrative analysis as a process of synthesising data rather than a separation of it into its constituent parts. This stage of the analysis also tries to retain a sense of the coherent whole and this is what I strived for in this study.

The second stage of my data analysis took the form of analysis of narratives (Polkinghorne, 1995). According to Polkinghorne (1995, p.13) "the paradigmatic analysis of narrative seeks to locate common themes or conceptual manifestations among the stories collected as data. ... The researcher inspects the different stories to discover which notions appear across them." My approach here was to construct seven key questions to interrogate the narrative. My answers to these seven questions were then used to identify several overarching propositions.

In this study I used combinations of particular description, general description and orienting commentary (Erickson, 1998). Particular description took the form of narrative vignettes and quotes from the two study teachers' journals or personal writings. Where appropriate I employed general description to show patterns of generalisation within the case. As much as possible I tried to foreshadow what was to come next in the text and aftershadow that which had been presented. Fore- and aftershadowing was also used at the beginning and end of each section and subsection of text.

Access

For both of the study teachers, access to their schools was relatively straight-forward. Joel was the acting principal, so few formalities were necessary. He introduced me to his fellow staff members so that they should not be surprised to see me visiting his classes. Gerty's school was going through some problems regarding the post of principal when we started this study. The new principal found that Gerty and I had already agreed to collaborate. However, for the sake of courtesy during my first classroom observation visits we went to his office to explain what we were doing and seek his endorsement. My relationship with this principal was very good because we
had previously attended mathematics conferences together and he was very active in mathematics activities in the province.

Ethical considerations

At the start of the study both teachers were informed of the nature of the study, the purposes, potential audiences and substantive foci of the research. Right from the start I made them aware that they were free to voice their opinions, give advice and withdraw if they wanted. With regard to the learners, I left it to the two teachers to explain our mission. They did this during my first visit into their classrooms. Erickson (1998, p.1161) writes: “consent that is genuinely informed and without coercion reduces the risk of social harm because it affirms the dignity and respects the agency of those who will be involved in the study”. Because I knew that I would be depending on the two teachers for data, I was forthright and specific about what this study involved. I was open to them so that they should not feel compelled (as my students at the start of the study) to participate. I have obtained the written permissions from both teachers. It should also be noted that both teachers requested that I use their real names in the thesis (to reflect the genuine nature of our collaboration). While the actual teacher names have been used, the names of students are pseudonyms.

Quality criteria

Mullholland and Wallace (2003) refer to three criteria for judging the quality of education research – strength, sharing and service. The strength criteria are those relating to the validity of the study, the sharing criteria attend to issues of representation and the service criteria are concerned with the usefulness of the study.

This study involved prolonged engagement over three years, the use of multiple data sources (written responses to questions, reflective journals, observational notes), our shared experiences of literature readings, discussions and interpretations during our collaboration and the inclusion of all the participants' voices (including me as a collaborator researcher). In this way, I established my credibility with the two study teachers (Guba & Lincoln, 1989). These features or qualities also showed how I
satisfied the strength criteria as explain by Mulholland and Wallace (2003). They conclude that the strength criteria require that “research is conducted in a way that provides evidence of its thoroughness and fairness and also that researchers document their subjectivity” (p. 21).

In this study I present the shared story of all the participants’ experience (the two study teachers, Gerty and Joel, and me). We established a good rapport and built the mutual trust and comfort necessary to uncover our ideas. In my description and analysis of data I have tried to represent all the participants’ voices. In this way the reader has close contact with data gathered and can experience vicariously the world of the participants. This is an aspect that to a large extent attends to the sharing criteria (Mulholland & Wallace, 2003).

The service criteria refer to the usefulness of the study. It allows educational experiences to be understood in new ways (Mulholland & Wallace, 2003). I have argued that the study was primarily useful to the participants – helping us transform our practice. It is also hoped that the messages from the study, particularly the propositions, will be of value when shared with others in similar settings.
CHAPTER 4

CASE 1: GERTY

This chapter is designed to highlight Gerty’s (a female secondary school teacher) learning as it unfolded during this study. To organise my description and analysis I use as heuristic devices and convenient organisers the three characteristics of teacher learning that I identified in my literature review chapter. These three characteristics are: teacher learning as situated, teacher learning as social, and teacher learning as distributed. I am aware that these characteristics overlap but I use them to help me tap into Gerty’s views about the various contexts within which she is learning. My description and analysis portrays Gerty’s learning as it unfolds in three stages: ideas and instructional practice early in the study, ideas and instructional practice during our collaboration, and ideas and instructional practice at the end of our collaboration.

Teacher learning as situated

In this section, I start by giving a brief background of Gerty and her working environment. After that, I describe and analyse Gerty’s learning as it unfolded when she interacted with, and responded to, some readings on outcomes-based education (OBE) curriculum and constructivism. I also describe how her learning within the other contexts revealed itself during this study. The following sub-headings are used to organise these descriptions - outcomes based education (OBE) curriculum, constructivist ideas and other contexts.

Background

In the commencement of the study Gerty held a bachelor degree in library science and a senior primary teachers’ certificate. She had 17 years of teaching experience at the high school level. Gerty joined her current school in 1994 and since then had taught Grades 8-12 mathematics. The school had limited facilities/resources, although it was fenced, electrified and had a telecommunication facility. Although the school was opened in 1989, the classrooms looked old and were packed with learner desks and chairs. There was no proper staff room (one burglary-proof room
was partitioned to serve as a Grade 10, 11 and 12 physics and mathematics classroom, a duplicating room and a staff room). The partitioning was made up of large cardboard boxes filled with outdated textbooks and surplus stationery from the Provincial Department of Education. Some of the cardboard boxes were filled with odd pieces of equipment like candles, ramps, cold-drink bottles, etc. The science kits (7 in total), donated by the Mathematics, Science and Technology Education Schools Project (MSP) and the Provincial Department, were placed at the middle of the room (there was no laboratory) and loosely packed with dirty glass beakers and microscopes. The ceiling of the room consisted of a roughly assembled combination of unused corrugated iron, old textbooks, an old table, hose pipe, old doors, barbed wire and planks. There was no water at the school. Teachers could not claim their own space on the teachers' tables and there were no cupboards or cabinets for use by the teachers, no mathematics equipment, no recent mathematics textbooks (relevant to OBE) and no library. Two computers and one photocopier (which by then was not functioning well) were donated by the MSP and these computers were later reported stolen. There were some typewriters and a broken duplicator. I learnt from Gerty that the school used the photocopying and computer facilities of its nearby feeder primary school which, comparatively speaking, had better facilities than the secondary school.

**Response to readings on outcomes-based education (OBE) curriculum**

This subsection outlines Gerty's learning as it unfolded during her readings of some outcomes-based education (OBE) curriculum documents. Gerty read and responded to these documents when she was studying for her Further Diploma in Education early in the study, in 2000. Being aware that I cannot fully access Gerty’s thinking, I interpret her learning from writings and conversations with me about the new OBE-oriented curriculum, its descriptors, its demands, the role of the mathematics teacher in teaching the new curriculum, and her new role in comparison with how she used to teach.

In her writings, Gerty described OBE as a process of learning in which learners must demonstrate what they have learned. Teaching, she went on, must not be a one-way
process (from the teacher to the learner). It must be based on mutual dialogue. She reflected further that in OBE teaching is not examination directed.

At this early stage of her learning about OBE, Gerty wrote that she felt unprepared for the new curriculum. She wrote:

Challenges are that I do not have enough confidence, information and skills to change from the traditional teaching style to OBE. Implementing OBE in overcrowded classes has also been a difficulty when controlling the groups during discussions. In-Service Training is therefore necessary. (Personal writing, May 2000)

Throughout her writing there was an indication of an awareness of the type of teaching and learning implied by the new curriculum. She commented about the OBE approach and its introduction and stated that it heralded a long-awaited finale for teacher-centred, single-textbook-driven, exam-by-memory type of education. She saw OBE as a learner-centred approach, using authentic situations to contextualise “lessons” and relying on varied learning resources, not just one textbook. The intended outcome, as she put it, was a balance of skills, knowledge, attitudes and values. She hoped that the new approach would create citizens of the future who were thinking, questioning and problem-solving individuals.

She seemed to have an understanding of what might happen in the classroom although she had some fears. Her willingness to participate in in-service training indicated some readiness for change. She even suggested the focus the in-service training should take. She would like to see the training addressing the practical frustrations that she had experienced as she tried to implement OBE.

Reflecting on her teaching, Gerty wrote:

In my teaching, I strived to complete the syllabus before the end of the year so that learners could succeed to the next class. In OBE there is no syllabus, but learning programs based on the needs of particular learners designed by teachers. ...The only pointers that are provided regarding the content or context in which learning should
take place in each learning area are the range statements provided in the Policy Document. (Personal writing, May 2000)

As Gerty reflected further, she cited the literature (Monau, 2000) and said that the curriculum document was creating problems for teachers. She claimed that most teachers were unable to find the main specific outcome for a particular topic in the document and also had difficulties in finding related specific outcomes in mathematics and in other learning areas. She stressed:

The Department of Education must arrange for in-service training workshops so that teachers can transform the culture of learning and teaching in schools and use participatory, learner-centred methods. (Personal writing, May 2000)

She saw provision for in-service training as the answer and made several suggestions about the content of in-service workshops.

Gerty further clarified that in OBE the emphasis is on the outcomes. Therefore learners are not supposed to cover a certain topic within a stipulated time as it happened with her teaching. She felt that the teacher's time is now flexible and therefore learning programs are to be designed according to the needs of learners. She also mentioned a focus on a multicultural program and defined that as a program that should not focus on one culture to the exclusion of other cultures represented in the class. Referring specifically to some of the literature on the topic, she wrote:

Each child is a unique individual with something special to contribute and must be treated with special care (Monau, 2000: 23; Gomez, 1991: 54). "If a teacher is to understand the whole child, he or she must become aware of the child's cultural background" (Gomez, 1991: 54). (Personal writing, May 2000)

Gerty highlighted the issue of the interaction between culture, the learner, and the teaching of mathematics. She challenged the belief that in mathematics “facts” are true irrespective of culture or of the individual or of time. She indicated that to assume the role of a facilitator she was therefore faced with a challenge of designing a learning program that would accommodate all learners’ cultures in the class. While
she recognised the role of culture in teaching mathematics, Gerty felt that accommodating cultural differences required a lot of time and effort from the facilitator.

Citing some literature, she outlined the intentions of the OBE curriculum. She wrote that the teacher as a facilitator can only be sure that learning had taken place if learners could demonstrate through actions that they had acquired the desired learning content (she quoted Monau, 2000, p. 12). She viewed this intention as being projected through the following critical outcomes (CO) and specific outcomes (SO): CO₁, CO₄, CO₆, SO₁, SO₃ and SO₄ (these symbols are used to represent names of outcomes from the new curriculum) (see Appendix A). However she did not provide an explanation about how she related the intention with the identified outcomes. Reflecting on the facilitation role of the teacher, Gerty wrote that in OBE:

both the teacher and the learner are sources of knowledge. The teacher learns from the learner as he is busy teaching. He stimulates the child to learn and help him to acquire knowledge and find meaning. He sits on the back seat and places the learner in the front. (Personal writing, May 2000)

She also saw the teacher’s role as that of serving as the guider and supporter of the learners’ invention of viable mathematical ideas, rather than the transmitter of her/his own way of doing mathematics. She explained further by saying that the teacher’s role is not to sit back and do nothing, but rather be directly involved in the teaching-learning situation. However, Gerty did not elaborate the role of the teacher in ensuring that learning had taken place or monitoring learners’ demonstration of learning through actions. Rather she focused on the facilitation part of the intention.

She stated that teaching was shifted from teacher-centredness to learner-centredness (she quoted Monau, 2000, p. 12). She related this intention to the following critical outcomes (CO) and specific outcomes (SO): CO₁, SO₆, SO₈ and SO₁₀ but did not explain their relationship. Her interpretation of ‘learner-centredness’ was that OBE regarded the learner as the co-partner in teaching. She explained ‘being a co-partner in teaching’ by saying that the learner learns from being taught and teaches the teacher at the same time. She saw this intention as offering learners an opportunity to
become independent and self-motivated in their carrying out of the mathematical activities. She also indicated that this intention encouraged learners to use their own methods and thinking for solving problems.

She further stated that teachers should restructure their teaching methods in line with OBE (she quoted Monau, 2000). She saw this intention projected through critical outcome CO$_8$, and specific outcomes, SO$_6$, SO$_9$ and SO$_{10}$, but did not explain how this intention is related to the identified outcomes. Although she did not directly explain what Monau meant by ‘restructuring of teaching methods to be in line with OBE’, she went on to say that teaching methods should be appropriate to the outcomes and allow learners to be creative, problem solvers and critical thinkers. Teaching and learning, she added, must be open, invitational, challenging to facilitators and learners and must encourage participation and questioning. She cited discovery, experimentation, discussion, group-work and questioning as strategies to be included in mathematics teaching. She added that not only textbooks should support learning but material such as charts, audio and audio-visual media.

Gerty also stated that in OBE content in the various learning areas has to be integrated and not treated in isolation (she quoted Monau, 2000). She identified critical outcomes CO$_7$, CO$_9$ and CO$_{10}$, and specific outcomes SO$_2$, SO$_3$, SO$_4$, SO$_5$, SO$_7$ and SO$_8$, as relevant to achieving the goal of integration. She referred to constructivism and indicated that ideas are made meaningful when children integrate them into their existing structures of knowledge. Content in OBE was interpreted by her based on the output made by the learner. She said that assessment should be based on achievement of outcomes.

Gerty said that a further challenge brought by the new curriculum was to be found in the statement that “all learners are capable of learning and can succeed” (she quoted Monau, 2000, p. 12). The implication was that a teacher must know all the learners in the class and be aware of their individual needs. She felt that the expectation of continuous assessment of individual learners in large classes was a nightmare and impractical. She also mentioned that the focus is on learners’ required use of appropriate teaching aids. She said that learner support material must be provided and schools should have libraries and laboratories to support learning.
Two years later, Gerty was still involved in this study. Reflecting on the implementation of the OBE principles by her university facilitators, she thought that although all the principles were well catered for, she was impressed by how the fifth principle (on time) was attended to. She wrote that since they started attending contact sessions, she had realised that time was not used as a criterion for achieving outcomes, but differences in the rates and aptitudes of students’ learning were considered. This, she felt, was an excellent observation. To conclude, Gerty wrote:

Friends and colleagues, no matter how dark things may appear, do not lose courage. There is light at the end of every tunnel and there is no tower however high that does not start on the ground. The best way to begin with OBE is to begin NOW, but never blindly without a focus. Together U and I in collaboration with SMED can right the challenges of OBE and succeed (Personal writing, May 2002)

Reflecting on her experimentation of ideas — for example on the use of integration of the specific outcomes in her planning of the lessons and on the use of textbook — Gerty wrote:

When I designed activities, I always believed in proceeding from known to unknown or from simple to complex. I planned my work in such a way that SO1 would be treated before SO2, for example. When we had to plan for the third term, I told Satsope that I had to treat SO7 and SO8 before SO9 because the former are about properties of shapes and the later on measurement.... Instead of treating SOs in isolation and regarding the others as related, it is better to give SOs equal attention in planning. .... I have adopted this style of planning my activities that sometimes it is difficult for someone to detect which SO is being addressed since more than one SOs seem to be dominating.... I also learned that activities from the textbook need to be analysed before they are given to learners. (Personal writing, October 2002)

These reflections highlighted some important peak points in her experimentation of some OBE oriented key principles: integration and the use of textbook. She reflected on the same identified points in April 2003. Undoubtedly, Gerty preferred the integration part of her teaching and that was even taken to work across the learning areas/subjects. As part of her April reflections she wrote:
After one of our educators was redeployed at the end of the first term, I had to offer LLC (English) in Grade 9 which implied that I was supposed to offer two learning areas in the Grade. It was sort of a blessing because there is a lot of integration in MLMMS and LLC which I was not aware of. Sometimes when I present my lessons during LLC period, learners confuse it with the MLMMS period. I am able to offer English (LLC) using MLMMS and vice versa. It was also interesting when I gave learners an assignment “to do different shapes to decorate their first page”. Learners confused it with Technology and Arts and Culture. (Personal writing, April 2003)

In summary, early on in the study, Gerty regarded herself as not having enough confidence, information and skills to change from the traditional teaching style to OBE. She also raised the issue of implementing OBE in overcrowded classes as being difficult. She further saw her teaching as initially characterised by her striving to complete the syllabus before the end of the year so that learners could proceed to the next class. After interpreting OBE curriculum documents, Gerty revealed her willingness to participate in in-service training. This indicated her readiness for change. From her interpretations of the OBE intentions the following issues emerged: facilitator’s time as flexible; interaction between culture, the learner, and the teaching of mathematics; both the teacher and the learner as sources of knowledge; a shift from teacher-centredness to learner-centredness; restructuring of teaching strategies; integration of content within mathematics and in various learning areas; time not used as a criterion for achieving outcomes and the use of textbook. Considering what she reflected on regarding her experimentation of ideas, she emphasised the use of integration of the specific outcomes in her planning of the lessons and the use of textbook. These two key ideas appeared to remain her area of focus within the OBE curriculum.

**Response to readings on constructivism**

In this subsection I describe and analyse Gerty’s learning as it unfolded after she had interacted with some readings on constructivism. I use her writings in which she either directly or indirectly quoted some constructivist ideas to support her thinking and her reflections on her interpretation of OBE oriented ideas, her interactions with her learners, other teachers and me.
Earlier on in the study, Gerty reflected on her teaching as being that of encouraging her learners to learn the rules or laws, and axioms or theorems. Seeing her approach as being supported by the absolutists and behaviourists, she felt that learning by rules is often easier than learning by understanding because students experience success immediately. She was aware that less knowledge is involved in learning a rule. She commented further that answers are often obtained quickly and reliably using rules. Comparing this absolutist ideology of learning by rules as easier with constructivist ideas, Gerty said that in constructivism learners are encouraged to think, rather than to work with paper and pencil. Reflecting on her current practice then she regarded her teaching as being supported by behaviourism. At the same time, whilst explicating this position, she also went further to cover features of constructivism and fallibilism. She wrote:

Constructivism and fallibilism did not feature in my teaching. Going through the literature, I realised that the two philosophies encouraged learner participation and therefore tried to include them in my discussion. Absolutism is in line with behaviourism and therefore discussion was discouraged by this philosophy. The absolutists indicate that pupils must be given chance to do exercises and practice Maths (Threlfall, 1996: 19). (Personal writing, May 2000)

It appeared that Gerty based her conclusions on what she read from the literature. She made it clear that constructivism and fallibilism were included to clarify her position regarding 'learning by rules'. The meaning I attached was that Gerty in her practice encouraged learning by rules. In her writing she further pointed out that she employed question and answer, problem solving, self-discovery, discussion and textbook as teaching strategies in her teaching. By employing these different teaching strategies, she saw herself as being supported by constructivism, fallibilism and absolutism philosophies. She accounted for her position in the following manner:

Constructivism states that learners are given chance of explaining their thinking (Kamii, 1990: 30). When learners were given written work, they were given chance to write their solutions on the chalkboard. The fallibilists in Brodie (1991) state that discussion helps to generate questions among the students which extend mathematical knowledge. The absolutists indicated that pupils must be given chance to do exercises and practice Maths and be encouraged to discuss (Threlfall, 1996: 19). (Personal writing, May 2000)
It appeared that as long as a teacher allows learners to write solutions on the chalkboard, it does not matter whether the learners copied the solutions from somewhere, or whether the learners could demonstrate that they understood how to deal with the given work. According to Gerty, that is constructivism. However, she was unclear about how fallibilism featured in her use of discussion as a teaching strategy. According to Gerty, if the teacher interchangeably used question and answer, problem-solving, self discovery, discussion and textbook teaching strategies, it meant that she encouraged learner participation. Gerty said that during oral questioning she used to select learners randomly to avoid having the same learners answer the questions. She therefore involved everyone irrespective of whether a learner's hand was raised. She pointed out that learners must be encouraged to talk and listen to each other.

Two years later, while commenting on what her colleagues (other teachers) used to say informally during breaks at the start of the science and mathematics education program, Gerty said the following:

The given activities were based on pyramids and pattern searching. They raised a lot of fear and concern in most teachers. Some primary school teachers felt that they were not correctly placed and thought of withdrawing from the course because they alleged that the activities were designed for secondary school teachers. Some secondary school teachers, on the other hand, felt that they should not be given activities to work on; instead they should be taught because that is what they came for at UNIN. A lot of confusion reigned. (Personal writing, May 2002)

Here, Gerty suggests that her fellow teachers expected the facilitators to stand in front of the class and provide details of what OBE entailed. Between the lines in this extract from Gerty's writing, I could read two possibilities. One possibility could be that Gerty herself would like to be told about the rhetoric of OBE rather than be asked to put it into practice. But instead of directly saying that, she described the action of other teachers as a way of expressing her view. Another possibility could be that she saw herself as being different from the other teachers.
Reflecting on the strategies used by the university facilitators during the mathematics contact sessions, Gerty stressed:

In designing the activities, they took our prior knowledge into cognisance. They realised that as teachers we know of the basic operations. In activities 1 to 7, we were given chance to detect relationships and to build new ideas on what we knew. (Personal writing, May 2002)

She concluded that the approach — she hinted in the extract above as used by her facilitators — is supported by constructivism. She reasoned that constructivism states that students come into classroom with their own experiences, and a cognitive structure based on these experiences. Citing the literature she further pointed out that teachers must assist students to develop new insights and connect with their previous learning. Gerty’s writing often employed the pronoun ‘we’. To me this implied that she now saw herself as a member of the whole group whereas previously she tended to comment on what other teachers were saying during the breaks. One other notable thing was her regular use of the literature to support her reflections. Regularly when she supported her ideas, she would single out constructivism.

She further stressed that according to constructivism students are encouraged to use their own methods for solving problems. And students are not asked to adopt someone else’s thinking, but encouraged to refine their own. She felt that their facilitators encouraged them as students to use their own methods. Citing an example of what transpired during contact sessions, she wrote:

My most memorable day was when we had to determine the area of a triangle. We assumed the solution would be easy because we knew the formula for determining the area of a triangle to be 1/2 base x height. It was that day that I realized that I did not know what the formula represented. E.g. the facilitator asked: “1/2 of what? It was an interesting discovery and I then realized that it was best to use your own findings than to use someone’s thinking. (Personal writing, May 2002)

Acknowledging the literature she had read, Gerty further stressed that the focus of constructivism is on learner-centredness and encouraging students to apply what they
have learnt in schools to the various and unpredictable situations that they might encounter over the course of their lives. In response to this she wrote:

Our facilitators have successfully used this approach because as students in this project, we are expected to apply what we have learnt to our learners and colleagues in different schools and to our colleagues in different areas. I have already used some activities on patterns in Grade 12 for the section on sequences and series. The approaches used in all activities are learner-centred. (Personal writing, May 2002).

