Investigating the opportunities and challenges for professional growth created through a process of developing learning support materials

by

Kim Draper

Submitted in fulfilment of the academic requirements for the degree of:
Mater of Education in the
Department of Curriculum Studies
Faculty of Education
University of Pretoria
Pretoria

October 2005

ACKNOWLEDGEMENTS

To my supervisor, Dr. Loyiso Jita:
Thank you for the time and advice that you gave in adding valuable insight to the interpretation of my data, directing my ideas and bringing clarity to my writing.

To special people:
A special thanks to my husband, Peter, for supporting me throughout this process, believing in me, and giving me time and space when I needed it.
Professor Paul Hobden: Thank you for the thankless job of reading my endless drafts and for your advice at every stage of this study.
My friends Cathy and Heather: Thank you for frequently taking on the job of looking after my two children over the last three years, allowing me the time to complete this thesis.

PREFACE

The work described in this thesis was carried out in the Department of Curriculum Studies and the University of Pretoria, from January 2002 to October 2005 under the supervision of Dr. Loyiso Jita (Supervisor)

This study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others, it is duly acknowledged in the text.

Kim Draper
October 2005

TABLE OF CONTENTS

ABSTRACT

Science and maths teachers in Mpumalanga were selected to participate in a Japanese International Cooperation Agency (JICA) funded programme of professional development, the Mpumalanga Secondary Science Initiative or MSSI. The basis for the professional development is the formation of clusters of schools, organised by the curriculum implementers (CIs) in the province and lead by cluster leaders (CLs). Clusters are expected to meet regularly to work together towards their own professional development. The University of Pretoria (UP), in collaboration with the Mpumalanga Department of Education (MDE) and members of Japan International Cooperation Agency (JICA), have supported the CIs and CLs by participating in the development and distribution of learning support materials in the form of study guides for use by the teachers in the cluster meetings as well as in the science classrooms. As the CIs and CLs are involved in the development of the materials, the process of development is expected to contribute to their professional learning and growth.

This case study investigated some of the opportunities for professional learning and growth that the materials development processes provide, the challenges to professional growth, and the lessons that can be learnt from such a process. The study shows that involving CIs in materials development provides rich opportunities for professional growth and a chance to take ownership of the process and product. However, organisational constraints, time, and inadequate subject content knowledge of participants pose serious challenges to the processes. While the MSSI has been effective in setting up a province-wide system of clusters providing professional development opportunities to all teachers in the province, it has not been as effective in providing a learning environment for its CIs, CLs or teachers to developing effective learning materials in the future. If these constraints

are not properly addressed, it will seriously impede the value of professional growth opportunities that the CIs as MSSI leaders can be provided with in the materials development processes.

Key words

Professional growth; professional development; materials development; learners; learning support materials; constructivism; teachers as learners; teacher leaders

NOTES ON STYLISTIC CONVENTIONS USED IN THE TEXT

This is case study in which I was involved to mostly as a participant and an observer. To gather data, I established close and personal relationships with some of the participants in the project. To protect anonymity of those involved, pseudonyms have been used throughout this report.

LIST OF ABBREVIATIONS

CASME	Centre for the Advancement in Science and Mathematics Education
CI	Curriculum Implementer
CL	Cluster Leader
COAST	Coaching to Support Science and Mathematics Teachers
DCES	Deputy Chief Education Specialist
DOE	Department of Education
ESL	English Second Language
FET	Further Education and Training
GET	General Education and Training
INSET	In-service Education and Training
JCSMTE	Joint Centre for Science, Mathematics, and Technology Education
JICA	Japan International Cooperation Agency
LO	Learning Outcome
MDE	Mpumalanga Department of Education
MSSI	Mpumalanga Secondary Science Initiative
OBE	Outcomes Based Education
RNCS	Revised National Curriculum Statement
TIMSS	Trends in International Mathematics and Science Study (previously Third International Mathematics and Science Study)
PBS	Project-based Science
PCK	Pedagogical Content Knowledge
PEI	President's Education Initiative
POE	Predict, observe, Explain
PSP	Primary Science Project
RNCS	Revised National Curriculum Statement
SCK	Subject Content Knowledge
SEP	Science Education Programme
UP	University of Pretoria