Towards the end of her third year in this study, Gerty reported trialling the approaches, which she learned in her university study, not only in Grades 8 and 9, but also in Grade 12. She pointed out that last year in Grade 12 she had only two learners passing during the monthly tests. The same learners, she continued, obtained a 40% pass as their final percentage at the end of last year. Remarking about the performance of her students since her trial in implementing new ideas she was learning, she wrote:

Since I used the learner-centred methods, my learners’ performance improved so remarkably. It was for the first time in quarterly schedules that we had 3 learners obtaining more than 80% in Maths at the school. Paper 2 which seemed to be a problem to all learners, is no more. Learners enjoy working on Geometry riders and they even request to be given a test in Geometry, which they were reluctant to do last year in Grade 11. (Personal writing, July 2002)

From this I became convinced that Gerty was putting into practice what she was learning during the contact sessions. Notably it also sounded to me that she was trying out the implementation across the Grades she was facilitating.

As part of her reflection, towards the end of her third year in the study Gerty stressed that concepts must be developed before they are given names. She said that mathematical terminology and notations confuse learners if learners do not know how these entities have been developed. As an example she cited the problem she experienced in Grade 9 when treating “Algebraic expression” (this was in one of the lessons I observed). She gave learners rules, (e.g. - x - = +, + x + = +), but the rules seemed not to be working. What she reported having learnt from my intervention
was that as educators we must teach for understanding, instead of teaching to complete the “syllabus”. Reflecting on her classroom intervention, she wrote:

I had a tendency of giving answers to learners if I felt that they were taking time to find a solution. Through Satsope’s facilitation, I learnt that learners must be given chance to work on their own and at their own pace. What impressed me most was her way of facilitating. She would lead a learner through her questioning to realise his/her own misconceptions. Other learners would also realise where the reporter had a misconception and would help clarify it before the facilitator intervened. (Personal writing, October 2002)

This I thought was a step forward because these types of reflections were also used by Gerty as part of her portfolio recordings. I gained the impression that she had taken them into consideration for her further experimentation process.

Finally, Gerty saw that the mathematics component of her university study was designed to provide teachers with opportunities to broaden and deepen their own mathematical thinking processes, abilities and confidence to bring about improved mathematics teaching and learning. Reflecting on contact sessions she confessed:

When I first met Satsope (program facilitator) in the Advanced Certificate in Mathematics Education program and saw how she and her team presented their lessons, I told one of them that I would never apply “their” approaches in my class. I felt comfortable in giving learners a rule or formula and then many exercises to apply it. It seemed to be working in class, but when learners were given tests and exams, they performed poorly. (Personal writing, October 2002)

Embedded in this confession I could detect a process of change. It could be that Gerty was seeing herself as different from where she was three years previously when this study commenced.

In summary, this section describes Gerty’s teaching which started by encouraging her learners to learn by rules. Being aware that less knowledge is involved in learning a rule, she commented that answers are often obtained quickly and reliably using rules. She saw herself employing a variety of teaching strategies. To Gerty, if
the teacher interchangeably used different teaching strategies, it meant that she encouraged learner participation. As she continued interacting with constructivist ideas, Gerty began to trial some constructivist strategies in her teaching, and identified some key issues. These issues are: the importance of prior knowledge in teaching, concept development, learner-centredness, transferability of ideas, and teaching for understanding.

**Learning within other contexts**

This subsection outlines Gerty’s learning within other contexts experienced during this study based on her journal entries and conversations with me during our collaboration.

As part of her reflection writing in May 2002, Gerty raised her concerns and noted that the Department of Education expected teachers to undergo “a metamorphosis” with limited in-service training. In her writing she further acknowledged the importance of her university study.

My first visit to Gerty’s school was marked by some interesting experiences. On my arrival at the school, Gerty came out of the staff room to meet me. On our way to the principal’s office Gerty shared her experience in the school and explained the type of environment we would be working in – the condition of the staff room, other educators’ comments about her classroom practices (both negative and positive), learners’ behaviour and the classrooms’ conditions. On meeting the principal, who was relatively new to the school, we explained the reasons for my visit and for the upcoming visits. The principal welcomed me and was happy with what we intended to do. He said:

You will help us because I do not understand these OBE things. I hate people who just talk about OBE and do not come to our schools to really show us how it works. Just talking as if it is easy to put into practice. We do not have facilities – you see you are better off at the university. Even the MASTEC computer is stolen. Maybe you will help us get another one from MASTEC because you are closer to the bosses there.
From what Gerty shared with me on our way to the office and from the principal’s comments, I could already detect some negative perceptions about the OBE implementation.

After our first lesson, on our way to the staff room, Gerty complained about the class (Grade 9B) we attended and said:

You know Satsope, this class is giving me a headache. They are learning very slowly. Maybe the problem is that they do not have mathematics textbooks to refer to at home. (Personal writing, April 2002)

I became interested to know why her learners did not have textbooks because the Department of Education supplied schools with textbooks. To my surprise I learnt that the Head of Department at the school made a wrong order. She ordered as many copies of the teachers’ guide as the number of the learners in Grade 9 but just one learner’s textbook! As I learnt from Gerty, the Department of Education could not help to rectify this costly mistake. It also had some negative effect on her perceiving the experimentation of new ideas relating to OBE implementation.

The week following my first visit, I arrived at the school an hour earlier so that I could make my suggestion of trying out something different in Gerty’s teaching – to contextualise the sums. In the staff room we first discussed the amended question paper and she was happy about it. Commenting on my suggestion, she felt that it was already late to try out my suggestion especially for the topic that was being taught. We agreed that she would continue and see what came out. She added that she did not want to be behind in what she was supposed to cover for the year. She mentioned the district’s plans and the demands brought by continuous assessment. I detected that Gerty was in a dilemma of prioritising between the district’s demands and the innovation. It appeared that the district’s demands did not allow her space to experiment, therefore she decided to compromise on the innovation.

It was the beginning of the third term of our classroom collaboration and mutual support. After two days of our term preparations, Gerty pointed out that I must stop paying her visits. She documented this disappointment in her journal:
Unfortunately, I could not continue with teaching in Grade 12 because some of the teachers still had to give class work, home work, assignments, practical and about three tests for Grade 12 CASS [continuous assessment as abbreviated in the new curriculum documents] from the 19th August 2002 until 29th August 2002. Not only were Grade 12 lesson periods disturbed, but Grades 8 and 9 as well. Educators requested me to help them in compiling mark sheets, especially in conversions of marks. (Personal writing, September 2002)

I felt disappointed at hearing the above because I saw it as a limitation to our collaboration and experimentation. Later I looked at it more positively. It indicated the cooperation that Gerty had with her colleagues. I also thought that the district office was pressuring the teachers and thus Gerty seemed to be finding it difficult sometimes to make decisions relating to trialling the curriculum implementation.

Reflecting specifically on assessment, Gerty indicated that she had learned that learners should be assessed on an on-going basis (referred to this as CASS) and a record should be kept. She further indicated having kept a record of learners in Grades 8, 9 and 12 in various forms of assessment. She cited an example of what was required from them by the district office and she wrote:

CASS for Grade 12 learners was to be submitted to the district office on the 30th August 2002. We were expected to have given five tests before the said date. I had already given six tests and learners had to select five of the best. My task was to complete mark-sheets from the department. ...When I submitted CASS on the 30th August, the Maths coordinator was impressed by my work and it served as an example to other educators. The principal was also impressed by the remarks from the district maths coordinator and he indicated that my efforts have doubled since the average percentage for learners changed from 16.7 to 39.0 in HG and from 20.8 to 46.1 in SG in 2001 and 2002 respectively. The pass percentage changed from 17% to 64%. (Personal writing, September 2002)

From these reflections I could read some positive perceptions. It would seem that Gerty was now realising the fruits of her trials in implementing new ideas in her classes. She indicated an excitement especially about the remarks that came from the district mathematics co-ordinator. It appeared that her work was found to be impressive and therefore was used to assist other teachers in the district in improving
theirs. These acknowledgements by the district official seemed to have motivated Gerty in her learning. She could see herself a step further. The second message I read from the above journal entries was that even if our collaboration was in Grade 9, Gerty was seeing the benefits in other Grades. That in a way was saying the implementation process of the new ideas was taking place in all the Grades she was facilitating. Repeated also as part of her October 2002 reflections was that her new approach to teaching yielded good results in Grade 12 tests, particularly during that year’s trial examinations. She indicated that there was a remarkable change even in the quality of the results as compared to the other subjects in which the learners usually do well.

In summary, the emerging themes in Gerty’s learning within other contexts are: limited in-service training, lack of supportive resources, (for example, condition of the staff room, condition of the classrooms and no mathematics textbooks for use by learners); district’s plans on the work to be covered for the year and the district’s demands regarding continuous assessment. In this section Gerty appeared to have started with a negative perception. As she progressed with her experimentation, in certain cases she appeared to have gone through a dilemma of prioritising between the district’s demands and the innovation. Later on she seemed to have developed a more positive perception and this resulted in her excitement at the end of our collaboration.

Teacher learning as social

In this section I describe and analyse Gerty’s learning as it unfolded during her interactions with other people in social settings. I begin with a description of learning as she interacted with her learners in the classroom setting. This is followed by a description of her learning during interactions with other teachers. Finally, I discuss Gerty’s learning during her interactions with me as a collaborator.

Interactions in the classroom setting

This subsection begins with a general overview of how I saw Gerty’s approach to her learners during our classroom collaboration. Drawing on my observations of her lessons I construct three classroom vignettes.
Typically, Gerty commenced her lessons by asking questions. Thereafter she allowed learners to work either individually or as a group. She asked learners to share their findings by writing them down (first in their books and later on the chalkboard) and then explaining how they arrived at their answers. She would often ask questions so that learners could defend their positions and in this way she sustained discussion. The following three vignettes provide specific examples of Gerty’s teaching.

**Vignette 1: When to tell?**

On entering Gerty’s class for the first time, I found learners who were seated in 10 groups of 6, mixed by sex. The room had little space to allow freedom of movement. While I was finding myself a seat at the back to join one group, Gerty explained my visit to her learners. Before she started the lesson, she came up to me and explained her plan for that lesson. She said, “we are busy with multiplication of polynomials and conversion of polynomials to product expressions. I realised in their March test, which was their test 2, that they still experienced problems on these. They did not perform well in that test, especially this class”. She then continued with the lesson which was mostly characterised by question and answer strategy. At the start Gerty seemed to be managing her lesson well. During the course of the lesson it seemed the interaction was not progressing as she expected, as indicated by the following:

Gerty: (in front) OK class, take out your homework books and let us continue where we stopped yesterday. Each group come and write your answers on the board. If you have the same procedure and answer as the one already written do not come to rewrite that.

The group responses were as follows:

<table>
<thead>
<tr>
<th>Group 1: (p+3) (p-3)</th>
<th>Group 2: (p+3) (p-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p(p-3) + p3(p-3) )</td>
<td>( p(p-3) + 3(p-3) )</td>
</tr>
<tr>
<td>( p^2 - 3p + 3p - 3p )</td>
<td>( p^2 - 3p + 3p - 9 )</td>
</tr>
<tr>
<td>( p^2 - p - 3p )</td>
<td>( p^2 - 6p^2 - 9 )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 3: (p+3) (p-3)</th>
<th>Group 4: (p+3) (p-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p(p-3) + p3(p-3) )</td>
<td>( p(p-3) + 3(p-3) )</td>
</tr>
<tr>
<td>( p^2 - 3p + 3p - 3p )</td>
<td>( p^2 - 3p + 3p - 9 )</td>
</tr>
<tr>
<td>( p^2 - 6p - p^2 )</td>
<td>( p^2 + 6p - 9 )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 5: (p+3) (p-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p(p-3) + 3(p-3) )</td>
</tr>
<tr>
<td>( p^2 - 3p + 3p - 9 )</td>
</tr>
<tr>
<td>( p^2 + 6p - 9 )</td>
</tr>
</tbody>
</table>
After the group representatives wrote their answers on the board, no one else came up to write an alternative answer to the ones above. To my mind, this implied that the five groups had already established their answers. Gerty, with a smile and moving in between the groups, asked Group 1 to explain how they arrived at its answer. Granny, a girl who was repeating Grade 9, from Group 1 stood up and went to the board to explain.

Granny: We said \( p \) into \( p-3 \) plus \( 3 \) into \( p-3 \) (then she deleted \( p \) in \( p3 \) appearing in their second step) we get \( p^2 - 3p + 3p - 3p \). Then \( -3p + 3p \) gives us zero and the answer becomes \( p^2 - 3p \). (first amendment)

Gerty: You are talking fast Granny. Go slowly, listen to yourself and explain how you got \(-3p; +3p \) and \(-3p\).

Granny: No. There is something wrong in step 2; \( p \) into \( p-3 \) plus \( 3 \) into \( p-3 \) gives us \( p^2 - 3p + 3p - 9 \) and this will become \( p^2 - 9 \) (second amendment)

Gerty: (smiling) Do you agree with what Granny is saying?

Some learners said "yes", some said "no" while hiding themselves from being seen and giggling underneath their desks. Gerty did not indicate whether or not the answer was correct and she proceeded to ask other groups to explain their answers. She asked Group 2 to explain how they got \(-6p^2\). At the same time she asked Groups 4 and 5 to be ready to explain how they got \(6p\) and \(-6p\) respectively. The lesson continued with the learners accounting for their answers and rectifying their mistakes. The members of Group 3 instead of explaining their answer, said that they understood their mistake. Gerty insisted that they explain their mistake. They proceeded in the same way for the other two sums: \((2q-3)\) \((2q+3)\) and \((m+5n)\) \((m-5n)\). For this last sum Gerty focused on the answers given by the two groups:

\[
\begin{align*}
\text{Group 1: } & (m+5n) (m-5n) \\
& = m(m-5n) + 5n(m-5n) \\
& = m^2 - 5mn + 5mn - 25n^2 \\
& = m^2 - 25n^2
\end{align*}
\]

\[
\begin{align*}
\text{Group 2: } & (m+5n) (m-5n) \\
& = m(m-5n) + 5n(m-5n) \\
& = m^2 - 5mn + 5mn - 10n^2 \\
& = m^2 - 10n^2
\end{align*}
\]

Learners argued about the order of the letters. Some learners argued that line 3 in Group 1 was not correct; that it was supposed to be \(-5mn + 5mn\) because \(-5mn\) and
+5nm cannot be added; and that they are unlike terms. Gerty asked them the reason for saying that -5mn and +5nm were unlike terms.

Robert:  (using the mother tongue) “Di em le di en ga di latele le go swana”
(The way the variables are written do not follow each other the same way (my translation)). In the first term, after the 5 follows ‘m’ then ‘n’ and in the second term 5 is followed by ‘n’ then ‘m’.
(Other learners laughed and others said yes, he is right)

Gerty:  Wow!! This is interesting. Does it matter?

Learners: (answering in chorus form) Yes mami! Unlike terms cannot be added.

Gerty (a bit frustrated but smiling) looked at me and started to explain how the order did not make the two terms different and then proceeded to the last part of the two groups’ answers, that is, -25n^2 and -10n^2. Whilst pointing to the board, she asked what the correct answer was and what to do to get the correct answer. Learners became quiet for some time. I then requested Mary from Group 2 to explain how they got -10n^2 While Mary was trying to explain, she used code-switching from her mother tongue to English and back. The bell rang and the period was over. Before this problem could be solved, we left and returned to the staff room.

Commenting on the last sum of the above problem, Gerty indicated to me that she was a bit frustrated when the learners said that 5mn and 5nm were unlike terms. During her interactions with the learners regarding this last sum, I guessed that her frustration, her smile and by her gaze at me were sending a message to say that she had to resort to telling students the answers. This was later revealed by her immediate comment after the lesson: “I did not know whether to tell them or not and if I asked them further questions it was going to drag for too long, so I had to tell them”. She then asked me, “When should I tell in cases like this?” Gerty seemed to be conscious of the decisions she was making in the classroom. Although she did not directly say it, she seemed to be confronted with the situation of trying to move away from the telling issue. But then she seemed unsure whether the way in which she intervened was acceptable or not. Thus, by asking the above question ‘about when to tell’, she wanted some confirmation from me.

***
When I looked at Gerty’s initial classroom interactions as portrayed in the above description, I could see that the learners during whole class’s discussion only talked or responded to her. Learner-learner interaction was missing. Also it appeared that the emphasis was placed on the product rather than the process. This was indicated by her emphasis that if the learners had the same procedure and answer as the one already written on the board, they should not come to rewrite that. Procedure in Gerty’s case was step-by-step writing. And this did not necessarily accommodate individual learner’s thinking or other groups’ thinking. This is generally a reflection of how Gerty was interacting with her learners earlier on in our collaboration regarding her classroom instructional practice. This form of interaction was one of the many issues that we continued to reflect upon after each lesson. Below is the second vignette about the impact of our reflections on this aspect of her practice.

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Vignette 2: It is exciting

My fourth visit took place a week later. At the beginning of the lesson the learners were requested to recheck what happened when they added, multiplied, divided numbers having same signs and those differing in signs. When they worked with numbers, they were able to come out with the commonly used arithmetic rules. Gerty brought in also some examples that required removing the bracket, for example, simplifying sums like \(3(4r)\); \(3(4 + r)\); \(3(4p - r)\); \(3p (4p + r)\) etc. The learners succeeded in explaining how different these sums were. Their work that day looked promising.

Gerty later confronted them with a task of converting polynomials to product expressions. Most learners gave the correct solutions and explained how they arrived at their answers (as expected). Interestingly Gerty spotted one learner who had something different and she asked him to copy his solutions on the board and to explain. The learner wrote:
1) \(3a + 6 = 3\)
   \(3(a + 2) = 1\)
2) \(5rt - 3r^2t^2 = 5 - 3rt\)
3) \(6a^2b^2 - 3a^2b^2 = 3a^2b^2\)
   \(3a^2b^2(2-1) = 1\)
4) \(6ab + 4ab - 2b2 - 2b\)
   \(2b(3a + 2a - b - 1)\)
5) \(4x^2 + x^2 = x^2\)
   \(x^2(4 - 1) = 1\)

On that day (through the facilitator's questions), the learners managed to argue by referring to what they had as solutions and rectified each other. Gerty asked further whether the learners understood what was written on the board. One boy loudly asked for an explanation. The boy who wrote his answer on the board responded:

The boy: (he said it in mother tongue, what follows is my translation) In number 1, I said 3 is the common factor of ‘3a’ and ‘6’ then write = 3 to show that point. In the next step I put 3 outside the bracket and inside the bracket I write ‘a’ because 3 into ‘3a’ goes ‘a’ times plus 2 because 3 into 6 goes two times. I also write is equal to 1 because this 1 comes from the fact that 3 into 3 (common factor) goes 1 time”.

Granny: OK explain number 2.

The boy: In number 2 the common factor is ‘rt’ (he did not write that) and it goes 5 times in 5rt and goes 3rt in 3r^2t^2, so I could just write 5 - 3rt.

Another learner: (seated in front) why don’t you write it like you did in number 1?

The boy: I already know. (Quickly he added ‘rt’ and the brackets and ended up having rt (5 - 3rt)

Granny: What made you to write = 3 in the first place?

Another learner: Because 3 is a common factor that he explained.

They continued in a similar vein with Gerty and I quietly listened to their arguments. As the learner tried to explain how he arrived at the answer for number 3, other learners questioned him and seemed to be successful in convincing him to agree with
their solutions. I was convinced that he understood what he was talking about. However, this method did not seem to make sense to other learners. He used an equal sign to mean something different from how the other learners used it or how we used it to explain its meaning. An intervention by either Gerty or me was necessary here to explain his use of an equal sign but we did not. We were so absorbed in the classroom discourse that day that we did not even realise that the teacher to follow was standing at the door. So we had to apologise and then returned to the staff room.

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Gerty was patient as indicated by the ample time she gave her learners in order to explore a task. To do that she spotted this one learner who had something different. She could have just picked a learner whom she knew and found solutions that many learners would have agreed on for reporting. This marked a move towards pursuing learners’ thinking, into emphasising the process rather than just the procedures and answers. Gerty also accommodated learners’ pre-knowledge and that worked for her. It appeared that she succeeded in fostering an environment that allowed her learners to explain and justify their ideas. That helped to sustain the discussion. There was a moment where Gerty could have intervened – by explaining the use of an equal sign – but she did not. Although Gerty complained about the process being slow, she did not stop to introduce new ideas during her interactions with her learners. This becomes evident in the next vignette.

Vignette 3: Taking time

After several weeks of focusing on ‘multiplication and division of polynomials’ (5 weeks after the excitement) it was time to move on. Gerty’s interactions with learners continued in the same way of engaging learners in discussions and targeting learners who had unusual responses to give reports, to explain and justify their thinking. During a particular day of my visits, Gerty decided to offer her learners the opportunity to start from a practical exercise in learning about ‘data gathering and representation’ – the topic that was also on the list for the Grade 9 syllabus.

Deviating from her usual practice of using exercises from the prescribed textbook, she wrote the following instructions on an A4 paper:
Working in your groups:

- First make a plan on how you are going to find out how many learners in your class like drinking cola; orange; cream soda; strawberry; lemonade; and other.
- Thereafter carry out your plan.
- Represent your results using a table.
- Then use a pictograph to show your results.

The process of data collection went a bit slow as all the 10 groups (with 6 members each) argued on how they would like to operate. As a result, the lesson was extended to two more periods. Their plans to collect data ranged from some groups sending one individual to collect data to some groups sharing responsibilities among the members. The first two target groups to give reports had the following (Figures 3 and 4):

**Group 1**

<table>
<thead>
<tr>
<th></th>
<th>cola</th>
<th>orange</th>
<th>cream soda</th>
<th>strawberry</th>
<th>lemonade</th>
<th>other</th>
</tr>
</thead>
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![Pictograph](image-url)
Figure 3: Responses from Group 1

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<tbody>
<tr>
<td>Cola</td>
<td>Orange</td>
<td>Cream soda</td>
<td>Strawberry</td>
<td>Lemonade</td>
<td>Other</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>11</td>
<td>13</td>
<td>5</td>
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Figure 4: Responses from Group 2
With an interrogative look, Gerty came nearer me and whispered: “how are we going to handle this situation? Especially the incomplete pictures?” Even before I could answer she quickly started an open discussion. While I was still looking closely at the first group’s presentation, and trying to think of the questions I could later ask to invoke a response, one learner interrupted: “If we use drawings like those, how are we going to show numbers like 1 in 11; 3 in 13; 6 etc.?” This question gave Gerty some direction because she nodded her head and said: “Let Group 1 tell us how they solved that?” No one from Group 1 answered and that brought another tension as other learners also seemed not to be seeing anything funny. One boy from the group with whom I was seated commented that he had something in mind but his group refused to accept it because it seemed a long procedure. He wanted to represent one learner by one full picture because there is no half a person or a quarter person. He reported that one member of the group asked if they would draw 50 pictures when they had 50 learners who liked cola. He did not see anything wrong in drawing 50 pictures.

I intervened: Let us use Group 1’s responses. Which drink is represented by the tallest bar?

Learners: (answering in chorus) Cola.

I asked: Which drink is taken by the fewest number of learners?

Learners: Cola.

Further question: Why do you say is cola? How do you know that?

One learner: (saying it aloud) Because in their table they have indicated that 5 learners like cola.

I continued: Does it make sense to have the same answer for both questions: tallest bar and least number of learners?

The learners became quiet and looked at me. For about 10 seconds the class was quiet. “OK”, I continued, “if I can only see the bars not the numbers, will I be able to tell which drink is taken by the fewest number of learners?” Some learners said “yes” in a low tone, some said “no” - doubtful still. They became quiet for a while and then slowly I continued and asked them if I could only see the bars not the numbers, whether I would be able to tell how many learners liked strawberry and how many liked lemonade? My intention for asking these questions was to hint to Gerty on the sort of questions she could ask to bring disequilibrium so that learners could think
seriously. I then rephrased the last question “How will I know which drink is taken/liked by many learners?”

At this point Gerty seemed to have picked up the point I was driving learners towards and took over the questioning.

Gerty: How many learners like strawberry?
Learners: 13.
Gerty: How many learners like lemonade?
Learners: 13.
Gerty and I: (coincidentally asked the same question) How can they be equal and yet represented by different bars?

In certain cases I could not convince myself that the learners really did not know. After asking them the last question above, some learners started laughing in a way that was not indicative of seriousness. It was hard to read from that laughter if the learners were realising something, some direction. Hiding my anger, I looked at Gerty expecting her to call them to order but she did not. I called myself to order so that I become patient. The process was slow and Gerty seemed not to worry about time. She kept on asking questions until one learner from Group 2 said: “check what we have. Ours make sense and is simpler. The numbers on Group 1’s graph do not follow each other the right way. From zero we cannot go to 10 then to 13; 6; 11 and back to 5. In mathematics we cannot write that way.” Some boys laughed. Seriously with a changed face I said, “Why are you laughing?” I regretted this at first but it seemed to work. All learners started to pretend to be serious and to think about the work. One dialogue is as follows:

Gerty: (asked) So you think what you are saying affected the way they drew their graph?
Learner: (code-switching) Yes, that is why graph ya bona e sa kwešišagale. (my translation. Yes, that is why their graph does not make sense).

Other learners started to become freer in sharing their thinking and that assisted in redirecting the lesson to focus on how they could improve their writing of numbers so that they make sense to other people. Another boy from Group 1 was interested in
how the other groups represented numbers like 11, 6 and 13 using pictures. Using the mother tongue, he said "Gape re botšeng gore le bontšhitše bjang tša lena ka dipictures for dimomo tša go swana le 6 le 13 le se ke la no hlwela tše tša rena?" (My translation: Tell us how you have used pictures to show numbers like 6 and 13 and do not just dwell on ours without coming out with the solution?). My interpretation was that this question was directed to Gerty and me because the other groups had the same problem. Fortunately the period was over and Gerty asked the learners if they all heard the last question. She remarked that it would be homework for all of us – to find out how we could use pictures to represent 6 learners; 11 learners and 13 learners. We returned to the staff room.

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Besides the richness in the mathematics content and the learners’ learning embedded in their responses, Gerty’s interactions with the learners as described in this vignette marked a shift to a situation where the learners were challenged to think deeper. Even if some learners seemed to be losing concentration and interest on the way, their use of pictographs opened a new window for their search for meaning. Indirectly, Gerty was challenged to go beyond the mathematics textbook she used for her lesson preparations. I am saying this because when Gerty and I reflected after that lesson, we referred to the textbook Gerty had been using and there we found similar pictures, e.g., those of drawn cars and some were not complete. She commented, “Learning activities from the textbook need to be scrutinized before they are given to learners”. Her challenge became how best she could improve the representation of 6, 11 and 13 learners using the examples of pictures reported in class. Her interactions with the learners that particular day marked another milestone in her learning.

One other issue that Gerty appeared to have picked up was learning how to ‘bring disequilibrium’ during discussion. This was evident in most of her subsequent classroom interactions, where she was able to identify instances/episodes where learners revealed their misconceptions or alternative conceptions. By listening carefully she was able to confront her learners with questions that brought disequilibrium. She captured this learning as part of the reflections in her journal.
She even considered seeing beyond good listening as being important during her classroom interactions. For example, she wrote:

As I listened to the discussions, I realised that the given scale might have led to the misconceptions. Activities given to learners must be realistic. During discussions, one learner indicated that she did not count pictures without ‘heads’ or ‘shoulders’. I then realised that it is necessary to scrutinize activities before they are given to learners. (Personal writing, May 2002)

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The preceding three vignettes illustrated Gerty’s learning as it unfolded through classroom interactions during our collaboration in this study. We first saw her being confronted by a situation that had provoked her to ask the question “when to tell?” This was mainly due to her way of facilitation as learners were only talking with her. In the second vignette, we saw a different picture of her interactions with the learners who were then freely interacting amongst themselves without seeking permission from Gerty. This made Gerty excited although she was still worried about such slow-paced interactions. In the third vignette, Gerty seemed to have fully adjusted to such pace of the interactions. She allowed learners ample time to explore concepts. Somehow she seemed to have understood the value of these learner-learner interactions as confirmed by her journal entries. She wrote:

I have also realised that learners understand better if they are “taught” by their peers. (Personal writing, October 2002)

*Interactions between Gerty and other teachers*

In this subsection I describe and analyse Gerty’s learning as she interacted with other teachers.

Gerty’s involvement in her university study offered her an opportunity to interact with other teachers from three districts of the Limpopo province. Having had opportunities to interact with me for almost two years, upon meeting these other teachers, she revealed that she saw herself as a bit different. This could be confirmed
by her writings as she reflected on her involvement in the university science and mathematics education project. She wrote:

> From the comments given by teachers, it could be detected that they expected the facilitators to stand in front of the class and start giving details of what OBE entails. When talking with teachers during breaks, I realised that they know the rhetoric of outcomes-based education, for example, words like learner-centredness, discovery learning, critical thinking, and problem solving roll off their tongues, but their practices portray their traditional teaching styles and teacher-centredness. (Personal writing, May 2002)

Gerty's use of the words "I" and "the teachers" seemed to indicate that she was distancing herself from what she claimed the teachers commented about. This indirectly tells a story about how Gerty interacted with the other teachers. As she continued with her university study, she revealed having accepted to cooperate as confirmed by the following entry in her journal:

> Initially we wanted the primary school teachers to be separated from the secondary school teachers because it appeared the former were dominated by the latter. As we progressed, we realized that the two groups benefit from each other and everybody was comfortable within the group. (Personal writing, May 2002)

Unlike the previous extracts, Gerty's use of the word "we" in this extract seemed to point to her acceptance as a member of a group. She no longer used "I" and "the teachers". Her interactions with others seemed to be improving. She indicated that everybody (primary teachers and secondary teachers) felt comfortable in belonging to a group. This sense of her belonging is confirmed by the following example that she gave:

> We had a lengthy debate on the concepts "enlarge", extend and increase, until we reached a consensus as a class. (Personal writing, May 2002)

Later on Gerty revealed having attributed significance to the interactions that should go beyond her university colleagues. She saw her interactions as being extended to her colleagues at their schools and also to a wider community outside her school.
Reflecting on how her facilitators at the university allowed them ample opportunities to discuss their various solutions, she wrote:

As students in this project, we are expected to apply what we have learned to our learners and colleagues in different schools and to our colleagues in different areas. I have already used some activities on patterns in Grade 12 for the section on sequences and series. (Personal writing, May 2002)

She still appeared to be missing a sense of ownership in what she regarded as important. Hence she used words like “we are expected to …” She sounded as if it was because of the teachers’ involvement in the project that they were expected to share what they had learnt with those who were outside the project. Gerty’s improved interactions with the other teachers became more evident when she decided to collaborate with the other three teachers from three different schools to jointly write a conference paper that they presented first at the university in November 2002 and later at a provincial conference arranged by Limpopo Department of Education in January 2003. Their research paper was entitled “poor performance of Grade 12 learners in Euclidean geometry”. Through this collaboration Gerty and the other three teachers interviewed 50 learners in their individual schools.

In summary, Gerty’s learning through interactions with other teachers appeared to have evolved by coming to appreciate the comments made by her colleagues involved in the university project. Initially she appeared to be distancing herself from the other teachers. This indirectly impacted on her interactions. As she continued to be in the project, she appeared to have developed a sense of belonging. She could be seen participating actively in the discussions. This sort of interaction was extended to her learners at her school, to her colleagues at her school and even to colleagues outside her school. This assertion is confirmed by her continued collaboration with the other three teachers from different schools. And that resulted in Gerty and the other three teachers engaging themselves in interviewing learners from their individual schools to investigate what they had identified as their common problem. Their further interaction were extended to the university community through their conference paper that they presented. That did not end there as they presented their paper to a wider community at the provincial level.
Interactions between Gerty and me

What follows is a description and an analysis of Gerty's learning as she interacted with me as a collaborator. To organise my description and analysis, I use three phases that appeared to characterise our interactions. These three phases are: negotiating entry, sharing facilitation and becoming independent.

Phase 1: Negotiating entry

Our interactions were not automatic. At the start of our collaboration Gerty just knew me from a distance as her university facilitator and as the ex-coordinator of the mathematics, science and technology education project – the project that her school had been involved in for just one year. Thus her initial interactions with me seemed to be that of a lecturer and a school teacher. She seemed to be conscious of my position. I thought this had some impact on our initial interactions which ended up being characterised by several issues: complaints, fear, lack of trust, lack of confidence, seeking for confirmation, and frustrations. For example, during my first visit to Gerty's school, she complained about her learners in Grade 9B (the class she identified for our collaboration). She pointed out that they had no textbooks, had a problem of expressing themselves in English, were learning very slowly and were not serious in their work. She also complained about her learners' poor performance in Test 1. Gerty did not stop complaining because during my second visit she indicated to me that she did not want to be behind what she was supposed to cover for the year. She refused right away my suggestion that I made regarding an attempt to contextualise learning activities for her class. She mentioned district plans, and the assessment demands. I was frustrated. To confirm her initial fears, Gerty, while reflecting on our collaboration, wrote:

Initially ... I was afraid that I would not be able to treat all the SOs [specific outcomes as abbreviated in the curriculum documents] before the end of the year.

(April 2003)
Gerty was not the only one that experienced internal struggles during our initial contacts. I also encountered some frustrations as it could be confirmed by, for example, the following experience as captured in my field notes:

After observing Gerty’s first presentation, which for me was more on familiarising myself to Gerty and her learners, she asked: “when should I tell?” Hesitantly I replied: “I do not know.” (April 2002)

Obviously, the question was difficult for me to answer. I did not want to appear prescriptive also and wanted Gerty to come up with a solution. After five days, Gerty, still full of complaints about her learners’ slow learning, asked:

If the problem is not solved, what do I have to do? Proceed? Or repeat several lessons to solve the problem? Repeat using the same strategy I used when teaching that section or try another strategy? (April 2002)

The questions Gerty asked were still difficult for me. I once again felt frustrated. At the same time I did not want to answer them because I felt I would be prescriptive. I hinted to her the strict usage of the textbook but Gerty did not want to entertain that. We seemed to be operating at different angles. For her it was more of seeking for confirmation whereas I saw it as a lack of confidence, fear and a lack of trust. These frustrated me and resulted in my fear also. I thought that our collaboration was not going to be effective. I wanted us to interact as equal partners as we collaborated and it seemed not to be working as I thought it would. What kept me going was that I kept convincing myself that maybe it was still early for her to trust me. These examples highlighted above represent generally what characterised our initial interactions during our collaboration.

Phase 2: Sharing facilitation

As we continued, our interactions seemed to be improving. Generally this phase was characterised by openness to each other, acceptance, feelings of togetherness and this resulted in both of us feeling free to intervene during lesson presentations. Reflecting back Gerty had the following to say:
During interactions, Satsope did not just tell me what to do or how, but her leading question made me discover what I should have done or what to do and how. (October 2002)

This extract by Gerty reveals a feeling of appreciation and that seemed to have been brought by me not imposing ideas during our interaction. She appeared to be seeing some benefits in our collaboration, for example,

Since I collaborated with Satsope last year ... We then planned an activity that involved five SOs. ... I am able to integrate the SOs. I have already treated all the SOs in Grades 8 and 9 now. (April 2003)

This example, which starts by indicating team planning, the use of and a move to "I am able", characterises our collaboration into the next phase of our interactions.

Phase 3: Becoming independent

This phase was mostly characterised by Gerty taking control during our collaboration. In certain cases I found myself being called to maintain order as Gerty would take her time to allow the learners to explore. For example, during one of her lessons on 'data gathering and representation' (see Vignette 3), I became impatient and took over the intervention. Although I intended to show Gerty how she could bring disequilibrium and she picked that up, later on when Gerty reflected on our collaboration she wrote:

I had a tendency to give answers to learners if I felt that they were taking time to find a solution. ... I learned that learners must be given chance to work on their own and at their own pace. (October 2002)

What comes out of this writing by Gerty is that she seemed no longer to be worried by the pace of her learners' learning. Instead I was the one who was worried about the pace hence I gave a long intervention. To Gerty, time appeared no longer to be the issue.
She also revealed some signs of being able to make quick decisions in class to sustain the discussions thus moving towards being more independent. For example, as cited in Vignette 3, Gerty with an interrogative look came nearer me and whispered: "how are we going to handle this situation? Especially the incomplete pictures?" Even before I could answer she quickly started a discussion. This, in a way, indicates a move towards more independence and thus towards taking control of the learning process. Generally these marked phase three of our interactions during the collaboration.

In summary, in this subsection I have tried to describe and analyse Gerty's learning as it unfolded through interacting with me during our collaboration. I identified three phases: negotiating entry, sharing facilitation and becoming independent to mark how our interactions progressed. Under each of these phases I identified some themes that I observed as we collaborated. Phase 1: (negotiating entry) was characterised by complaints, fear, lack of trust, lack of confidence, seeking for confirmation and frustrations. Phase 2: (sharing facilitation) was characterised by openness to each other, acceptance, feelings of togetherness and this resulted in both of us feeling free to intervene during lesson presentations. Phase 3 was characterised by Gerty taking control of her learning and later by being able to make quick decisions in class, and thus a move towards becoming more independent.

Teacher learning as distributed

In this section I highlight the distributed character of Gerty’s learning during our collaboration. Earlier on in our collaboration Gerty appeared to have developed awareness that as an educator she needed to share her learning with those participating in the learning context. Although she was reflecting on her university study, her ideas embedded in her reflection confirmed this awareness. She wrote:

As students in this project, we are expected to apply what we have learned to our learners and colleagues in different schools and to our colleagues in different areas.
(May 2002)
Gerty's reflection indicated a need for her to distribute her learning to various co-participants in the learning process. To do this, Gerty revealed herself experimenting her new ideas in her other classes she was facilitating, but not confining her learning in Grade 9, the grade she identified for our collaboration. She wrote:

I have already used some activities on patterns in Grade 12 for the section on sequences and series. (May 2002)

On seeing some benefits on trialling new ideas across her Grades, Gerty commented:

My new approach to teaching yielded good results in Grade 12 tests, particularly during Trial Exams. There was a remarkable change comparing even the quality of results. The performance is commendable compared with other subjects, in which learners usually do well. (October 2002)

Gerty's learning at this point appeared to be mostly distributed among her learners.

Her further excitement occurred after she had submitted her continuous assessment work at the district office. She reported to have done excellent work as compared to other educators in their district. This could be confirmed by what she recorded as part of her journal entries. She wrote:

When I submitted CASS on the 30th August, the Maths coordinator was impressed by my work and it served as an example to other educators. The principal was also impressed by the remarks from the district maths coordinator and he indicated that my efforts have doubled since ... The pass percentage changed from 17% to 64%. (September 2002)

This writing reveals that Gerty's learning at that point was extended to other educators (teachers) in her district. It seems the maths coordinator saw some quality in Gerty's work, which she could use to assist other teachers. In this way, Gerty got some motivation from the appreciation she received from the district maths coordinator and the principal.
Gerty continued to share her ideas to a wider community. To do that, she collaborated with three teachers from three different schools. This is confirmed by Gerty and the three teachers working on a conference paper that they subsequently presented at two levels: university and provincial. During the conferences Gerty and the other three teachers strongly suggested what they would like to see happening in schools. For example, they said.

As Mathematics educators [teachers] we feel isolated at our schools. We need support from our curriculum advisers. Their job description should be modified. During school visits, instead of them counting the number of class-work, homework and tests, they should also assist us in dealing with the problems in our learning area. Educators who produce good results should be used as key educators or be promoted to advisory level to help other educators. (January 2003)

Gerty and the other three teachers suggested that the job description of the curriculum advisors should be reviewed. They indicated as teachers they needed support from the advisors. They would like to see the advisors assisting them in dealing with the problems in their learning area. They also suggested that teachers who produce good results should be used as key teachers or be promoted to an advisory level to help other teachers. These sorts of comments coming from the teachers show a step forward. They showed their confidence in, commitment and dedication to what they were doing. The comments also appeared to be revealing of some feelings of empowerment on the teachers’ side.

In summary, Gerty appeared having tried to distribute her learning first among her learners, especially in Grade 12. Later she felt confident to share her ideas and thus extending them over to a wider community. I highlight here how Gerty’s work was used to assist other teachers in her district and this was made possible by the district maths coordinator. Gerty’s excitement motivated her further. Her learning continued to be distributed across two levels: university and provincial and amongst herself and the teachers from different schools through co-authoring and co-presenting their conference paper.
Chapter summary

In this chapter I employed three characteristics of teacher learning as heuristic devices or convenient organisers to describe and analyse Gerty’s learning. These characteristics are: teacher learning as situated, teacher learning as social and teacher learning as distributed.

*Teacher learning as situated*

Gerty’s learning unfolded after she had interacted with some readings on outcomes-based education (OBE) oriented curriculum documents. She pointed out at the start that she had no confidence, information and skills to change from the traditional teaching style to OBE. Her willingness to participate in in-service training revealed her readiness for change. She challenged the belief that in mathematics “facts” are true irrespective of culture or of the individual or of time. Gerty raised several issues she had learnt from reading about the OBE oriented teaching. These issues included: interaction between culture, the learner, and the teaching of mathematics; both the teacher and the learner are sources of knowledge; restructuring of teaching strategies; integration of concepts or topics and specific outcomes within mathematics and across learning areas; all learners are capable of learning and can succeed; time is not to be used as a criterion for achieving outcomes and the use of textbooks. Some ideas and instructional practices in line with constructivism emerged. These ideas and practices included: emphasis on the importance of prior knowledge; problem solving; learner centredness; transferability of ideas; emphasis on concept development and teaching for understanding. These emergent constructivist ideas and practices challenged Gerty to experiment with them in her classes. Lastly, I acknowledged other contexts that we experienced during our collaboration. Gerty’s school lacked some important learning resources and facilities. For example, the condition of the staff room was not conducive for learning. Gerty, thus, started our collaboration revealing negative perceptions centering on OBE implementation. She mentioned district plans and the demands brought by continuous assessment. These brought some tension as Gerty faced a dilemma of having to prioritise between the district’s demands and innovation. As we continued in our collaboration she became
motivated, especially on seeing benefits in her Grade 12 class. She ended up perceiving the whole activity more positively than previously.

*Teacher learning as social*

Gerty interacted with her learners, with other teachers and with me as a collaborator. My early visits to Gerty's school revealed her being provoked to ask the question: when to tell? Initially her learners, during whole-class discussion, only talked or responded to her. Gerty learnt to encourage learner-learner participation in her class. She also put emphasis on the process in her mathematics teaching. This brought excitement. She could then be seen taking time during her teaching. She was no longer worried about completing the syllabus and consciously encouraged learners’ understanding. Gerty’s social interactions with other teachers improved. She became accommodating of their ideas and learnt from them. She developed a sense of belonging. She continued to collaborate with other teachers she met through her involvement in her university study. They continued working together resulting in Gerty and the other three teachers working on a conference paper based on the research they conducted in their teaching. Gerty’s interaction with me was not automatic. It was characterised by three phases: negotiating entry, sharing facilitation and becoming independent.

*Teacher learning as distributed*

Finally, Gerty’s learning was distributed amongst her learners (particularly her Grade 12 classes), her colleagues at school and colleagues outside her school, including me. This sharing (and thus distribution of learning) took place during her teaching, her interaction with me, her attendance at university courses, conferences and workshops, and informal contact with other teachers in her school and in schools in her cluster.
CHAPTER 5

CASE 2: JOEL

This chapter presents the case of Joel, a male primary school teacher. It follows the same format used in Chapter 4. I have organised my description and analysis using the three characteristics of teacher learning that I identified in my literature review. These three characteristics are: teacher learning as situated, teacher learning as social, and teacher learning as distributed. I use these three characteristics as heuristic devices or convenient organisers.

Teacher learning as situated

In this section, I start by providing a brief background of Joel and his working environment. After that, I describe and analyse Joel’s learning as he responded to some readings on outcomes-based education (OBE) curriculum and constructivism. I also include a description of how his learning unfolded within other contexts that revealed themselves during this study. Thereafter I give a brief summary.