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1
ORIENTATION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION

> ***"…. professional development too often introduces educators to trendy but unproven ideas, as though these ideas were validated and likely to lead to improvements in student performance. This is worse than a waste of time; it undermines the motivation for professional learning and threatens the welfare of students" (Hawley and Valli, 1999)***

As a teacher of science, I have always been interested in ways to improve learners' understanding of science. It was while working as a teacher in close collaboration with a science education specialist in the early 1990s that I first became aware of the role that learning materials can play in improving the teaching and learning practices in science classrooms. As a specialist, the learning materials he designed were informed by research findings and underpinned by the 'prevailing theoretical perspective to the understanding of problem-solving' (Hobden, 1999). There were great hopes that these materials might contribute to better teaching and learning in science classrooms.

Throughout my career as a teacher, I attended numerous workshops which presented teachers with new teaching strategies and new teaching and learning materials. As I was convinced by the value of good learning materials and used them in my teaching practice, I was struck by the poor uptake of the materials as part of teachers' practice in general. Despite the encouraging response to the materials at workshops, teachers continued to see the materials as 'additional' activities, only to be used if they had time after completing the prescribed syllabus, rather than as an integral part of their teaching practice.

It is this problem on the development of teacher learning support materials and information from workshops and other professional development sessions that I wished to investigate

further. The purpose of my study is to contribute to an understanding of the various professional development efforts available in South Africa. In particular, I focus on the role the development of learning support materials play in the professional growth of science teachers in one provincial initiative in South Africa.

The pass rates for Science (Physical Science and Biology) in South Africa are alarmingly low. In the 2003 Trends in International Mathematics and Science Study (TIMSS, 2003), South Africa scored lowest out of 45 countries for science. Despite the shock of these results, it is hardly surprising as recent studies in South Africa have established that despite years of professional development programmes, the subject matter knowledge of most science teachers is poor (Chisolm et al, 2000; Jita and Ndlalane, 2005; Taylor and Vinjevold, 1999). Much attention is now focused on ways to improve the science results throughout the country.

In the mid-1990s, there was a call from South African leaders to international communities for financial assistance to develop secondary science and maths education. This call came in the form of what is now known as the President Educational Initiative[1] (PEI). The Japan International Cooperation Agency (JICA) responded by funding and providing technical assistance to the Mpumalanga Secondary Science Initiative (MSSI), a project conceived and promoted by the Mpumalanga Department of Education (MDE) (Memorandum of Agreement, April 2003). Mpumalanga is one of nine provinces that make up South Africa[2] and the project goal is to establish a province-wide system of continued in-service training for mathematics and science teachers so that this development of capacity may grow into a sustained practice. The medium term goal of MSSI is to improve the quality of teaching

[1] In the 1990s, the Teacher Development Centre, on behalf of the South African Department of Education, commissioned research under the auspices of the President's Education Initiative
[2] Mpumalanga is mostly rural with few large cities with an economy based mainly on agriculture and tourism

in mathematics and science in the province while the long term goal is to ensure that secondary school science and mathematics learners acquire enhanced skills in mathematics and science (Memorandum of Agreement, April 2003). Since 1999, JICA has been collaborating with the MDE and the University of Pretoria (UP) to assist mathematics and science teachers in implementing outcomes based education (OBE) in their classrooms (Rogan and Aldous, 2005). The MSSI is essentially a province-wide professional development programme with a particular focus on cluster-based[3] professional development. As part of this initiative, a parallel research programme is being conducted to explore various questions and implementation challenges. The present research forms part of that larger MSSI research programme by the University of Pretoria. The study seeks to uncover the opportunities and challenges for professional growth that present themselves in the processes of developing learning support materials as part of the MSSI professional development initiative.