Background

Joel held a three-year Primary Teachers Diploma and at the start of this study had five years of teaching experience. He was acting as a principal and teaching Grade 7 mathematics. Joel’s school was equipped with sanitary water, telecommunication facilities, sufficient classrooms equipped with desks and chairs, enough textbooks (although outdated and not OBE oriented) and good supplies of stationery. However, the school did not have electricity, good security or adequate teaching equipment (such as science kits, mathematics teaching aids, and computers). Towards the end of 2000, the school was electrified and some classrooms burglar proofed to tighten the security. By the end of 2001, it had upgraded the science equipment, mathematics teaching aids, toys for the Foundation Phase, a mobile library, a computer laboratory (one computer for administration use and 14 for use of learners), two printers and a photocopier. These resources were donated by the mathematics, science and technology education schools project (MSP). At the beginning of 2002, Joel applied.
for the principalship post at the same school but was unsuccessful. The new incoming principal, who was from a secondary school, relied on Joel because of his rich primary school experience.

**Response to readings on outcomes-based education (OBE) curriculum**

This subsection outlines Joel’s learning as it unfolded through his readings of some outcomes-based education curriculum documents. I use Joel’s writings and our conversations regarding the interpretation of the new OBE-oriented curriculum, its descriptors, its demands, and how he perceived the role of the mathematics teacher in line with the OBE curriculum, and his new role teaching this curriculum.

Joel viewed OBE as a kind of teaching approach which challenges the traditional way of teaching mathematics. Using OBE, teaching is no longer defined as just the transmission of knowledge, rather it is defined as the process of helping learners to understand information, transform it into their own personal knowledge and apply this knowledge meaningfully. Reflecting on his teaching, he wrote:

> In my lesson presentation, I put more emphasis on content. ... I wanted learners to master the content... my assessment was based on results. In my teaching my starting point was rules not specifics. (Personal writing, July 2000)

Joel’s main emphasis on teaching appeared to be on content mastery. That seemed to have occurred through exposing learners to mathematical rules not the ‘specifics’ taught by him. That influenced the way he assessed his learners. Citing an example from the lesson he presented on ‘the properties of counting numbers’, he wrote:

> I wanted learners to use the principles established by someone, not giving them a challenge to come with their own expression or investigate which basic operations can work with the Associative property. (Joel’s Personal writing, July 2000)

In this extract, Joel stressed his point on basing his teaching on rules. However he appeared to be becoming aware that he did not offer his learners opportunity to think
for themselves. Hence self-expression by learners was limited to what they had been
told. Investigation had not been catered for in Joel’s teaching.

Joel added that according to OBE beliefs all individual learners must be allowed to
learn to their full potential regardless of their background, previous achievement,
age, gender and other differences. He concluded that OBE oriented curriculum
discourages unfairness between learners (both males and females – his interpretation)
and encourages equity (human rights). He perceived in OBE that the attention had
shifted to what the learner should know, understand and be able to do. Joel
explained:

That is learners must not only acquire knowledge but also understand what they are
learning and in the learning process develop appropriate skills, attitudes and values.
(Personal writing, July 2000)

The main point Joel seemed to be bringing forth is equality for all. In acquiring
knowledge, according to Joel, emphasis should be placed on understanding.
Development of skills, attitudes and values should also be encouraged.

Joel clearly stated that OBE’s main focus was on the outcomes of learning which
were long-term with a focus on knowledge, skills, attitudes and values developed
during the learning process. Citing an example, Joel referred to one critical outcome
(CO) stated in the Policy Document saying “A learner should be able to work
effectively with others as a member of a team, group, organisation or community”.
He had seen the emphasis in this case as being placed on co-operative learning.
Learners, Joel added, have the opportunity to work at their own pace and in different
ways, depending on their individual abilities and levels of development. Joel wrote:

OBE further believes that every learner has the ability to do some thing, so it is the
responsibility of the teacher to realise his/her ability. (Personal writing, July 2002)
Joel saw the teacher’s responsibility in OBE as that of realising every learner’s ability. To cater for that, he continued to say OBE requires positive and constructive continuous assessment to measure the development of skills, attitudes and values. The teacher in OBE was seen by Joel as a facilitator of the learning process. As the teacher does the facilitation, Joel thought he/she should accept and encourage different ideas, allowing different opinions and tolerating dissent. He further thought that the teacher also should act as a mentor who advises learners on their approach to learning and on life in general.

Joel further stressed that the teachers of different subjects or learning areas, should work together in their facilitation. He explained:

OBE endorses a more holistic approach where integration of learning content is emphasised, instead of teaching in isolation. Learning should also be related to learners’ culture and their environment. An integrated environmentalist approach as one of the curriculum categories also supports this as it is based on the conception that mathematics should be taught in context and integrated with other subjects (Neyland, 1996). (Personal writing, July 2000)

In this extract, Joel put forth that in the new OBE oriented curriculum the emphasis is on integration. Thus teachers teaching different subjects should work together – team work spirit. He also seemed to be interpreting integration as accommodative of learners’ cultural and environmental background. He backed that up by referring to an integrated environmentalist approach to mathematics teaching. To be more specific, Joel also wrote:

All the 10 specific outcomes in mathematics literacy, mathematics and mathematical sciences will be achieved by developing the learners’ communication skills. Communication is the aid of mathematical thinking and is essential if the learning of mathematics is to be a constructive, positive and successful experience. All aspects of learning, problem solving, critical thinking, discussion, demonstration, etc are bound to develop learners’ communication skills. (Personal writing, July 2000)
Joel raised the importance of developing learners' communication skills. He thought that for learning mathematics to be a constructive, positive and successful experience, learners' communication skills should be developed.

On reflecting on his experience regarding the district's OBE workshops, Joel wrote:

The workshops helped me to get familiar with the concepts used in OBE. My preparation of lessons changed as I had to show the SOs, phase organisers, programme organisers, educators' and learners' activities. From those workshops my classroom arrangement changed, learners were then seated in groups. I was also introduced to the ideology/analogy/principle that 'I do, I remember': that means learners have to learn by themselves. Learning was said to be learner centred. District workshops also helped me to know that educators need to plan together in order to make learning more effective, and that each learning area is related to the other so they need to be integrated when facilitating. (Personal writing, April 2003)

In the above extract from Joel's reflections, it appears that he had familiarised himself with the concepts used in OBE during the districts' workshops. His familiarisation resulted in his inclusion in his lessons' preparations new terminology (such as specific outcomes, phase organisers, programme organisers and educators' and learners' activities). His classroom arrangement changed with his learners seated in groups. It appears that Joel was also introduced to the importance of allowing learners to learn by themselves. Learning was considered to be learner-centred. Joel also learned about integration across learning areas.

Reflecting on his university study, Joel had the following to say:

That helped me to understand OBE better as I compared the way I was teaching with what the approach requires. With the programme I learned that OBE is not totally a new thing as some of the practices done before I was exposed to the approach are also recommended in OBE. I mean that one cannot separate all behaviourist ways of doing things from the constructivist ways. I benefited a lot in the programme as I now know that after every practice I engage myself in I have to reflect in order to
improve on the next day. In class the reflections help me to see whether I presented well and were my objectives achieved and if not, what area need to be improved. I also learned on how to find my learners difficulties and to make them improve. (Personal writing, April 2003)

Joel seemed to have improved his interpretation and understanding of OBE. He found OBE not a 'totally' demanding new teaching or learning approach. He pointed out that in OBE curriculum, one cannot separate a behaviourist way of teaching from a constructivist way. Joel saw his university study as having introduced him to the role of reflection in teaching.

He continued to say that he initially regarded learning in groups as time consuming because he thought that all learners were supposed to report back. To his surprise he was unable to cover all the work he wanted to cover. He reported that now as an educator he just spotted certain groups to give reports, groups with interesting findings and those with misconceptions. He stressed that he came to understand what it means by facilitating learning and what learner centredness is all about.

Reflecting on his involvement in the study, and especially further on his instructional practice, Joel commented:

Since I started to facilitate, attempting to be an ideal OBE facilitator I realised that I was no longer presenting first to learners as I used to. ... To me I am no longer presenting (teaching) instead I make learners learn by themselves. My role is to develop their thinking, monitor their learning process which will automatically lead me to assessing their process/progress when learning. I came to understand 'when they' say learners learn through doing. I am no longer presenting to my learners. I only intervene when learners report their findings and give clarity or even ask clarification from learners. An educator is also a learner in the classroom. This really shows that learners are not empty vessels, they can learn without being told, only through what they know. Simply, I can say they learn from their thinking. Really the OBE approach develops learners to be independent thinkers. (Personal writing, September 2002)
Joel appeared to be reflecting time and again on his learning process and instructional practice. He revealed to have attached a new meaning to, and thus learnt, what it means by learner-centredness. He mentioned that learners can learn without being told and only through what they already know. In this sense, I think, Joel was considering the learners' prior knowledge as a basis for their learning. He also pointed out that learners learn from their thinking. Reasoning in this way, Joel emphasised what he saw as his new role: to develop learners' thinking, monitor their learning process which will lead to continuous assessment. Joel further pointed out that a teacher is also a learner in the classroom. Joel concluded that OBE approach really develops learners to be independent thinkers.

In summary, Joel's learning in this study started by first acquainting himself with the OBE terminology during the district's workshops. Using this terminology to prepare his lessons, he later acquired new meaning of the terms or concepts used and also developed new understandings of those words as he progressed in the study. He started to be aware that he did not offer his learners opportunity to think for themselves. He raised a number of issues: equality for all, cooperative learning, learners working at their own pace and in different ways, the teacher acting as a mentor, emphasis on integration within mathematics and across other learning areas, accommodation of learners' cultural and environmental background, the importance of developing learners' communication skills, the role of reflection, group work, learners learning by themselves and learning through doing.

**Response to readings on constructivism ideas**

In this subsection I describe and analyse Joel's learning after he started reading the documents on constructivism. I use his writings in which he either directly or indirectly quoted some constructivist ideas to support my interpretations about his thinking, his reflections on OBE, and his interactions with learners, other teachers and me.
Earlier on in the study, Joel revealed that he introduced his lessons by posing questions. In that way he tried to link what he was going to teach with what his learners already knew. He cited the following as an example:

The topic was ‘The properties or laws of counting numbers’

Q: What are counting numbers?

A: Counting numbers are numbers that we use when we count things i.e. whole numbers.

Q: What are the elements of a set of Whole Numbers?

A: \[ W = \{0; 1; 2; 3; 4; \ldots \} \]

Q: Name four basic operations.

A: Addition, Subtraction, Multiplication and Division. (Personal writing. July 2000)

Joel thought that by introducing his lessons with questions his approach was in line with that of the constructivists. He justified this idea on the use of question and answer strategy by paraphrasing from Ernest (1996) to say that constructivists see the importance of asking questions as a way of finding out what the child already knows before commencing teaching. He believed that whilst he was still introducing the lesson, the learners should be asked questions that he, as the educator, could answer but the learners could not. He thought that would enable him to link what the learners knew with what he was going to teach. Joel also thought that would arouse learners’ interest and promote their listening and be attentive. When learners failed to answer, he would then provide the answer by presenting the new subject matter. Joel did not explain clearly how he managed the question and answer strategy as it was not clear from his writings whether learners’ constructions were accommodated when questions were asked.

In his presentation, Joel preferred using a narrative method. By using this method, he saw his role as a teacher who deposits knowledge into the minds of the learners. He emphasized that learners had to listen and capture what he was going to give them.
Joel believed that the teacher should be the presenter and the learners should be the listeners and absorbers of what the teacher imparts/teaches. To explain the new subject matter about counting numbers, Joel wrote:

I would explain to learners what properties of counting numbers are. "Properties or laws of counting numbers are the rules we follow when simplifying counting numbers with operations. Those properties are the Distributive, Associative, and the Commutative property." (Personal writing, July 2000)

Joel believed that a teacher should deal with one aspect after the other in his/her teaching of a topic. Taking the Associative property as an example to explain his presentation, he continued:

"If a, b and c are counting numbers, then (A+B) +C = A+ (B+C) and (A*B)*C = A*(B*C)". (Personal writing, July 2000)

Joel indicated that after his explanations he would select a few examples from the textbook and show his learners how the Associative property works. After that, he would use a drill method varying it by sometimes asking questions to capture the learners' concentration. Knowledge delivery, according to Joel, should be applied through giving learners homework or class-work. His assessment had heavy reliance on marks obtained. He reported emphasising rote learning and recall of information in the assessment, but not the application of knowledge or research skills such as critical thinking and problem solving.

About a year later, reflecting on one of his visits into my university class, Joel said:

Today I was just learning like the students. As they discussed, I had new understanding of what I understood by constructivism. The article was just a good piece of work to read. I was challenged every time to keep on reading until I finished up the article. This article also helped me to understand OBE. I had another different version so this article opens up further my understanding of OBE. (Personal writing, June 2002)
Joel reported that he developed new understandings on constructivism and outcomes-based education. He mentioned the reading he shared with his students on constructivism written by Applefield, Huber and Moallem (2000); he indicated how that opened up his further understanding of OBE.

Reflecting on the lessons he presented on ‘fractions’ using Cuisenaire rods, Joel had the following journal entry:

The responses proved to me that learners can think and come up with something from what they see... I realised that I should sit down and really understand what I want learners to learn from the questions given in the activity... I have two questions that stand out to me, when do learners learn? I have two answers to find out: after getting the product (answer) or during the process of finding the product. When we say learners learn through doing, does it mean using resources or when they use their thinking or both? My approach now will try to address the questions. (Personal writing, September 2002)

Joel appeared to be convinced that learners can think and can learn by seeing. He perceived the challenge to really understand what he wanted his learners to learn from given activities. He raised two important questions that he would like to pursue. The first one is: when do learners learn? After getting the product (answer) or during the process of finding the product? The second question is: when we say learners learn through doing, does it mean using resources or their thinking or both? These two questions reveal a huge step in Joel’s learning. He seemed to have realised the need to critically think about the learning process, to critically question the demands of the new curriculum and the implied constructivist approach.

In summary, Joel’s learning appeared to centre on several issues. Those issues are: the importance of asking questions, offering learners an opportunity to think, and teaching for understanding. He further raised two important questions that formed the core of his learning. The first question is: when do learners learn? The second question is: what does it mean when we say learners learn through doing? Joel regarded these two questions as important to him and indicated that his ‘approach’ would try to address them.
Learning within other contexts

This subsection outlines Joel's learning within the other contexts experienced during this study. I use Joel's journal entries and conversations with me during our collaboration.

My first visit to Joel's school (the acting principal then) was marked by elements of cooperation amongst the staff members. On my arrival, already knowing why I was there, Joel quickly went out of the office to the staff room to call other teachers so that he could explain my visit and my other oncoming visits. He found that necessary because teachers at that school knew me already as the mathematics, science and technology education schools project (MSP) primary PRESET-INSET coordinator, thus they had to know my new role.

Joel's school was identified as a nodal school for the other three MSP cluster schools. Serving as a key teacher Joel was expected to run workshops for the other teachers in the cluster schools. His first days of running the workshops for teachers appeared to be marked by disappointments. For example in his journal, he wrote:

What I encountered is the educators were slumbering and some of the issues were not captured. I dominated the workshop and that led to passive participants. (Personal writing, March 2001)

Conducting a workshop is not like presenting a lesson in a class....The thing that I noticed was the problem of managing time. One other thing is the attendees took it that as I am facilitating it means that I know better than they do. Fortunately the problem was solved. (Personal writing, May 2001)

In the first example, Joel indicated to have been confronted with a situation in which he spent most of the time talking alone. He realised that he dominated the workshop and that resulted in the participants slumbering. In the second example, Joel found conducting a workshop being different from presenting a lesson in the classroom. He appeared to have experienced a problem of managing time. Also, Joel appeared to have experienced a problem with the participants. Hence he said that the attendees
took it that as he was the facilitator he knew better than them. I thought that this remark implied that Joel was confronted with the questions that he had no answers at the time of the workshop. That brought disappointment on Joel’s side. The disappointment was confirmed by his reflections later as he continued to run some more workshops. He wrote:

There were areas whereby I attempted to answer all questions asked as a facilitator....This was not good as I acted like a master mind....I learned that when conducting a workshop and a question is posed, it is not for the facilitator to answer it. The question should be posed back to the entire participant group and discussed. This is a nice skill of conducting a workshop. This should be done so that if the facilitator doesn’t know the answer the participants will help. On the other hand if the facilitator tries to answer the question directly and fails, the workshop might degenerate and the facilitator lose direction. (Personal writing, May 2002)

Joel indicated having learned how to manage questions raised during a workshop. Rather than regarding himself as a mastermind, he preferred to pose the questions back to the participants for a discussion. He realised that managing questions is important and concluded that it was “a nice skill” in conducting workshops.

Joel also appeared to have worked well with the district office. His journal entries indicated that he planned his cluster workshops in cooperation with the district officials. For example, he wrote:

This was a school-based workshop – to be prepared with the arrangement of the school management. According to the district office a workshop of this kind should be held in the afternoons. So I had to plan the workshop for the time stipulated by the district. My manager did not have a problem with that. (Personal writing, March 2001)

The other challenge Joel mentioned was that OBE emphasises that different stakeholders in education such as the community, teachers, learners and parents share the responsibility for learning. There must be cooperating partners both in curriculum development and implementation. To this, he stressed:
The thing is, the people from our community when they are called for a meeting at school, they do not show up. The implementation of the approach will be somehow difficult. (Personal writing, July 2000)

Joel called for cooperation by all, particularly the community. It seemed the community in which Joel’s school was situated, did not respond to invitations for school meetings. Thus Joel saw that as a challenge to the implementation of the new OBE curriculum. Almost two years later, Joel appeared to have learnt how to involve the community better in the education of their children. He wrote:

MSP also validated it to me that all stakeholders share responsibility for the learning process of the learner and that if parents are shown the purpose of their part in the learning process of their children, then they are supportive. It showed me that the usage of Technology media is important if it is only used sufficiently. (Personal writing, April 2003)

Joel highlighted the importance of making the purpose clear to the parents regarding the learning process of their children. He pointed out that if parents are shown the purpose of their part in the learning process of their children they become supportive. The usage of technology media was also brought into the picture. Joel in this case specifically referred to the computers that they received as a donation. That appeared also to have been a contributing factor to the support he received from the parents or the community.

In summary, Joel cooperated well with other staff members at his school. With his school identified as a nodal school he became the key teacher and worked with three cluster schools. He, therefore, was expected to facilitate workshops for the cluster schools and that went beyond his three cluster schools. He cooperated well with the district office and appeared to cope with its demands. Initially the community was not responding to his invitations to them for meetings. Later, when the people in the community realised the progress that had taken place at the school, they started to be supportive. The big difference seemed to have been made by the introduction of computers at the school. In short, the contextual factors experienced that had contributed towards Joel’s learning included his working relationship with other staff.
members, his school having been identified as a nodal school, his working relationship with the district office and the role played by the community in which the school is situated.

**Teacher learning as social**

This section provides the description and analysis of Joel’s learning during his interactions with other people in social settings. I start by describing and analysing Joel’s learning in the classroom with his learners. This is followed by how his learning unfolded in interactions with other teachers. Lastly I present how his learning unfolded in interactions with me as a collaborator.

**Interactions in the classroom setting**

This subsection gives a general overview of how I saw Joel’s approach of presenting himself to his learners during our collaboration. To give a clear description, I include two classroom vignettes showing how Joel interacted with his learners. The heading I use for each of the two vignettes generally explains my opinion of each lesson.

Joel’s approach to interacting with his learners appeared generally to be that of offering learners an opportunity to take control of their learning. In turn, learners took upon themselves to direct their daily activities, making sure that they proceeded from where they stopped in the previous lesson. And this occurred in cases where the given activity was said not to be satisfactorily handled. It appeared both Joel and his learners shared the responsibility of asking questions where necessary.

**Vignette 1: Sharing control and code-switching**

As we entered the classroom, the learners, who were seated in six groups with six members of mixed sex, stood up and greeted us in a chorus. Together we responded positively to their greetings. As I was trying to find for myself a place at the back of the room to sit, Joel explained how I was going to be involved with them throughout the year. While some learners were still showing welcoming smiles, one girl who
seemed to be serving as the leader of one group stood up and said: "OK class let us continue with the corrections". Without hesitation every one of them took out his/her scribbler and they started discussing in their groups question by question. Joel came nearer me and said, "they are discussing how they have attempted questions for our district mathematics common test 1". As he moved from one group to the other questioning and sometimes requesting clarification, it appeared to me that the learners were stuck on one question. The question read:

Six learners attended a class party and ate a variety of food. Something caused them to become ill. John ate pizza, hamburger and pie and become ill. Mpho ate hamburger and pie but not pizza and become ill. Lorraine ate pizza but neither hamburger nor pie and felt fine. Dudu did not eat anything and also felt fine. Refilwe ate pizza and pie but not hamburger and became ill. Jane ate hamburger and pie and stayed away from pizza, he also gets sick. Determine the food that probably caused the illness. (April 2002)

All I could see were that some learners worked as individuals first, then talked to their neighbours and thereafter joined the bigger group. Joel was moving from one group to the other questioning and in certain cases encouraging. It seemed the learners were all struggling to make sense of the question. That went on for a while until Joel interrupted and said: "OK let us all try to attach meaning to this question. Who can explain to us what you understand by this question?" One learner stood up and whilst struggling to explain in English his understanding he stopped and said: "Sir, I want to explain using my mother tongue". Even before Joel could answer all learners agreed and said: "Yes, yes we will understand better". Explaining it slowly in N. Sotho (the language that they could all understand) one boy then quickly rose up and rushed to the front, picked up a chalk and started writing. On the board was written:
Answer is Pie

One learner seated at the back said aloud: “No sir, he can’t just write let him explain how he arrived at the answer.” That boy explained using code-switching from English to N. Sotho and back to English. For a while the learners became engaged in a discussion in their individual groups while Joel remained quiet and moved from one group to the other. This time I could hear voices shouting “I got it” and sometimes expressions of frustration as other learners were still making sense of the question itself. It seemed that they did not want to take the summary as it was written by that other boy at the board. Some were still busy, the bell rang and we went out of the class to the office.

Joel quickly asked me, “Do you think there is anything wrong in allowing code-switching in teaching mathematics?” I thought Joel was indirectly trying to bring language as an issue with regard to this particular activity. It appeared that he felt a bit unsettled when his learners during my presence used their mother tongue. He indicated having realised that his learners made sense of the question after it had been explained using their mother tongue. Although the question had more to do with the reasoning skill, it appeared that the learners encountered some problem with the language used. Also, the problem could have been created by the type of food mentioned in the activity.

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It appeared to me that Joel managed to share control with his learners during classroom interactions. There were indications of good communication between Joel and his learners - freedom of choice. On one occasion a learner pointed out that he
wanted to explain a question in his mother tongue. Although the learners were still young you could hear them disagreeing out loud in certain cases. This indicated to me that Joel was succeeding in centering on the learning process of his learners. If learners could understand better when they used their mother tongue they should be allowed to code-switch and thus construct their own knowledge.

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Vignette 2: At home with multiple realities

Whilst on our way to the class, Joel explained how his learners were exposed to the computer “Math Trek” program to learn about creating number patterns. He was excited as he explained how the newly received program from the mathematics, science and technology education schools project (MSP) works. As we entered the classroom, the learners seemed to be preparing themselves to go to the computer room and Joel with a smile announced that we would be working in the class.

Looking a bit disappointed, no one this time stood up to say what should happen. Quietly Joel then moved to the board and wrote: “Look at the following pattern 1, 3, 5, 7, 9, 11 - . Can you find the next number I should write?

One learner: (quickly answered) 13.
Joel: How did you get 13 Thelma?
Thelma: I just guessed.
Another learner: (trying to help Thelma) It is a pattern of odd numbers.
Magoro: Because we add 2 to get the next number. That is, we add 2 to the previous number to get the next one.

Joel at this stage intervened and explained how they could know that their answer was correct. By referring to the numbers on the board he pointed out that it was the addition of two to the last number. Then whilst writing he said: “Here is another pattern 1, 2, 4, 8, 16, 32 - . Come out with the explanation of how this pattern works. How is this pattern formed?”
For a while the learners worked in their groups. As Joel moved from one group to the other, the learners did not seem to notice him and kept on talking with each other. He was then attracted to one group and he was smiling as he observed them. I quickly stood up and became interested in what he was doing. One learner was trying to convince her group members to listen to how she was seeing the pattern. What follows is what she had:

```
1  2  4  8  16  32
1  2  4  8  16  32
```

She continued, Every time I add the previous number to itself then you get the next number. Check 1+1=2; 2+2=4; 4+4=8; 8+8=16; 16+16=32; 32+32=64 therefore the answer will be 64.

One other member of that same group said: We just continue using times.

Another girl: No. We add not multiply.
Joel: Generally how can you explain this pattern?

This time it seemed that all learners heard Joel's question. It was no longer just one group's question as one learner from another group shouted: "We add each number two times to get the next number." Even before Joel could make some follow-up remark, two learners following each other said: "We add each number one times to get the next". "We add the number that we get to get the second number". There was one girl seated at the back who was quiet for a long time. She stood up, went to the front and said: "To get the next number we multiply the previous number by two".

Joel asked: Why's that?
She said: Because the number we will multiply with is a prime number.
What a surprise. I did not expect that reasoning. Already I thought this learner was going to come up with a good reason and that she understood the pattern.

Joel: (relaxed) Is 4 a prime number?
Learner: Wait, a prime number is a number having only two factors. Then 4 is not a prime number. (This was the same learner rectifying her mistake)

There was another learner from the group I was seated with. She saw the pattern as:
2x1=2; 2x2=4 2x2x2=8 2x2x2x2=16 and so on she continued.

I asked her to explain to me how she got that. Unfortunately she couldn’t explain how. Because Joel did not see her, she was not given a chance to share her understanding.

Joel insisted that they should think carefully again to address his question. He said, “Check the given patterns closely and carefully. Use all the operations to trace how the pattern was formed”. Thereafter each group was asked to pick up one pattern from the ones given. They had to first find the next number to be written and then explain in writing first how the pattern was formed. The patterns given were:

53; 48; 43; 38; -
176; 167; 158; 149; -
1; 2; 4; 8; -
26; 38; 50; 62; -
1; 4; 16; 64; -
26; 32; 38; 44; -

The learner who introduced the multiplication bit in the previous pattern (1, 2, 4, 8, 16, 32) was seated with the group that Joel was trapped in their discussion. He used his same reasoning for the pattern 1, 4, 16, 64, - and had:
This was the learner who was called to order by one girl who insisted and said: “No we add not multiply”. Working alone this time, the learner continued and wrote:

\[
1 \times 4 = 4 \\
4 \times 4 = 16 \\
16 \times 4 = 64 \\
64 \times 4 = 256
\]

It appeared that this learner was convinced that multiplication was working. What seemed to be his problem was to convince his group-mates so that they could see what he was seeing. Two other girls who were seated next to him were struggling to confirm his answer by using addition. They had:

\[
\begin{array}{ccc}
64 & & 64 \\
64 & & 64 \\
+ & 64 & + & 64 \\
64 & & 64 \\
\hline
2416 & & 264
\end{array}
\]

These two learners looked puzzled but could not detect what their problem was. Repeatedly adding, they seemed not to be getting the answer they were looking for, that was 256. Joel at that time was seated with another group that was trying to convince him about their response. The period was over and we left the classroom.

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Joel's learners appeared to be finding it hard during this lesson on 'pattern spotting' to generalise the given patterns to meet new situations. It was exciting when members of the same group failed to convince each other on how they saw the patterns. Some learners could only see addition working while others approached the patterns by applying multiplication. Interestingly, they did not agree on what approach to use. After giving the explanation of how the first pattern worked, Joel decided to offer them sufficient time to explore on their own. He appeared relaxed and kept on asking follow-up questions to provoke the learners to think deeper. His questioning skill was excellent. He also seemed not to be worried by the shouts the learners made. Learner-learner participation was excellent. On reflecting on his facilitation he commented in the following manner (and I found the same comments later in his journal):

I realised in one of the MSP workshops that follow-up by the teacher to wrong answers given by learners is important. The teacher should not just say to the learner "that is not correct". The teacher should tolerate the learner as there was a thinking that led to the wrong answer. The thinking behind which brought the learner to the wrong answer should be investigated by the teacher through asking the learners questions on how he/she came to the answer. By explaining, the learners can therefore realise their faults and from that point they can get through to the correct answer. These are all what an OBE mathematics teacher should do by facilitating the learners' creative thinking. Most of us (the traditional teachers) are interested in the clean work done in the home/class work book of the learner not realising that most of the thinking is shown on the rough paper the learner has thrown away. (Personal writing, May 2002)

What I could deduce from these journal entries by Joel are: the importance of asking follow-up searching questions, tolerance by the teacher, respect for learners' responses, the teacher's investigation of learners' responses or learners' thinking, encouragement of the learners' explanation and self correction. Joel stressed that all these are what an OBE mathematics teacher should do to facilitate the learners' creative thinking. He also highlighted that 'traditional teachers' are interested in the clean work done in the home/class work books of the learners without realising that most of the thinking is shown on the rough paper the learner has thrown away. Joel
emphasised a shift towards marrying the process and the product in teaching mathematics. That is, he emphasised the accommodation of the process in the learning process. This was an excellent point entered by Joel in his journal.

Joel further regarded reflection as playing a major role in his teaching. To this he added:

The mathematics teacher should always reflect back on whether his/her objectives are attained or not. If attained, how? and if not, why? and where the problem lies? In simple terms he/she has to keep a diary or a journal, recording the happenings about a previous lesson or activity.... I have to reflect in order to improve on the next day. In class the reflections help me to see whether I presented well ... if not what area needs to be improved. I also learned on how to find my learners difficulties and to make them improve. (Personal writing, April 2003)

Joel emphasised the role played by reflection through journal keeping in his teaching. He concluded that reflection is important for the mathematics teacher. He pointed out that through reflection he had learned how to improve his classroom facilitation. And that in turn helped him to make his learners improve their learning.

He continued and commented that he initially regarded learning in groups as time consuming because he thought that all learners were supposed to report back and to his surprise he was unable to cover all the work he wanted to cover. He reported (April, 2003) that now as an educator he just spots certain groups to give reports: groups with interesting findings and those with misconceptions. He stressed that he came to understand what it means by facilitating learning and what learner centredness is all about.

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In summary, these two vignettes illustrate how Joel’s interactions with the learners impacted on his learning. At the start of our classroom collaboration his learners already had control over their learning. Joel appeared not to be worried by their
shouts, their disagreements and freedom to code-switch from English to their mother tongue to try to make sense of the question. All these could be traced in the two vignettes presented. Particularly in the second vignette, Joel was seen relaxed with learners' various ways of attaching meaning to the given patterns. He succeeded in provoking learners' thinking through questions to explain their responses.

**Interactions between Joel and other teachers**

In this subsection I describe and analyse Joel's learning through interacting with other teachers.

Joel appeared to have gained confidence to interact with other teachers through his university study and through being engaged in the mathematics, science and technology education project (MSP). He also worked well with his colleagues at school. During our collaboration, Joel accepted to make his first paper presentation at the Association of Mathematics Education of South Africa (AMESA) provincial conference. After having experienced interacting with other teachers in a wider community, Joel wrote:

> I found it difficult to present at the beginning but during the process I became settled and continued with confidence. The only problem in the beginning was the stage fright. I think as mathematics educators we need to be empowered by being given an opportunity to conduct workshops at school level and even with cluster schools. (Personal writing, May 2001)

It was not easy for Joel to present his first paper at a provincial conference. He indicated that it was the first time he had attended a conference. During his presentation he reported having gained confidence. He said that mathematics teachers need to be given opportunities to conduct workshops at school level and with cluster schools. He seemed to be motivated to take further steps in his learning. Reacting to comments made after his presentation, Joel accepted that they were critical questions for him to further develop his thinking. He later shared with me the following:
Presenting is to be taken as a developmental process. The comments helped me as I would like to see myself presenting the very same paper at another conference. (Joel, May 2001)

Joel pointed out that conference presentations should be taken as a developmental process. He also indicated that he would like to continue presenting papers in conferences.

Joel went on to work with other teachers. He conducted workshops at his school, in the cluster schools and also in the combined cluster schools. After interacting with teachers on several occasions, he wrote, as part of his journal entries:

What I noticed is that educators do not teach the learners topics they find difficult for them as educators. They don’t even make an attempt to consult and search for references on how to teach that particular topic. Really the workshops are essential for all of us as educators. (Personal writing, September 2001)

Joel mentioned the role of literature in teaching. He pointed out that he had noticed that teachers did not teach topics they found difficult. It was not clear in this case whether he included himself in this observation and whether he was also not teaching what he regarded as the difficult topics.

Joel’s interactions with other teachers continued to be taking new shape – improving every time they met. He seemed always aware that all of them were learning. For example, in his second year working as a key teacher, Joel documented in his journal that as teachers they have learnt to respect each other’s ideas. He wrote:

The purpose of our meeting was to help each other on how to prepare and present an activity in a mathematics class....Participants noticed that the response given by someone should be respected and think on what the person came up with. (Personal writing, May 2002)

Team work spirit appeared to be encouraged as Joel then saw himself as also a participant during the workshops – no longer regarding himself as just a facilitator.
This could be confirmed by his use of words, for example, ‘our meeting’; ‘to help each other on how to prepare and present’. He further hinted the importance of discussion and reflection during his interactions with other teachers in a workshop setting. He wrote:

Participants should discuss ... Suggestions should be discussed... Reflections done in a classroom situation is more or less the same as in a workshop. Misconceptions during the conduct of a workshop should be recorded for improvement. It is important for one who is conducting a workshop to model and demonstrate then allow the participants to reach consensus and agree on something rather than to regard yourself as an expert. (Personal writing, May 2002)

Joel emphasised the role played by discussion and reflection in working with teachers. He did not regard himself as an expert. He thought that participants should be allowed to reach consensus rather than always seek answers from the facilitator. He also regarded modelling and demonstration as important strategies for facilitation.

In summary, Joel gained confidence to interact with other teachers through his university study and through his involvement in the project. This resulted in his presentation of a conference paper for the first time in his life at the provincial level. He was motivated by the comments and the suggestions made during the conference. He also conducted workshops at his school, and in the combined district cluster schools. He highlighted the role played by the relevant literature. As he continued interacting with other teachers, he pointed out that he had learnt to respect other teachers’ points of view. He also emphasised the importance of discussion and reflection. He discouraged the consideration of himself being an expert.

*Interactions between Joel and me*

What follows is a description and analysis of Joel’s learning through interacting with me as a collaborator. To organise my description and analysis, I use three phases that appeared to characterise our interactions. These three phases are: setting a goal, setting a pace and feeling empowered.
Phase 1: Setting a goal

After five weeks of visiting Joel and working with him in his classroom, Joel said to me:

To be honest with you Satsope, I do not see that much of a problem in the way I teach. I could manage that only if you could help me in journaling. I want to reflect better and, I am convinced, that would help me improve my teaching (Joel, May 2002).

Joel was bold enough to tell me that his interest did not lie in our classroom collaboration. My initial plan was for Joel and I to collaborate in the classroom. Seemingly, I had my expectation and Joel had his for our collaboration. I thought I would assist Joel in pursuing ‘assessment as in OBE’. That was because he identified assessment as the area he felt he needed to change in his writing in the year 2000. He appeared to have changed his focus. He was convinced that if he was able to reflect better through writing journals he would improve his instructional practice. I was confused for a while and disappointed. Hiding my feelings, I asked him how he would like to have us do it and where he would like us to begin. Quickly he took out his last year’s mathematics, science and technology education schools project (MSP) journal and then took out one sheet as an example. That sheet appeared to be what he regarded as a micro-plan. He then said:

'Tomorrow I am having a meeting with educators (teachers) in our cluster. I have to facilitate the meeting on ‘how to plan an OBE lesson’. I think that is where we should start. I do not know whether what I am doing is the right thing, but I am following the guide we received from the district on how to plan an OBE lesson (Joel, May 2002).

We then agreed to meet the following day starting early in the morning to finalise his preparation because the meeting with educators in his cluster was to be held in the afternoon. Although I felt disappointed I convinced myself that maybe it would not be a good idea to disagree with him about that. Hiding my disappointment, off I went to the university.
On my way back to my work I struggled with my ideas. I did not know whether I took the right decision or not. My initial agreement with him for the collaboration was based wholly on classroom observations. It seemed that we were then taking another direction. I thought of his learners, how interesting it would be when they work and asked each other questions, etc. I thought there would be no harm if I continued to attend Joel’s lessons. At last I thought if that was what he wanted, fine. Let me just go for it so that we would see what we would learn from our collaboration. Otherwise my focus was to be on his professional learning not on what the learners would do if he facilitated their learning. I felt I should just leave him to take control and direct his learning.

Phase 2: Setting a pace

Following the day when Joel indicated his focus of our collaboration was not in the classroom, we met at Joel’s school to jointly plan for the afternoon workshop he was to run for his cluster schools. He was worried that he seemed not to be doing it the right way. He pointed out that he would like the teachers to ‘construct’ how to plan an OBE lesson rather than his telling them how he was doing it. He raised the question: “Is there a difference between preparing for an activity and lesson preparation?” Without addressing Joel’s question I requested him to show me how he planned for the workshop. Evident was a plan in which he neatly outlined the learning area, phase organiser, programme organiser, learning programme, focus, main specific outcome, related specific outcomes, resources, facilitator’s activity, learner’s activity and a hint on assessment. Under this focus he had ‘creating number patterns’. I suggested that we use the same activities he gave his learners in class the previous day to plan for the workshop. That seemed not to be making sense to Joel. Instead of responding to my question, he looked surprised.

He asked: How to do that because I have already indicated what the facilitator’s activity and learner’s activity are?

My response: OK, if it happens that you are held up resulting in you not managing to go to the workshop would another teacher be able to run the workshop on your behalf using the same preparation you have?
Quietly Joel revisited his preparation and for a while he seemed to be giving it another thought. Slowly he responded, "No, my preparation is not telling the whole story. I should think we need to clearly outline the activity first. But the problem would be using the word ‘activity’ more than once. Won’t that be misleading?" I then requested him to think about the words that we could use to substitute the word in those cases where he had facilitator’s activity and learner’s activity. I was cautious not to be prescriptive and wanted Joel to take the lead in whatever we were doing. Still showing the learning area, phase organiser, programme organiser, learning programme, focus, main specific outcome, related specific outcomes and resources on top of his preparation, we included a better-designed activity. He decided that the word ‘role’ sounded appropriate for substituting the word ‘activity’ in the brief writing about his expectation regarding what the facilitator and the learners would be doing when the outlined activity was carried out. Joel loudly remarked:

Wow, it seems it is becoming easier to know what to say or to write under facilitator’s role and the learners’ role if you have clearly outlined the activity on top. It makes sense. After the teachers have carried out the activity I could then ask them what they see as the roles of the educator and those of the learners when the given activity was carried out. (Joel, May 2002)

Joel felt that should be enough for the day as time was already against us. For the last part on assessment, he decided to use the same guide he received from the district office. He indicated that he still needed some assistance on designing an observation sheet. I did not accompany him to the workshop.

A day after Joel had run his cluster workshop, he phoned me to request an appointment. I suspected that he encountered some problems during the workshop. Friday afternoon was the only time I could have and that was three days after the workshop. His main concern was centred around the question: "What to reflect on and how: class situation versus workshop situation. Will the reflection be the same or different?" What follows is what I found from Joel’s journal entries:

After I worked with a colleague firstly trying to come up with a micro plan (and daily preparations) I found that there is no lesson without an activity. With the
activity I have to know what I want learners or teachers to learn, as I have that I should know how should they learn that...Reflections done in a classroom situation is more or less the same as in a workshop. Misconceptions during the conduction of a workshop should be recorded for improvement. (Personal writing, September 2002)

Joel indicated that classroom presentations are not that different from workshop presentations. He realised that challenging learners’ misconceptions helps to bring about improved learning.

Joel continued that way, calling me for meetings that addressed different issues when he felt the need. For example, he called (June 2002) to say that the school had received mathematics equipment from mathematics, science and technology education schools project; therefore I must pay him a visit to unpack the boxes. His main intention was for us to check whether what was inside the boxes could help him teach ‘fractions’ using a practical approach. After unpacking the boxes, we then spent two days planning several activities on ‘fractions’ for his Grade 7 class using Cuisenaire rods. During September 2002 he also arranged for a meeting. The purpose for that meeting was to brainstorm how he could design a ‘self assessment form’ for learners. His suggestion was to separate items suitable for a ‘self assessment form’ from items suitable for a ‘peer assessment form’. We did that and he came up with rich questions that accommodated a variety of skills. Examples of the questions included (in the self assessment form) were:

Did I read all the instructions for the given activity? Did I understand all the questions asked? What was my understanding? What are my responses to the questions asked? Which question was difficult for me and what was the difficulty/problem? Did I share my problems with other group members? What were their responses to my problems? Which ideas for getting the answers did I share with other group members? Did I give other group members chance to talk?
Phase 3: Feeling empowered

Reflecting on how he viewed his teaching during our collaboration, Joel wrote:

The most important thing I like and which I think should be done (even though I have not gone deep into it) is collaborative teaching. All these came after I had someone whom I went with to the class. (Personal writing, September 2002)

Joel regarded collaborative teaching as important. He added that our collaboration was a good one because for him OBE concepts had become clearer. He claimed that because of our collaboration his learners developed “a real trust” (his words) in him. He added that through our collaboration he learnt how to design activities. He pointed out that this was important for him because he previously relied heavily on textbooks and was unable to make use of the suggested materials in those textbooks. He indicated having learnt to adapt ideas from the textbook and that cautioned him to be creative. He stressed that in the following manner:

This factor (referring to the collaboration and support) is good as learners develop a real trust in the educator, they admire what their facilitator wants from them as they realise that someone different from their educator also needs that. I learned how to design activities while working collaboratively. This is important to me as I relied much on the textbook of which I was unable to use some of the material as they did not outline how to use those materials in those textbooks. …I learned that there is a need for an educator to be creative and not rely on other’s ideas but rather adapt the ideas. (Personal writing, April 2003)

Joel pointed out that the support he received during our collaboration helped him to reflect on his practice. He mentioned that the introduction of writing journals had made a big difference. He wrote:

I had a problem when coming to reflections (journaling). The support I got helped me to overcome the problem as I was helped on that. It is good to journal as it promotes self-development and it makes a facilitator become a lifelong learner. But if you don’t journal you might not notice that you have learned something from the learners that day. (Personal writing, April 2003)
Joel concluded that reflection promotes self-development and lifelong learning. He pointed out that if a person did not write journals he or she might not notice that he or she had learnt something.

In summary, in this subsection I have tried to describe and analyse Joel’s learning as it unfolded through interacting with me during our collaboration. I identified three phases: setting a goal, setting a pace and feeling empowered to mark how our interactions progressed. Under each of these phases I identified some themes that I observed as we collaborated. Phase 1: setting a goal was characterised by Joel becoming honest and bold enough to tell me that his interest for our collaboration did not lie in the classroom. He became vocal in refocusing on our collaboration and thus gave it a new direction. I became confused and disappointed. I struggled with my ideas but ended up going for the new direction. Phase 2: setting a pace was characterised by Joel calling for meetings and suggesting what should be discussed. In all the meetings we team planned whatever issue he brought to the table. I was careful not to impose my ideas on him or appear prescriptive. As a result we both experienced a fair exchange of ideas. Phase 3: Feeling empowered was characterised by Joel sharing what he learned from our collaboration. He mentioned his being able to do most of the activities alone, for example, designing learning activities, adapting activities from textbooks, feelings of creativity, reflections and writing journals. He singled out “journaling” and stressed that journaling promotes self-development and makes a facilitator to become a lifelong learner.

**Teacher learning as distributed**

In this section I describe and analyse Joel’s learning from a distributed perspective.

After presenting a paper for the first time at a conference, Joel felt a need to share ideas with other teachers at his school and outside his school to a wider community. He pointed out that sharing empowered him when he conducted workshops for teachers. He commented:

> I think as mathematics educators we need to be empowered by being given an opportunity to conduct workshops at school level and even with cluster schools.
Conferences offer more opportunities for us educators to meet and share ideas. It is where issues that bother educators are clarified. I accepted the comments as critical questions, comments and suggestions are main factors that develop an educator. ...I would like to see myself presenting the very same paper at another conference. (Joel, May 2001)

Joel said that conferences offer opportunities for teachers to meet, share and clarify ideas. He added that comments and the suggestions made during conferences contribute towards the development of a teacher.

Joel indicated that during our collaboration he was exposing his learners to learning using the computer. He hinted having introduced the theme ‘pattern spotting’ using the program ‘Math Trek’ (see Vignette 2: At home with multiple realities, p. 98). Much of his interest and time was also devoted to facilitating workshops for his colleagues at his school and to the cluster schools. They shared, for example, learning activities Joel brought to the workshops on both mathematics content and mathematics teaching, how to design learning activities, how to micro plan and how to prepare and to present OBE-oriented lessons.

In summary, Joel tried to distribute his learning to a wider community — first at his school with his learners in the classroom and other staff members, then in cluster schools and finally at provincial level by paper presentations. His major contribution was made through facilitating workshops within his district.

Chapter summary

In this chapter, I have described and analysed Joel’s learning using as heuristic devices, three characteristics of teacher learning: teacher learning as situated, teacher learning as social and teacher learning as distributed. In each case I have considered Joel’s learning as it unfolded from the beginning of the study until at the end of our collaboration and mutual support.
Teacher learning as situated

Joel’s learning was situated when he interacted with some readings regarding outcomes-based education (OBE) curriculum documents. Early on in the study, Joel viewed his teaching as based more on rules, content and product but he became aware that process in teaching mathematics is also important. Several issues were also highlighted regarding his learning within the OBE curriculum. For example: equality for all; cooperative learning; acceptance and encouragement of different ideas, opinions and tolerance of dissent; teacher acting as mentor; facilitation of learning, emphasis put on integration and role of reflection. Some ideas and instructional practices that emerged were considered by us to be in line with constructivism. For example, Joel emphasised the importance of asking questions to find out learners’ prior knowledge. He also pointed out that during the introduction of the lesson it was important to ask a question that provokes learners’ thinking – complex, problem-based and real-life problems. He raised two important questions that formed the core of his constructivist learning and revealed a huge turn around in his professional learning — when do learners learn? and how do learners learn through doing? Joel became challenged to experiment by trying to answer these questions for himself. Lastly, I also acknowledged some contextual factors that had an impact on Joel’s learning during our collaboration. They included cooperation with the other staff members at his school, the school identified as a nodal school resulting in him serving as a key teacher, district demands and community involvement. Joel positively coped with the challenges he encountered and thus learnt more than expected.

Teacher learning as social

Joel’s learning was social as he interacted with his learners in the classroom, with other teachers at conferences and workshops and with me as a collaborator. In the classroom setting, Joel shared control of the learning process with his learners, promoted teacher-learner relationships and respected every learner’s ideas and freedom of expression. Joel’s interactions with other teachers were further provoked after he presented his first conference paper and workshops in his and other schools. Our collaboration was first based on his classroom but later was refocused on
working with the teachers in the workshop settings. Reflection through writing journals became the main activity for our collaboration. Joel was empowered by our collaboration.

Teacher learning as distributed

Finally, Joel’s learning was distributed across his learners, his colleagues at school level, his colleagues in the cluster schools and beyond in a wider community. This was done through the sharing of computer skills, discussions on constructing OBE oriented lesson plans, micro plans, and curriculum materials and through a paper presentation at the provincial conference.
CHAPTER 6

DISCUSSION

The study reported here highlights some important aspects of teacher learning. In my description and analysis of data I used as heuristic devices or convenient organisers three important interrelated characteristics of teacher learning: teacher learning as situated, teacher learning as social, and teacher learning as distributed. What emerges from the two case studies are several questions clustered around these three characteristics of teacher learning.

The first cluster of questions concerns the situated nature of the learning of the study teachers. These questions are: (1) How is teacher learning situated within the specific and critical outcomes listed in the new South African outcomes-based education (OBE) curriculum? (2) How is teacher learning situated within the constructivest views that are implied by OBE? (3) How is teacher learning situated within other contextual factors experienced by the two study teachers?

The second cluster of questions looks at social aspects of teacher learning. These questions are: (1) How is social interaction facilitated in the classroom setting? (2) How is social interaction facilitated when a teacher is engaged with other teachers? (3) How is social interaction facilitated between the teachers and me (as a collaborator)?

The final question looks at the distributed nature of teacher learning. In particular I am interested in: How is teacher learning distributed across a wider community who employ artefacts that teachers come to share?

While recognising that the answers to these questions may overlap and intersect, nonetheless, they provide me with some useful starting points in examining my understanding of the learning of these two teachers.
Teacher learning as situated

In my examination of the situated nature of teacher learning I am guided by three questions about the OBE curriculum, about constructivism and about other continual factors.

*How is teacher learning situated within the specific and critical outcomes listed in the new South African OBE curriculum?*

In this question I am interested in how the learning of the two study teachers, Gerty and Joel, was situated in the context of the curriculum reform. Both teachers were engaged in an intense way with some of the detailed theoretical ideas behind outcomes-based education. They chose to engage with these ideas through their participation in university study, their interactions with me and with their colleagues. Moreover, they experimented with these ideas in their own practice with the learners in their classrooms.

When I examine their writings about outcomes-based education (OBE), several key issues come to the fore. For example, in Gerty’s writings and conversation with me she referred to a learner-centred approach, using authentic situations to contextualise lessons and relying on varied learning resources, not just one textbook. She also referred to a balance of skills, knowledge, attitudes and values. She emphasised the importance of changing to a more integrated type of planning within and across the various learning areas. She also highlighted the use of textbooks and a classroom culture of rightness. In Joel’s writings and reflections on his university study and on workshops’ facilitation he referred to equality for all and development of knowledge, skills, attitudes and values. He emphasised a shift towards a more holistic approach where integration of learning content within mathematics and across learning areas is encouraged, that is conceptual interrelatedness. He highlighted the importance of reflection, group-work, learning through doing and the new roles for teachers.

Both teachers engaged with these issues in different ways. In trying to answer the question about how they situated their learning in the context of the new curriculum I focus on those issues which they reflected on during their classroom
experimentation. These issues are integration of specific outcomes or concepts in their mathematics teaching, a classroom culture of rightness, the use of textbooks the role of reflection and new roles for the teacher.

The first issue concerns the way in which the two teachers attempted to incorporate integration of outcomes and concepts in their mathematics teaching. In both case studies, the data revealed a shift from designing activities that isolated the basic skills, teaching these separately and building these incrementally before tackling higher order tasks, to the integration of specific outcomes in the designing of the activities. In Gerty’s case, for example, while in her third year in this study (October 2002), she reflected on how she shifted from her belief in proceeding from ‘known to unknown’, from ‘simple to complex’. She explained in October 2002 and again in April 2003 that through our collaboration she had learned to adopt the style of designing activities in a way that it was becoming difficult for another person to detect which specific outcome of mathematics was being addressed. Also she reported being able to integrate mathematics concepts across other learning areas and cited an example of her English teaching (Personal writing, April, 2003). For Joel, on the other hand, his shift in promoting integration in instruction appeared to have occurred through team planning.

The second issue — a classroom culture of rightness — concerns how the two study teachers gradually broke away from a belief that in mathematics, there is only one correct answer to every question or problem. According to this belief or pattern, questions have no different alternatives or points of view. This was proved not to be the case after Gerty and Joel adopted a practical approach in designing the learning activities. They discovered that learners come out with different understandings and that these understandings had sense from their points of view. For example, in Gerty’s case, this becomes more evident in the way that she facilitated her learners to use pictographs to show the results of their data collection. Her learners were confronted with a situation where each group’s representation made sense. For example, using a scale to represent 6 learners, 11 learners and 13 learners on a pictograph the same learners argued and questioned their mathematical representations when they looked at the task from a real life point of view. Joel, on
the other hand, invited learners to offer their own explanations of how different patterns work. Different responses were accommodated.

The third issue deals with the use of textbooks in shaping the practices of the study teachers. In particular, I am interested in how their learning about OBE teaching was shaped by the presence of textbooks. Both the study teachers used textbooks with titles indicating that they were OBE-oriented. Earlier in the study, most exercises that learners worked on were strictly taken from those textbooks. These exercises from the textbooks had something in common. That is, they reflected a particular view of mathematics, starting with the definition of concepts. Then, learn the rules, laws, axioms and theorems, followed by work with the symbols and mathematical signs. Application of rules, laws, axioms and theorems comes later in life.

The data from both case studies revealed a shift from the teachers taking the tasks as they were presented to scrutinising and adapting the tasks. Whilst reflecting (October, 2002) on her learners' responses, Gerty, for example, stressed that activities from the textbook need to be analysed before they are given to learners. This also marked a move towards questioning what is valued as mathematical knowledge by those who were seen as authorities of the subject (authors of textbooks in this case). Gerty commented about this point on several occasions in her journal. Joel pointed out that he learned that there is a need for the teacher to be "creative and not rely on other's ideas (textbook) but rather adapt the ideas" (Personal writing, April, 2003). Thus, for Gerty and Joel, the textbook lessons provided two types of resources: access to mathematical ideas and a map of the mathematical terrain (set of topics to be addressed) within which knowledge could be constructed, and materials (mathematical concepts, representations, and tasks) with which to build on. By themselves, these textbooks did not provoke reflection or change. Adapting the textbooks to learners' needs was part of the learning of the two teachers.

The fourth issue concerns how reflection featured in the two study teachers' learning. The data revealed that the two teachers' engagement in reflective practice did not occur suddenly but rather as a gradual and thoughtful process over time. Their reflective practices appeared to have been provoked by their involvement in the university study. Joel, for example, engaged in reflection when he compared the way
he was teaching with the OBE approach. Gerty was also engaged in the same reflection exercise during her university study. This reflective activity, as pointed out by Joel, provided a context for deconstructing ideas about current practice that were no longer viable and for constructing a vision for a more conducive OBE-based environment. That freedom to explore opened new pathways to construct a vision of what classrooms could be. Clear evidence of the role of reflection is seen in Joel’s practice throughout the study, especially in his involvement as a workshop facilitator. He confessed: “I now know that after every practice I engage myself in I have to reflect in order to improve on the next day” (April 2003). This shows confidence and commitment in Joel’s learning.

The final issue concerns how the two study teachers defined what they saw as their new roles. The data revealed that only after the two study teachers had defined for themselves what teaching meant in an OBE environment, they became challenged to experiment with their new understandings of the term. For example, Gerty defined teaching as not a one-way process. Rather, she saw it as a process based on mutual dialogue. This influenced the way Gerty saw her new role as a teacher. She emphasised that both the teacher and the learner are sources of knowledge. She saw her role as that of serving as the guide and supporter of the learners’ invention of viable mathematical ideas, rather than transmitter of her own way of doing mathematics. Joel, on the other hand, defined teaching as the process of helping learners to understand information, transform it into their own personal knowledge and apply this knowledge meaningfully. Defined in this way, he saw his role as that of realising every learner’s ability through positive and constructive continuous assessment to measure the development of skills, attitudes and values. This way of understanding teaching influenced Joel’s learning during his facilitation role. He said, “I came to understand ‘when they’ say learners learn through doing. I am no more presenting to my learners. I only intervene when learners report their findings and give clarity or even ask clarification from learners”.

Teacher learning, for these two study teachers, seems to be situated in each teacher’s attachment of meaning to the key reform concepts or ideas. Each teacher’s learning was also situated in the individual’s engagement with the process of outcomes within mathematics and across learning areas, a classroom culture of rightness, the use of
textbooks, the role of reflection and teacher’s role. Gerty, for example, emphasised the integration of specific outcomes, and scrutiny and adaptation of ideas from textbooks. She is seen throughout the study pursuing these ideas. Joel is seen emphasising the role of reflective practice through journaling. Other key ideas or issues were gradually brought into the picture during the teachers’ classroom experimentation.

How is teacher learning situated within the constructivist views that are implied by OBE?

In this question I am interested in how the learning of the two study teachers was situated in the context of the constructivist teaching ideas underpinning the OBE reforms. Both teachers were engaged with readings on constructivism. As part of their experience they were also taken through a process of reflection that allowed them to compare their current beliefs and practices with beliefs and practices grounded in constructivism shared from the readings. The language and concepts of social constructivism were woven into their university experience, their interaction with me and with their colleagues. Moreover, they experimented with these ideas with the learners in their classrooms.

When I examine their writings and conversations with me on their practice, several key issues come to the fore. For example, Gerty refers to how she gave learners opportunities to explain their thinking and use their own strategies to solve problems, considered prior knowledge and concept development, and encouraged learner-centredness, transferability of ideas and teaching for understanding. Joel, on the other hand, refers to the importance of asking questions as a way of finding out what the learners already know before commencing teaching and as a way of finding out the thinking behind learners’ or colleagues’ responses, offering learners opportunity to think and teaching for understanding. In trying to answer the question about how they situated their learning in the context of constructivist teaching and learning I shall discuss the following issues common to both teachers: teachers’ and learners’ prior knowledge, learner centredness, transferability of ideas and teaching for understanding.
The first issue concerns teachers' and learners' prior knowledge. I infer how Gerty's and Joel's initial beliefs contributed towards their learning as they continued experimenting with new ideas. The data highlighted the recursive nature of the two teachers' learning in relation to their initial ideas or beliefs. For example, Joel indicated early in the study that he believed in asking learners a difficult question towards the end of his introduction. This, he thought, provided him with the opportunity to teach his learners by linking their pre-knowledge with what he intended bringing as the new content. The same ideology led Joel to experiment with new ideas by giving learners complex, problem-based type of tasks that would cause them to seek his guidance. To offer that guidance he asked follow-up questions to the thinking behind his learners' responses. Joel's focus on asking complex or difficult questions to learners reveals a top-down view of instruction (Applefield, et. al., 2000). In this view learners are intentionally confronted with complex tasks that can only be performed with a teacher's guidance. This creates an immediate need to develop relevant skills. Joel continued using this same approach even when running workshops for teachers in his cluster schools. For example, when teachers (as his learners in a workshop setting) were faced with an activity on 'building polyhedrons and on solid nets', they had to first discuss and negotiate with Joel their understanding of the activity before they could proceed.

Gerty, on the other hand, reflecting on what she learned during the university course, recalled how her prior knowledge on 'determining the area of a triangle' was challenged. She also shared (May 2002) how she used her university experience to employ activities on patterns in Grade 12 for the section on sequences and series. Gerty's learning confirms what Feldman (2000) argues, that is, in the same way that a learner must become dissatisfied with his/her understanding, a teacher must become discontented with his/her practical theory because he/she recognizes it as unsuccessful or because it leads to dilemmas in practice.

With regard to learners' prior knowledge, Gerty reflected (October, 2002) on the problem she experienced with Grade 9 learners when they were learning about 'multiplication of algebraic expressions'. She gave them rules, e.g. \(-x = +\); \(+x = +\), but the rules did not seem to be working. This experience led her to conclude that concepts must be developed before they are given names. She also noted (October
having learned that mathematical terminology and notations confuse learners if they do not know how those terms and notations were developed.

The second issue concerns learner centredness. Learner centredness in this study involves another type of learning that appeared to play a significant role in the changes observed in both teachers' ideas and practices. It concerns what both Gerty and Joel learned about learners themselves. Through observing and analysing their learners' approaches to and struggles with mathematical tasks, they both gained insights into learners' abilities and ways of thinking and learning. For example, Joel reflecting on his observation of learners' learning about 'fractions using Cuisenaire rods'. He stressed that their responses showed him that learners can think and generate ideas from what they see. These encounters with their learners' understandings and struggles encouraged the teachers to revisit and to refine their goals and expectations for their learners' learning. For example, Gerty shared how her Grade 12 learners enjoyed working on geometry riders since using a learner-centred approach. Her learners even requested to be given tests in geometry. These changes appeared to influence the two teachers' interpretations of and responses to their learners' work.

The third issue is about transferability of ideas. Gerty emphasised that students must be able to apply what they have learned in schools to the various and unpredictable situations that they might encounter over the course of their lives. She learned about this through observing her university mathematics' facilitators modelling learner-centred approaches. She tried to use the same approach in her lessons at school. For example, after learning about pattern spotting at the university, she used some similar activities in Grade 12 for the section on sequences and series. Some of these activities were also tried in her Grade 9 class. Joel, on the other hand, transferred ideas through the use of learning resources. Joel's school was fortunate to be involved with a project that supplied resources or equipment. He was exposed to the use of these resources during the workshops he attended. Joel then used similar resources, in flexible ways, to foster his learners' active participation in meaningful learning activities, for example, his use of computers in introducing learning about patterns. Also, learners were exposed to learning about fractions using the Cuisenaire rods.
The fourth and last issue concerns teaching for understanding. The data revealed the two study teachers' attempted to change their instructional practice in favour of teaching for understanding. For Gerty, teaching for understanding meant moving away from giving learners a rule or formula and then many exercises to apply those rules, to give learners chance to explain their thinking, to use their own strategies for solving problems and to develop concepts. In order to work towards teaching for understanding, Gerty provided her learners chance to work on their own and at their own pace. Examples of how she interacted with her learners in the classroom are provided in the second and the third vignettes described in Chapter 4. Gerty thought that her attempt to teach for understanding was benefiting her Grade 12 learners. For example, she wrote in her journal, "Since I used the learner-centred methods, my learners' performance improved so remarkably. It was for the first time in quarterly schedules that we had 3 learners obtaining more than 80% in Maths at the school..." (July 2002). What Gerty regarded as teaching for understanding appeared to support what she valued or honoured as good student performance.

For Joel, teaching for understanding meant really understanding what he wanted learners to learn about the questions given on the particular activity. He attempted to show what he meant and what he understood by teaching for understanding by raising two questions that I find very important for teacher learning. The first question is: when do learners learn, after getting the product (answer) or during the process of finding the product? The second question is: when we say learners learn through (by) doing, does it mean using resources or when they use their thinking or both? Raising these types of questions, I think, reveals a milestone in teacher learning, especially when they come from the teacher not the researcher. The motivation for Joel's learning, especially in this case, appeared to be coming from within. I say this because he wrote in his journal: "my approach now will try to address the questions" (Personal writing, September 2002). This, I think, indicates the type of teacher learning that influences teacher decision making processes. Joel had set for himself the goal of trying to teach for understanding.

For each of these two study teachers, learning about teaching underpinned by constructivism appears situated in the kinds of explorations that they were engaged in as they experimented with the new ideas. Their construction of knowledge appears
to be situated in the context of prior knowledge, their learning about learners (learner centredness), transferability of ideas and their understandings about teaching for understanding.

*How is teacher learning situated within other contextual factors experienced by the two study teachers?*

Teacher learning has much to do with contextual factors. For each of the teachers there were challenges and pressures, coming not only from the teaching, but also from the school culture and district demands. In this question I am therefore interested in how the learning of each of the two study teachers is situated within the broader context.

Both teachers revealed a readiness for change at the start of this study. Gerty, for example, felt a need for in-service training. Although her school had limited resources and facilities, she had the support of the principal. She also cooperated well with other staff members. What shook her a little bit were the district term plans and the demands brought by continuous assessment, particularly in Grade 12, the final grade of the further education and training band. Thus Gerty felt pressure to respond to what the district valued as important. And, at certain times this pressure put her in a situation where she reverted to relying on the prescribed textbook (exercises) in order to cover the syllabus. This could be confirmed by her indication that she did not want to be behind in what she was supposed to cover for the year. She wrote: “it seemed to be working in class, but when learners were given tests and exams, they performed poorly.” (Personal writing, October 2002). Only after seeing the benefits of trialling the new ideas underpinned by what she understood by constructivism and teaching for understanding was she encouraged to continue. Gerty also became excited when the district mathematics coordinator acknowledged the quality of her work. Over the period of the study, she further developed positive perceptions towards the new curriculum reform.

As the acting principal, Joel on the other hand, found it easier for him to get the cooperation and the support from the other staff members for in-school experimentation. I think the major contributory factor for his readiness for change
was the identification of his school as a nodal school for the other three cluster schools. Accepting his new role as a key teacher, Joel found himself having to operate in another context, providing workshops for other teachers. In this context Joel’s learning encompassed the development of facilitation skills that worked back into his classroom. Extending his facilitation role to outside his school worked to his advantage because in that way he won the support of the district office. His commitment and dedication resulted in greater parental involvement and support for the school, something that he reported was not happening previously.

In summary, the two study teachers’ learning is also to be situated within the broader context. In Gerty’s case for example, these contextual factors included the cooperation and support of the principal and his colleagues, district demands for common testing and term plan completeness, and requirements for continuous assessment. For Joel, these include his role as a key teacher working with other teachers in cluster schools, district support and parental involvement.

**Teacher learning as social**

In this section I study teachers’ learning as they interacted with their learners, with other teachers and with me as a collaborator. To organise my discussion, I use the second cluster of questions listed at the beginning of this chapter.

*How is social interaction facilitated in the classroom setting?*

In this question I am interested in how the classroom social interaction contributed towards the two study teachers’ learning.

The data revealed that the two teachers learned about mathematics and its teaching, by being present with learners’ learning. Being present was being learning centred. For Joel, being present was being there to ask follow-up questions after incorrect answers were given by learners. He commented: “the teacher should not just say to the learner ‘that is not correct’. ...The thinking behind which brought the learner to the wrong answer should be investigated by the teacher through asking the learners questions on how he/she came to the answer” (May 2002). For Gerty, the presence of
the teacher is indicated by being able to spot areas where learners revealed having misconceptions or alternative conceptions. According to Gerty, in this way the teacher becomes a diagnostic assessor and intervenes by asking questions that bring disequilibrium during discussions. To be alert to learners' learning requires a teacher who is a good listener to learners' thinking rather than listening for only the right answer. Joel emphasised what he meant by the thinking behind 'wrong answers' and talked of "facilitating the learners' creative thinking" (May, 2002).

For both Gerty and Joel, as they struggled to be aware of their learners' learning, they explored the content in preparation to facilitate learner's learning, examined ideas underlying learners' confusion, and engaged in mathematical thought with learners. Gerty's approach of scrutinising textbook activities, adapting them for her learners and regarding learners' errors or misconceptions as important for giving whole class remedial work led her to examine mathematical ideas more closely and, consequently, to deepen her understanding of these ideas. The process of asking learners follow-up questions as they struggled with particular tasks led Gerty and Joel to explore the mathematical ideas underlying tasks. Gerty and Joel also found that revisiting the tasks set helped them make sense of learners' responses to those tasks. For example, Gerty wrote: "As I listened to the discussions, I realised that the given scale might have led to the misconceptions. Activities given to learners must be realistic" (May, 2002). Encounters with their learners' understandings and struggles prompted the two teachers to refine their goals and expectations for learners' learning. These changes seemed to influence their interpretations of and responses to learners' work, thus also improved the teachers' questioning skills.

The data also revealed the two teachers' attempts to contextualise their instructional practice. For Gerty, this contextualisation process was gradual. For example, in May 2000 she insisted that she was not going to change her style of selecting questions from the prescribed textbook because "learners are examined on content from the syllabus and emphasis is on output". She stressed that unless the syllabus is changed she will continue with how she had been planning her lessons. The first vignette in Chapter 4 illustrates this point. Gerty resorted to providing learners with exercises selected directly from the textbook. She continued with this practice until the second month of her third year in this study. The second and the third vignettes in Chapter 4

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show how her practice changed. Joel’s attempt to contextualise his instruction occurred a bit earlier, as indicated in the first vignette in Chapter 5.

In both cases, towards the end of our collaboration in this study, the teachers’ journal entries revealed some learning about contextualisation of instruction. For example, Gerty’s emphasis on scrutinising textbook activities and adapting them for her learners led her to integrate new ideas and design classroom tasks that were open-ended multiple-solution learner problems (see vignette 3 in Chapter 4). Joel took the opportunity of letting his learners work some mathematics activities using ‘Math Trek’ computer program. In that way his learners worked on multiple-solution problems. Vignette 2 in Chapter 5 also shows Joel’s attempt to expose learners to multiple-solution learner problems.

For both teachers, substantial learning seemed to occur during their facilitation of tasks in their classrooms. While the classroom activities may have been initiated by tasks or ideas from the textbooks, it was the teachers who were actively involved in pursuing the discussions of ideas. As they initiated the classroom discussions, they responded to their learners’ learning by being more curious. This, in turn, led to the two teachers reflecting on their learners’ learning on the spot and also after their classroom interactions. Joel, for example, commented about his reflective practice in the following manner: “The mathematics teacher should always reflect back on whether his/her objectives are attained or not. ...I have to reflect in order to improve on the next day. In class the reflections help me to see whether I presented well” (April, 2003). A shift towards these implied goals as shown in Joel’s comment, reveals learning by reflecting on the spot and reflecting after the lesson presentation.

_How is social interaction facilitated when a teacher is engaged with other teachers?_

In this question I focus on the conditions that supported the two study teachers’ learning during their interactions with other teachers. The data revealed that both the two study teachers did not locate their learning only in their classroom interaction. They cooperated with the staff members at their schools and other teachers outside their schools.
Both Gerty and Joel enjoyed collaborative working relationships with teachers at their schools and also outside their schools. This sharing was done in different ways. For example, in his role as a key teacher, Joel met with other teachers on a regular basis in cluster workshops for common planning and sharing of experienced classroom problems. These collaborative efforts provided Joel with additional materials as well as encouragement to try new ideas and acquire facilitation skills. Joel’s appreciation of his learning during workshop facilitation is revealed by his reflections after the workshops. For example, he wrote: “It is important for one who is conducting a workshop to model and demonstrate then allow the participants to reach consensus and agree on something rather than to regard yourself as an expert” (May 2002). For Gerty, on the other hand, her collaborative working relationships were developed during her attendance with other teachers at the university. Her continuing opportunity to interact with other teachers resulted in the production of a joint conference paper with three other teachers from different schools.

Thus, the type of the collaborative working relationship experienced by each of the two teachers appears to have played a crucial role in their individual learning. In both cases there was the opportunity for participants to discuss ideas, teaching strategies and classroom experiences; critique each other’s practices; support each other’s efforts; obtain information and sustain their efforts to reflect, examine, experiment and change in attitude and in current practices. In settings such as these, teachers also shared the frustrations or disappointments they encountered. Joel, for example, recalled how, early on, teachers in his workshops expected him to give responses to all of their questions. After the workshop, he reflected: “the attendees took it that as I am facilitating it means that I know better than they do. Fortunately the problem was solved” (May, 2001). Gerty also shared how initially one of the university students supported the idea that the primary school teachers be separated from the secondary school teachers during contact sessions (this is described in Chapter 4). Frustrations or disappointments such as these also contributed towards the two teachers’ learning.
How is social interaction facilitated between the teachers and me (as a collaborator)?

The collaboration between Gerty and me was challenging in many ways. It required considerable negotiation in order for us both to be fully present in the activity. For example, early on in our relationship, it was not clear whether she intended to withdraw her agreement with me or not. Examples of issues that characterised our initial interaction are highlighted in Chapter 4, such as complaints, and some elements of fear. To cite an example, Gerty explained: “Initially ... I was afraid that I would not be able to treat all the SOs before the end of the year” (April, 2003).

The data revealed that embedded in my collaboration with both teachers were issues such as honesty, perseverance, mutual respect, balance of power, effective communication/feedback, flexibility and adaptability to changes, risk sharing and fair exchange. Joel, for example, was honest about what he wanted. Early on he said: “To be honest with you Satsope, I do not see that much of a problem in the way I teach. I could manage that only if you could help me in journaling.” (May, 2002). Although I was disappointed at the time, I was prepared to take a risk to see what would come out of Joel’s line of experimentation. I understood that Joel was pursuing something he was unsure of and this was confirmed by the sorts of questions he asked during our preparations for his workshop activities. For example, he asked me to help him to design an activity for teachers. Thus, we shared the risk.

With Gerty, I learned a lot about balancing power in our collaboration. One example is provided in vignette 3 from Chapter 4, where I was frustrated by the learners’ behaviour. I expected Gerty to call the learners to order, but she did not. I felt she was not exercising ‘enough’ authority – not that she was supposed to be harsh or be at the centre. I wanted her to compete for a position in the power relation at the same time allow learners also to compete – somehow to me she appeared passive on this and I expected some sort of negotiation. This experience challenged me to find my own role in the collaborative relationship. With my strict personality, I learned to be patient and not to influence Gerty to follow my beliefs and thus respected hers. Gerty captured our mutual respect in the following manner: “During interaction, Satsope did not just tell me what to do or how, but her leading questions made me discover
what I should have done or what to do and how.” (October, 2002). Interacting that way also made it possible for us to balance our powers and fairly exchange our viewpoints.

What also counted during our collaboration and mutual support was being present for each other, being ready for inconveniences and being ready to listen. This aspect is illustrated in vignette 2 in Chapter 5. For example, over time, Joel became the initiator of our meetings and suggested the purpose of those meetings. His confidence in doing this built on our capacity to communicate and provide feedback for each other. In both cases, we relied on the laughter that we brought and turned it to form an integral part of our interaction. For example, our reflective sessions often entailed laughter and humour, thus creating a non-threatening situation for all of us.

In summary, the data reveal that successful collaboration relies upon accommodation of each other’s personality. How interactions are facilitated and what is learned from those interactions differs from one collaborative relationship to the other. Relationships remain unpredictable. In this study it seems the success of the collaborative relationship was brought by qualities such as honesty, perseverance, mutual respect, balance of power, risk sharing, fair exchange, flexibility and effective communication and feedback. What counted most was readiness to be present for each other, being ready for inconveniences, ready to listen and the laughter we all shared. All these were of great value and contributed in one way or another for each of us to be willing to experiment with the ideas and the practices implied by our new understandings of the process on teacher learning.

Teacher learning as distributed

_How is teacher learning distributed across a wider community who employ artefacts that teachers come to share?_

The data illustrate the various ways that the learning of the two study teachers’ was supported, enhanced or transformed by their engagements in various learning communities and with various tools. For example, the use of computers at Joel’s school served as a tool for Joel to introduce his learners to the notion of pattern
spotting (see vignette 2 in Chapter 5). Joel also hinted how the introduction of computers at his school motivated the parents to be supportive of their children’s learning (April, 2003). He also used the word processing facility of his computer to prepare his instructional materials, design and write reports, and sometimes write his reflections (journal entries) after presentations.

Gerty’s and Joel’s learning was also enhanced by their interactions with learners and with other teachers during in-service activities, workshops and conferences. For example, although my collaboration with Gerty was initially focused in Grade 9, she felt it necessary to experiment her new ideas in her other classes and found these ideas working well in her Grade 12 class. She commented: “My new approach to teaching yielded good results in Grade 12 tests, particularly during Trial Exams. There was a remarkable change comparing even the quality of results. …” (October, 2002). Gerty’s continuous assessment records served as tools to assist other teachers to learn. “… When I submitted CASS on the 30th August, the Maths coordinator was impressed by my work and it served as an example to other teachers. …” (September, 2002).

When Gerty participated in workshops and in-service activities, she usually adopted the role of the student. In this role with other teachers, she shared the curriculum materials (include assessment guidelines), classroom experiences and took part in discussions on OBE implementation. Joel, on the other hand, was the student and the facilitator of workshops in his cluster schools. Thus, in addition to his student role, he operated as a facilitator, sharing curriculum materials, learning activities, lesson plans and micro plans in a workshop setting.
CHAPTER 7

PROPOSITIONS

The purpose of this study is to explore the nature of mathematics teacher learning in the context of the South African OBE-based reforms. In order to describe and analyse the data generated from my collaboration with the two study teachers I used as heuristic devices or convenient organisers three characteristics of teacher learning - teacher learning as situated, teacher learning as social, and teacher learning as distributed (Putnam & Borko, 2000; Wallace, 2003). In the previous chapter I examined the data using several questions clustered around these three characteristics. In this chapter, I revisit these preliminary analyses to construct nine overarching propositions about the nature of teacher learning.

Proposition 1

Teachers reflect on and revise their personal practical knowledge when exposed to learning experiences that encourage them to attach meaning to and make sense of the underlying concepts behind new curricula.

There is evidence in this study that the two teachers gained insights into their own integrated set of knowledge, conceptions, beliefs, and values after they engaged with the literature on OBE-based curriculum. As they attempted to attach meaning to and make sense of the readings, they were able to interpret and reflect on the new demands of the OBE reforms. They were able to recognise the significance of my concepts when they attempted to unpack and to connect the specific outcomes and critical outcomes listed in the new OBE-oriented curriculum. For example, after the teachers identified integration as one of the key concepts in OBE, each approached the concept in a slightly different way. Gerty adopted a gradual approach, beginning with planning within the subject and later experimenting across the learning areas. She wrote:

When I designed activities, I always believed in proceeding from known to unknown or from simple to complex. I planned my work in such a way that SO1 would be
treated before SO₂, for example. ... Instead of treating SOs in isolation and regarding the others as related, it is better to give SOs equal attention in planning. ... I have adopted this style of planning my activities that sometimes it is difficult for someone to detect which SO is being addressed since more than one SOs seem to be dominating. (Personal writing, October 2002)

Realising that integration of the specific outcomes within the subject was possible, Gerty became more confident about trying it across the learning areas. She shared her experiences:

After one of our educators was redeployed at the end of the first term, I had to offer LLC (English) in Grade 9 which implied that I was supposed to offer two learning areas in the Grade. It was sort of a blessing because there is a lot of integration in MLMMS (Mathematics) and LLC which I was not aware of. ... It was also interesting when I gave learners an assignment "to do different shapes to decorate their first page". Learners confused it with Technology and Arts and Culture. (Personal writing, April 2003)

Joel, on the other hand, soon saw it necessary to approach integration from what he referred to as a holistic approach. He explained:

OBE endorses a more holistic approach where integration of learning content is emphasised, instead of teaching in isolation. Learning should also be related to learners' culture and their environment. (Personal writing, July 2000)

Joel seemed to attach a broader meaning to the concept of integration. This could be attributed to the readings on OBE. In Chapter 5, I have included Joel's reference to the integrated environmentalist approach as one of the curriculum categories. Making sense of what the concept 'integration' would mean in the OBE context, he concluded that OBE endorses a more holistic approach. This view influenced his approach to the concept of integration. He wrote:

Workshops also helped me to know that educators need to plan together in order to make learning more effective, and that each learning area is related to the other so they need to be integrated when facilitating. (Personal writing, April 2003)
In both cases, the teachers reflected on their own instructional practices and responded by experimenting with the concepts. Gert, for example, referred to a shift from teaching that was from ‘the known to the unknown’ or from ‘the simple to the complex’. She adopted a style of designing activities that made it difficult for another person to detect which specific mathematics outcome was being addressed.

In Chapter 6, I discussed some key issues that are also relevant to what I am proposing here. For example, the two study teachers gradually broke away from the belief that in mathematics there is only one “correct” answer to every question or problem. This belief was coupled with the practice of giving learners tasks just as they were presented in prescribed textbooks. Over time the teachers began to scrutinise and adapt tasks or exercises from the prescribed textbooks before they were given to learners. The reflective and sense-making activities it would seem, provided the two teachers with a context for revising their personal practical knowledge and instructional practices. The reflective activities allowed freedom to explore and opened new pathways to envisage what classrooms could be.

**Proposition 2**

**Interactions with literature improve the quality of teacher learning.**

In Chapter 6, I described how the two study teachers engaged with some of the readings on constructivism. As part of their experience they were encouraged to compare their existing beliefs and practices with constructivist ways. There is evidence in Chapters 4 and 5 that the two study teachers recognised the importance of their interactions with literature in shaping their constructions of knowledge and learning. For example, Gert wrote:

Constructivism and fallibilism did not feature in my teaching. Going through the literature, I realised that the two philosophies encouraged learner participation. … Absolutism is in line with behaviourism and therefore discussion was discouraged by this philosophy. The absolutists indicate that pupils must be given chance to do exercises and practice Maths (Threlfall, 1996: 19). (Personal writing, May 2000)
As Gerty grappled with these ideas, she put her instructional practice under a microscope. In Chapter 4 there is evidence that she gradually improved her understanding of constructivist views as she reflected on her practice. She started from a shallow attaching of and moved to a deeper appreciation of how these ideas were used. She also began to understand the context in which the ideas were used in the literature. For example, early in the study Gerty thought that because she gave learners the opportunity to write their solutions on the chalkboard, she was in line with constructivism. She reasoned that constructivism states that learners should be given chance to explain their thinking. As she continued her interaction with the literature she gradually refined her initial ideas. Joel, on the other hand, explained how he developed a new understanding of constructivism by listening to his workshop teachers as they discussed an article they had read. He said:

I was challenged every time to keep on reading until I finished the article. This article also helped me to understand OBE. I had another different version so this article opens up further my understanding of OBE. (Personal writing, June 2002)

The study shows that as the two teachers read about learning, they began to experiment with those ideas in their own classrooms.

**Proposition 3**

**Teachers are motivated to experiment with new ideas if they observe these ideas being modelled or put into practice.**

The study reveals that as the two teachers observed the practice of their university facilitators, they became challenged to experiment with those practices in their own classrooms. Gerty, for example, reported:

I have already used some activities on patterns in Grade 12 for the section on sequences and series. The approaches used in all activities are learner-centred. (May 2002)

As they experimented they asked questions that revealed powerful learning. For example, Joel documented in his journal:
The responses proved to me that learners can think and come up with something from what they see. ... I realised that I should sit down and really understand what I want learners to learn from the questions given in the activity. ... I have two questions that stand out to me, when do learners learn? I have two answers to find out: after getting the product (answer) or during the process of finding the product. When we say learners learn through doing, does it mean using resources or when they use their thinking or both? My approach now will try to address the questions. (Personal writing, September 2002)

These two examples illustrate that modelling ideas provokes active construction of knowledge and learning. For facilitators, the challenge is to create contexts that facilitate the construction of learning. The development of a quality teaching corps cannot happen in a situation where facilitators simply talk about learning or about learning procedures and information. If learning is about increased access to knowledge, skills, attitudes, values, their meanings and connections then the way to maximise learning is to perform. Rather than preaching it is better to practice or perform or model that which is important. In other words, teachers do not change instruction simply by being told to do so.

In Chapter 6 I showed how the two teachers experimented with constructivist ideas and raised questions about what teaching for understanding meant to them. Moreover, when the teachers attributed significance to learners’ construction of knowledge it led to their own construction of learning.

**Proposition 4**

Teachers develop positive perceptions about learning if their expectations are aligned with those of multiple stakeholders (both in and beyond the classroom).

The study reveals that the learning of the two study teachers was enhanced by the cooperation and mutual support of the principal, school colleagues, other teachers outside their schools, district officials and parents. What seemed to count most was that the expectations of stakeholders was not contradictory. For example, in Chapter 4 I described how Gerty rejected my suggestion to contextualise learning about polynomials in her Grade 9 class. She indicated that she did not want to be behind in
what she was expected to cover for the year. She mentioned the district plans and the
demands brought by continuous assessment. Thus, she found herself in a dilemma of
having to prioritise between the district’s demands and the innovation. She also
requested that I stop my visits because other teachers at her school wanted to use her
periods for class-work, home-work and assignments to complete the continuous
assessment demands of the district office.

Joel reported that he was disappointed when his workshop teachers slumbered and
did not respond to one of the activities. They preferred to wait for Joel to tell them
the answers to the activity. Joel captured this in the following manner:

One other thing is the attendees took it that as I am facilitating it means that I know
better than they do. Fortunately the problem was solved. (Personal writing, May
2001)

As Joel continued to acquire new workshop skills, he learned to ask the teachers to
share their expectations. He wrote:

This is a nice skill of conducting a workshop. This should be done so that if the
facilitator doesn’t know the answer the participants will help. (Personal writing, May
2002)

Gerty showed positive perceptions after her good work was acknowledged by the
district mathematics coordinator. She also realised that her experimentation with new
ideas yielded improved performance for her Grade 12 class. Her principal was very
pleased with these results.

Proposition 5

Good listening to learners’ thinking opens opportunities for explorations.

The vignettes in Chapters 4 and 5 revealed that the two teachers were learning to be
present to their learners’ learning, that is, to be learner centred. As they attempted to
be fully present, they were challenged to listen to learners’ thinking rather than
listening for only the right or the wrong answer. Joel, for example, commented about how he came to learn to listen to his learners:

I realised in one of the MSP workshops that follow-up by the teacher to wrong answers given by learners is important. ... The thinking behind which brought the learner to the wrong answer should be investigated by the teacher through asking the learners questions on how he/she came to the answer. ... These are all what an OBE mathematics teacher should do by facilitating the learners' creative thinking. (May 2002)

As Gerty and Joel struggled to be present to their learners' learning there appeared to be three kinds of explorations: exploring the content in preparation to facilitate learners' learning, examining ideas underlying learners' confusion, and engaging in mathematical thought with learners. Gradual attempts were also made to contextualise their instructional practice. Gerty, for example, was seen in vignette 3 making a change and starting to offer her learners the opportunity to learn from a practical exercise. During her interactions with the learners she was able to challenge them to think more deeply. She did this by listening carefully and spotting those learners whose responses were worth pursuing. In vignette 2 Gerty provoked the learners' thinking by spotting one learner who translated his understanding of converting polynomials to product expressions using mathematical sentences that were different from those of other learners.

**Proposition 6**

**Teachers respond to learners' learning by being more curious and pursuing classroom discussions.**

Over the course of the study, I found that the textbook's role became less important in facilitating learning. That is, the classroom activities may have been initiated by tasks or ideas from the textbooks, but the teachers were actively involved in pursuing the discussion of ideas. During classroom discussions, the two study teachers responded to their learners' learning by being more curious. This led to the two teachers reflecting on their learners' learning on the spot and also after the classroom interactions. Gerty, for example, said:
As I listened to the discussions, I realised that the given scale might have led to the misconceptions. ... During discussions, one learner indicated that she did not count pictures without 'heads' or 'shoulders'. I then realised that it is necessary to scrutinise activities before they are given to learners. (May 2002)

Joel, on the other hand, accounted for his curiosity in the following manner:

In class the reflections help me to see whether I presented well ... if not what area needs to be improved. I also learned how to find my learners difficulties and to make them to improve. (Personal writing, April 2003).

It appears that the two teachers began to view teaching as research. They seemed to connect with a view of learning as constructive and meaning centred. For example, when Gerty saw that one learner failed to make sense of pictures of persons without heads and shoulders, she was challenged to scrutinise activities before they are given to learners. Thus, she saw the need to emphasise individual meaning-making in learning.

Proposition 7

Teachers who play an active role in collaborative working relationships are more likely to revise their pedagogy.

Interactions with other teachers offered the study teachers opportunities to discuss ideas, teaching strategies and classroom experiences. As they engaged in discussions with colleagues, they were able to critique other teachers' practices in reference to their own understanding of the curriculum reform. For example, Gerty saw that she was ahead of the other teachers in the university science and mathematics education project. She wrote:

From the comments given by teachers, it could be detected that they expected the facilitators to stand in front of the class and start giving details of what OBE entails. When talking with teachers during breaks, I realised that they knew the rhetoric of outcomes-based education ... but their practices portray their traditional teaching styles and teacher-centredness. (Personal writing, May 2002)
From Gerty’s reflection, it could be claimed that she did not associate herself with the comments of the teachers. She could be saying that she was attempting to implement the OBE curriculum in her classes and did not just know its rhetoric. Joel emphasised the importance of discussion and reflection during his interaction with other teachers. He played an active role as a key teacher in his cluster schools. During his facilitation of the workshops, he transferred the skills he had learned to his classes at school. He stressed that he learned how to design activities and how to reflect through journal keeping. He reasoned in the following manner:

This is important to me as I relied much on the textbook of which I was unable to use some of the material as they did not outline how to use those materials in those textbooks. (April 2003)

His collaborative working relationships helped him to sustain his efforts and experiment with his learners. Over time, he changed his attitude and practices. Emphasising what he learned from journaling, he wrote:

I had a problem when coming to reflections (journaling). The support I got helped me to overcome the problem as I was helped on that. It is good to journal as it promotes self-development and it makes a facilitator become a lifelong learner. But if you don’t journal you might not notice that you have learned something from the learners that day. (Personal writing, April 2003)

The vignettes in Chapters 4 and 5 reveal that the two teachers attempted to create collaborative settings for their learners. As they interacted, learners also moved to points where they engaged with each other through questioning and thus challenged each other to think more deeply.
Proposition 8

True collaborative relationships cannot happen instantaneously.

This study revealed that my collaboration with the two study teachers went through several phases. These phases varied from one relationship to the other and depended on individual interpretations of the collaborative process. For example, my collaborative relationship with Gerty could be characterised by the following: negotiating entry, sharing facilitation and becoming independent. She indicated, for example, that initially she was concerned that if she was involved with me as a collaborator she would not be able to cover all the specific outcomes. Her fears and lack of trust frustrated me at the start. I learned to exercise patience. Our relationship gradually developed to a point where we were able to share our frustration and excitement. Later in the study, Gerty became more independent and exercised more patience with her learners.

My collaborative relationship with Joel was characterised by the following: setting a goal, setting a pace and feeling empowered. At the start he spoke out about his intentions which contradicted with my goals. This confused me for a while but I learned to dance to his tune, as reflected in Chapter 5. Surprisingly, the whole process was successful and we both learned.

I highlighted in Chapter 6 that embedded in our collaboration and mutual support were qualities such as honesty, perseverance, mutual respect, balance of power, effective communication and feedback, flexibility and adaptability to changes, risk sharing and fair exchange. This mixture of qualities — as referred to by Wallace and Louden (1994) — contributed to the success of our relationships. By highlighting these qualities, I am not arguing that they will be the same from one collaborative relationship to the other. Collaborative relationships, I conclude, remain unpredictable. What sustained us was readiness to be present for each other, readiness to be inconvenienced, readiness to listen and readiness to share the frustrations and the laughter. This readiness contributed to our willingness to experiment with the new ideas and the practices implied by our understandings of the learning process.
Proposition 9

Teachers will distribute their knowledge and learning to others if given the support.

In Chapter 6 I described how the two teachers responded to the support they received. In Joel’s case, for example, the presence of computers (donated by the mathematics, science and technology education schools project) encouraged him to facilitate learners’ learning on certain themes such as pattern spotting. Parental involvement at his school was also encouraged by the introduction of computers and he appeared to appreciate that involvement. The study teachers’ interactions with learners and with other teachers during in-service activities, workshops and conferences encouraged them to share their learning. For example, after Joel presented a conference paper for the first time he said:

I accepted the comments as critical questions, comments and suggestions are main factors that develop an educator. ... I would like to see myself presenting the very same paper at another conference. (May 2001)

Joel also commented he was empowered by his role as a workshop leader in his school cluster. He played a role of a key teacher in cluster schools and in that way he was able to distribute his learning.

Gerty also described how she was challenged to share her learning. She thought that it was important to involve everyone, including the district officials. During her conference paper presentation with three other teachers, she said:

As Mathematics educators we feel isolated at our schools. We need support from our curriculum advisers. Their job description should be modified. ... Educators who produce good results should be used as key educators or be promoted to advisory level to help other educators. (January, 2003)

Gerty was excited when the district mathematics coordinator distributed her learners’ continuous assessment records to other educators in order for them to learn and improve their records. Thus, acknowledgement by the district mathematics
coordinator and by the principal of her good work was further encouragement for Gerty to share her learning.

Summary

In this chapter, I revisited the issues that emerged from my data analysis to construct nine overarching propositions which may have applicability beyond the boundaries of this study.

Proposition 1: Teachers reflect on and revise their personal practical knowledge when exposed to learning experiences that encourage them to attach meaning to and make sense of the underlying concepts behind new curricula. As the two study teachers tried to attach meaning to and make sense of the readings, they began to interpret and reflect on the new demands of the OBE curriculum reforms. They reflected on their own instructional practices and responded in their own ways while experimenting with the concepts.

Proposition 2: Interactions with literature improve the quality of learning. The two teachers were engaged in a reasonably intense way with some of the readings on constructivism. The study revealed that as the two teachers gained insight in the readings about learning, they were encouraged to experiment with the ideas in their own classrooms.

Proposition 3: Teachers are motivated to experiment with new ideas if they observe these ideas being modelled or put into practice. The two teachers revealed that by observing their university facilitators modelling the ideas they were reading about provoked them to construct knowledge and learning.

Proposition 4: Teachers develop positive perceptions about learning if their expectations are aligned with those of multiple stakeholders (both in and beyond the classroom). The two teachers revealed that even though they were already learning, they needed the cooperation and mutual support of all the participants in the learning community.
Proposition 5: Good listening to learners’ thinking opens opportunities for explorations. As the two teachers attempted to be fully present to their learners’ learning — that is, to be learner centred — they began to listen to learners’ thinking rather than listening for only the right or the wrong answer. Three kinds of explorations appeared in their learning: exploring the content in preparation to facilitate learners’ learning, examining ideas underlying learners’ confusion, and engaging in mathematical thought with learners.

Proposition 6: Teachers respond to learners’ learning by being more curious and pursuing classroom discussion. As the two teachers pursued the classroom discussions and responded by being more curious, they reflected on their learners’ learning on the spot and also after the lesson.

Proposition 7: Teachers who play an active role in collaborative working relationships are more likely to revise their pedagogy. The vignettes included in Chapters 4 and 5 reveal that the two teachers attempted to create collaborative settings for their learners. Learners were also seen to be moving to points where they engaged each other through questioning and challenging each other to think deeper.

Proposition 8: True collaborative relationships cannot happen overnight. The study revealed that my collaboration with the study teachers progressed through phases. This progress depended on our individual interpretations of the collaborative process. What sustained us was readiness to be present for each other, readiness for inconveniences, readiness to listen, and readiness to share the frustrations and the laughter.

Proposition 9: Teachers will distribute their knowledge and learning to others if given support. The support the two teachers received came from different sources (their learners by being responsive, other teachers at their schools and beyond; principal; district officials; and mathematics, science and technology education projects). Both teachers responded to the support by willingly sharing their knowledge and learning.
CHAPTER 8

SUMMARY, IMPLICATIONS AND REFLECTIONS

The purpose of this study was to explore mathematics teacher learning in the context of the South African OBE-based reforms. While the study was guided by this broad purpose, some preliminary questions of interest that kept crossing in my mind were:

- What are teachers’ views regarding the characteristics of exemplary teaching in an OBE environment?
- What are the critical factors for initiating change in mathematics teachers’ instructional practice in the South African OBE context?
- What and how do other contextual factors impact on the process of becoming a mathematics teacher in this OBE environment?

As I unpacked these questions during the course of the study and explored the literature I came to realise that I could approach my investigation by employing characteristics of teacher learning: teacher learning as situated, teacher learning as social and teacher learning as distributed (Putnam & Borko, 2000; Wallace, 2003). These three characteristics of teacher learning were used as heuristic devices or as convenient organisers to describe and analyse the data generated from my collaboration and mutual support with two teachers. In this chapter, I present a summary of the findings, implications of the research, suggestions for further research, and my reflections.

Summary of the analysis

The findings of this study are organised for convenience around three characteristics of teacher learning: teacher learning as situated, teacher learning as social and teacher learning as distributed. Narrative analysis (Polkinghorne, 1995) was used to construct narrative accounts and vignettes of my experience with each teacher. Under teacher learning as situated, the accounts are organised around the themes of outcomes-based education (OBE) curriculum, constructivist ideas and other contexts. Under teacher learning as social, the accounts are organised around interactions in
the classroom setting, interactions with other teachers and interactions with me as a collaborator. A fourth account looked at distributed nature of the teachers' learning. In Chapter 6, I re-examined the narrative accounts by explaining several questions clustered around the three characteristics of teacher learning. These questions are: How is teacher learning situated within the specific and critical outcomes listed in the new South African OBE curriculum? How is teacher learning situated within the constructivist views that are implied by OBE? How is teacher learning situated within the contextual factors experienced by the two study teachers? How is social interaction facilitated in the classroom setting? How is social interaction facilitated when a teacher is engaged with other teachers? How is social interaction facilitated between the two study teachers and me as a collaborator? and How is teacher learning distributed across a wider community who employ artefacts or tools that teachers come to share?

The final stage of analysis employed what Polkinghorne (1995) calls analysis of narratives. I revisited the preliminary analyses to construct several overarching propositions about the study. These propositions are:

Proposition 1: Teachers reflect on and revise their personal practical knowledge when exposed to learning experiences that encourage them to attach meaning to and make sense of the underlying concepts behind new curricula reform.

Proposition 2: Interactions with literature improve the quality of learning.

Proposition 3: Teachers are motivated to experiment with new ideas if they observe these ideas being modelled or put into practice.

Proposition 4: Teachers develop positive perceptions about learning if their expectations are aligned with those of multiple stakeholders (both in and beyond the classroom).

Proposition 5: Good listening to learners' thinking opens opportunities for explorations.
Proposition 6: Teachers respond to learners’ learning by being more curious and pursuing classroom discussion.

Proposition 7: Teachers who play an active role in collaborative working relationships are more likely to revise their pedagogy.

Proposition 8: True collaborative relationships cannot happen overnight.

Proposition 9: Teachers will distribute their knowledge and learning to others if given support.

It should be noted that, although I have employed the three characteristics of teacher learning as convenient organisers for the analysis and have arranged the thesis using appropriate headings and sub-headings, when people learn, they learn about knowledge, skills, attitudes and values simultaneously. The different parts I have revealed should be seen as part of a whole learning process. Building on Ball and Cohen’s (1999) argument on teaching, learning about teaching appears to occur in particulars – particular teachers interacting with particular community (e.g. learners, colleagues at their schools, colleagues outside their schools, formal school leaders) over particular ideas in particular circumstances. Change, as Guba explained, “cannot be engineered; it is a nonlinear process that involves the introduction of new information, and increased sophistication in its use, into the constructions of the involved humans” (in Guba & Lincoln, 1989. p 45).

Implications

In this study learning was viewed as a process that takes place in a participation framework, distributed across persons and artifacts or tools, or at least among those participating in the learning context. Among other things, each participant brings to the learning process personality traits that shape or are shaped by the learning context. That means that all those participating in the learning context learn. It is important to note that when we learn, the following are inseparable: knowledge, skills, attitudes, beliefs, values and situations. We learn about all of them at the same time.
Three questions come to mind: How can we build on the situated nature of teacher learning? How can we build on the social nature of teacher learning? and How can we build on the distributed nature of teacher learning? With this in mind, I return to the three characteristics of teachers' learning – as situated, social and distributed – to organize my thoughts about the implications for my study.

**How can we build on the situated nature of teacher learning?**

If we South African educators are really serious about achieving the high standard goals that appear in our new OBE oriented curriculum documents, the way we view teacher learning should be revisited and revised. This study suggests the incorporation of multiple contexts for teacher learning. The two study teachers benefited from opportunities to combine various strategies, for example, university studies, workshops (at cluster schools’ level, at district level and beyond) and ongoing in-school support. Built in to these various strategies were such things as participants’ presence in the true sense of the word, good listening, active and ongoing mutual support. Mutual support and its partner, collaboration, are essential to the process of reform. Regular classroom consultation provides support for continued reflection as changes are introduced into the classroom (Edwards & Hensien, 1999). As this study reveals, collaboration which provides teachers with regular feedback and a voice in curricular decisions enhanced the participants’ learning.

What is implied is that multiple learning contexts should be underpinned by a democratic principle or a balance of power. Every participant should be seen and respected as a producer of knowledge. One-sided talk of teacher learning should be replaced by talk of both researcher and teacher learning. As this study revealed, the important learning took place in both teachers. If real change is to emerge in our mathematics classrooms, then the process by which it comes about is as important as the change itself and this necessarily implies full participation by those participating in the learning context.

This study also cautions the university educators to rethink what it means to learn and what it means to understand in the OBE oriented environment. We need to attach a deeper meaning about what it means to incorporate multiple contexts in our
programmes to suit teaching and learning in the OBE oriented curriculum. In attempting to address all these, we must also not forget that in the same way experienced teachers learn, student teachers and learners in schools also learn. We must keep in mind the questions of: How to maximise learning while ensuring democratic principles for all the participants? In other words, how to maximise learning while ensuring equality for all as emphasised by our new OBE curriculum.

In summary, multiple learning contexts should incorporate in and out of classroom settings. The contexts will depend on the specific goals for teachers’ learning. But what is important, I maintain, is for workshop facilitators and university educators to model using authentic activities, rather than simply talk or preach about learning. If we consider life long learning as one of the important goals in our new curriculum, then the key criterion for authenticity in our case should be to cater for the kinds of thinking and problem solving skills suggested by the outcomes of our new curriculum and its underlying constructivist views. Much as we support the importance of providing authentic learning experiences to learners, the same should apply to learning for experienced teachers and student teachers.

*How can we build on the social nature of teacher learning?*

If learning is a social and cultural activity, then knowledge and understandings will develop in relationships with others. In this study the two teachers worked in cooperative teams to ask questions, generate solutions, test out ideas, resolve problems, and construct new ideas. The social construction of the teachers’ knowledge through cooperative and collaborative interactions was critical to overall learning.

This study reinforces the importance of creating opportunities for co-participating, team planning, team teaching and collaboration. In order to confront the isolation of teaching and learning at schools and the universities, the study advocates collaboration and mutual support in communities. In this study, dialogue during our collaboration and mutual support was linked to caring and reason, thus confirming the findings of Bullough and Gitlin (1991). These authors concluded that the purpose of dialogue is to enable participants to come to a shared understanding of the subject
being discussed. However, shared understanding during social interactions does not necessarily imply that the interacting individuals end up with identical conceptual structures. Thus, teacher learning should not be viewed as a process of inducting teachers to converge to a particular way of perceiving or doing or practising instruction. In a collaborative relationship each actor should be empowered to rethink the way he or she sees the world and each actor should be provided with room to judge or reflect on his or her practice. Emphasis on individual meaning-making or sense-making in collaborative relationships means as we collaborate we must be ready to hear different meanings made by different participants and engage ourselves in conversation. Teachers will come to appreciate that learning occurs from social construction through their own learning experiences.

This study also revealed that collaborative relationships that support ongoing construction of meaning and reflection benefit all. One cannot be truly reflective unless one is willing to take risks and act (Goodman, 1991). One way of taking risks and acting is through action research, of the kind described in this study. In taking risks and acting we will stand a good chance of dealing with some of the inequalities in South Africa, since the end of such action research, I am convinced, is building the knowledge, skills, attitudes and values of all the participants.

Cochran-Smith and Lytle (in Zeichner, 1994) concluded that when teachers redefine their own relationships to knowledge about teaching and learning, they reconstruct their classrooms and begin to offer different invitations to their students to learn and know. A view of teaching as research is connected to a view of learning as constructive, meaning-centred, and social. These authors argue that teachers who are actively researching their own practices provide opportunities for their students to become similarly engaged. What goes on in the classrooms of teacher-researchers is qualitatively different from what typically happens in classrooms. This study revealed that all the participants benefited during social interactions, thus implying that the goal in collaborative relationships should be the joint production of ideas rather than one-sided productions.
How can we build on the distributed nature of teacher learning?

This study revealed that the activities we were engaged in during our collaborative relationships, during workshops, and during conferences were inextricably intertwined. These activities helped build a combination of knowledge, skills, information, mutual support, and accountability leading to an environment of taking risks, experimentation and reflection on new ideas and practices. The notion that teacher learning is distributed suggests that when individuals with different types of knowledge, skills, attitudes and values come together in discourse communities, community members can draw upon and incorporate each other’s expertise to create rich conversations and new insights into teaching and learning. Community building through face-to-face interactions in various settings (e.g. workshops and conferences) plays a major role in teacher learning.

In mathematics classrooms, resources are important in facilitating learning. Whether it is a piece of equipment, a textbook or simply the classroom and the way that a teacher and the children make use of the resources has implications for the style of teaching and the quality of learning that takes place (Goodwin, 1987). In reforming mathematics teaching, the question now to ask is whether the textbooks and other materials we use in our classes are fitting for our situation and for what we want to achieve with our learners.

This study also highlighted the importance of tools such as computers and reform-oriented textbooks. In Joel’s case the use of computers encouraged his learners to learn about pattern spotting. Also, parents were motivated to support their children’s learning which, in turn, supported both the learners’ and the teacher’s learning. The use of computers in schools may enable access to the wider outside community, and assist both the learners’ and teachers’ learning.

Early in the study, I realised that the two study teachers relied heavily on the reform-oriented textbooks for presenting tasks. To my mind, the tasks as they were presented in those textbooks, were not in line with the OBE philosophy. For example, in Gerty’s case, exercises about ‘polynomials’ were not contextualised and learners were failing to make sense out of them. Textbooks are well positioned to influence
teachers' work. However, for textbooks to play a greater role in instructional reform, they should be designed to support teachers in the process of curriculum enactment. For example, if we agree that constructivist learning theory provides the basis for the instructional approaches used in the new curriculum reform, then the tasks or exercises in the reform-oriented textbooks should be designed in such a way that they will offer opportunities for constructivist learning. The tasks or exercises should provide opportunities for learners to (1) reflect on their personal knowledge and prior experiences; (2) participate in interactive, hands-on activities; (3) ask questions, solve problems, and use new knowledge; and (4) communicate and work with others in cooperative teams.

Further research

Teacher learning, coupled with what I tend to call researcher learning, has not yet been exhausted as a research focus, particularly in developing countries. At both school level and university level it would be worthwhile to pursue questions such as:

- How do developing countries cater for multiculturalism in mathematics teaching?
- How can teachers be engaged as material developers as well as curriculum implementers?
- What challenges do teachers face in designing rich mathematical activities that break down race, class and gender barriers while also fostering critical and enquiring attitudes?

Further areas of investigation may include:

- This study highlights the need for teachers to share their experiences. One mechanism for doing this is through the development of teaching cases – a reform strategy used widely in other countries. Research on the use of cases could look at how South African teachers bring and share case experiences from their classrooms as part of their continuing professional development.
• In this study I collaborated with the two teachers as an outsider of their schools. It would be interesting to study collaborative relationships within schools, for example, those that attempt to make sense of and experiment with OBE oriented ideas and practice (and those relationships with conflicting ideas about OBE curriculum).

• In this study the role of reform oriented textbooks emerged as an issue. It would be interesting, for example, to investigate whether these textbooks support and/or enhance teachers’ learning.

Reflections

Learning about teaching is a challenging field of research. I entered this study with the aim of learning how the two teachers learned new ways of teaching in line with OBE, only to find that I became more aware of myself. As I reflected on my discussions with the two study teachers and their writings, I began to revise my practical knowledge, and improve my model for instruction. I started to think more deeply about knowing and learning. Just like the two teachers, I was in most cases stuck with questions such as: How can I develop curious and self-critical citizens who are able to participate creatively and critically in their social world? How can I make my teaching of mathematics contribute to the development of reflective and aware learners?

Adopting the habit of reflection, I learned to employ techniques to foster inquiry and investigation, techniques that treat every learner as a ‘mathematical thinker’ who is able to reason, communicate and use mathematics. I am convinced that one cannot be truly reflective unless one is willing to take risks and act.

I realised that the more I learned about teaching and learning, the more I understood the difficulties of being a good teacher. Understanding how teachers learn, think and work is important in helping them plan, interpret, and respond to tasks and activities. I believe that any subject can be effectively learned by involving learners in experimenting, observing, describing, questioning, reflecting, discovering, inventing and discussing. Few learners (including teachers and university educators) can truly understand a lecture or come to 'know' the natural world or the demands of new
curriculum reforms by reading about it in a textbook. They need real opportunities for direct investigation. A balance between what is contained in the intended curriculum and freedom in the classroom is important.

Collaboration is important — between teacher and learners, between teacher and his or her colleagues, and between teacher and people outside the school environment. Just as scientists and mathematics educators thrive on the exchange of ideas, teachers also benefit from working together.

Documenting my learning experiences in this study was one of the toughest tasks of my life. During the study itself, I became so immersed in the collaboration that I forgot about my researcher role. The two teachers also forgot that it was research. By the time I was supposed to start writing I realised that I was in trouble. In my initial attempts to write I failed to distance myself from the events I was describing. I thought that I needed to capture the learning experience exactly as it occurred. This approach resulted in my initial analysis taking the shape of listing the events sequentially as they occurred. In my attempt to honour the experience, I soon fell into the research trap of trying to describe everything. My supervisor kept encouraging me as I documented my experience. I continued writing until I had produced 80 pages for each case study.

The drama started when I began to write my discussion chapter. Out of my data emerged several issues that I organised using seven key questions. To answer each of the seven questions, I found that I was trapped into a situation in which I had to revisit the data from the two case studies page by page, that is rereading about 160 pages to answer each question. I felt something was wrong but it took me quite a while to realise that my analysis was just like keeping a diary – capturing the events and commenting about them. While busily answering the third question, I got tired of reading and rereading the cases. With my supervisor’s encouragement, I decided to leave the discussion chapter to revisit the literature. When I questioned my supervisor about this approach he said that was a question of the chicken and the egg – which one came first? In revisiting the literature review, I learned about the three characteristics of teacher learning. I went back to my discussion chapter, but I was
still in trouble. Going back and forth to read and reread the data remained a major problem.

When my supervisor went away for a month, I decided to devote some time to deepening my understanding of data analysis, particularly the meaning of narrative analysis. With a new set of understandings I was challenged to start my data analysis afresh. I convinced myself that if that was what it took to write a thesis, I would go for it. It was a very hard lesson to learn but I have learned it. I lamented, but it was a very powerful learning experience. I also learned what it means to supervise somebody's learning. And, most importantly, I learned by not being told but by being motivated to follow my way and experience the frustrations and the many road signs (particularly cul-de-sacs).
REFERENCES


APPENDIX A

SPECIFIC OUTCOMES (SO) AND CRITICAL OUTCOMES (CO)
IN THE SOUTH AFRICAN OBE-ORIENTED CURRICULUM DOCUMENTS
SPECIFIC OUTCOMES (SO)

The specific outcomes for Mathematics Literacy, Mathematics and Mathematical Sciences (MLMMS) as defined by the Department of Education (1997, p.3) are:

SO1: Demonstrate understanding about ways of working with numbers.

SO2: Manipulate number patterns in different ways.

SO3: Demonstrate understanding of the historical development of mathematics in various social and cultural contexts.

SO4: Critically analyse how mathematical relationships are used in social, political and economic relations.

SO5: Measure with competence and confidence in a variety of ways.

SO6: Use data from various contexts to make informed judgements.

SO7: Describe and represent experiences with shape, space, time and motion, using all available senses.

SO8: Analyse natural forms, cultural products and processes as representations of shape, space and time.

SO9: Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes.

SO10: Use various logical processes to formulate, test and justify conjectures.
CRITICAL OUTCOMES (CO)

South Africa needs citizens who can:

CO₁: Identify and solve problems and make decisions using critical and creative thinking.

CO₂: Work effectively with others as a member of a team, group, organisation and community.

CO₃: Organise and manage themselves and their activities responsibly and effectively.

CO₄: Collect, analyse, organise and critically evaluate information.

CO₅: Communicate effectively using visual, symbolic, and/or language skills in various modes.

CO₆: Use science and technology effectively and critically, showing responsibility towards the environments and the health of others.

CO₇: Demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.

There are another five critical outcomes that encourage learners to grow into active citizens of the future, who are able to make a contribution to society and to the economy of the country.

New learning programmes need to encourage learners to:

CO₈: Reflect on and explore a variety of strategies to learn more effectively.

CO₉: Participate as responsible citizens in the life of local, national and global communities.

CO₁₀: Be culturally and aesthetically sensitive across a range of social contexts.

CO₁₁: Explore education and career opportunities.

CO₁₂: Develop entrepreneurial activities.

Department of Education (1997)
http://www.juta.co.za/academic/schools/copy/obe.htm