1.2 BACKGROUND

The MSSI depends on collaborative partnership based on a continuous sharing and joint work on policy and management issues (Memorandum of Agreement, April 2003). The three partners are: JICA; UP; and MDE.

JICA, backed by the universities of Hiroshima and Naruto University of Education has the role of providing innovative and effective ways of handling science content knowledge. The Japanese participate in the initiative as subject specialists and sponsor and organise the CIs study mission to Japan. Part of this study mission is set up as a content enrichment

[3] A cluster is a group of teachers in a localised geographic region that teach a particular phase and subject. For example, the cluster forming the basis of this research was the FET Physical Science cluster in KwaMhlanga. A cluster is lead by a cluster leader who is a lead teacher in that group.

programme with a large part of the time spent on developing in-depth content knowledge on one small area of science (or maths), doing practical experiments in that subject area, collecting resources on subject content, and lesson study[4].

The second party in the collaboration is the MDE, and in particular the Deputy Chief Education Specialists (DCESs) and Curriculum Implementers (CIs). The DCESs are expected to help co-ordinate the initiative, select the CIs to go to Japan on the study mission, select the CIs who will participate in the writing workshops, set the dates and time-frames for the writing workshops, and assist in the writing workshops. Their role is to make sure that the MSSI is included as an integral part of the MDEs education improvement programme. The CIs have a large part to play in the materials development processes. Their role is to provide the subject topics for the writing workshops based on their experiences in Japan, to contribute ideas for teacher and learner activities, brainstorm activity ideas, and set up the framework for the activities to appear in the study guides using the resources collected and compiled in Japan (Rogan, 2003). Their role is also to train the cluster (teacher) leaders at a cluster leader workshop in the use of the study guides and support the cluster leaders in presenting the study guides to the educators at the cluster meetings (Memorandum of Agreement, April 2003).

The role of the third party, UP, is to work primarily at the CI training level, but to a smaller degree at the Cluster Leader (CL) level as well. They provide academic and professional support. They host the CI writing workshops, provide subject specialists to help in the development of the materials at these workshops, allocate a subject specialist to do the final compilation and editing of the study guide, and assist in the printing and distributing of the study guides to the CI and CL training workshops. UP provides academic and

[4] Lesson study, as used in the MSSI context, is the preparation and presentation of detailed lesson plans and lessons on specific sections of science.

professional support and is expected to continue giving content and professional support to the teachers in Mpumalanga even after the Japanese leave the project at the end of the contract funding period.

The MSSI project targets primarily three groups of people in the province: first there are the secondary school mathematics and science educators in the province. These educators are organised into clusters or groups who meet on a regular basis for professional growth activities; second, there are the mathematics and science teacher leaders who will assume a leading role in organising and promoting cluster-based and school-based professional growth activities and in ensuring the classroom application of materials and methods learned in the various in-service activities (Memorandum of Agreement, April 2003). The latter groups of teachers have been confirmed as CLs who are charged with the task of leading and facilitating the cluster meetings; third, there are the Senior Phase General Education and Training[5] (GET) and Further Education and Training[6] (FET) CIs for mathematics and science who are located in and assigned to the different regions of the province. The CIs are subject specialists and with the help of UP and Japanese experts will organise and support training activities and other education activities for the CLs at the regional and provincial level, as well as at the Teacher Centres.

Phase 1 of the initiative started in 1999 as a three-year project and was extended by 5 months to the end of March 2003. In June-July 2002, JICA carried out an evaluation of the project and concluded that progress has been made in establishing a province wide system of school-based cluster groups for maths and science teachers. Despite their initial goals, only 15% of schools participating in MSSI were actively involved in school-based professional development at that time. The project organising committee concluded that

[5] Grade 7-9
[6] Grade 10-12

MSSI should be extended to ensure that the work that had already been done does in fact reach the classrooms and ultimately benefit the learners. With this conclusion, the project was extended for a further period. MSSI Phase 2 started in April 2003 and is expected to end at the end of March 2006 (Memorandum of Agreement, April 2003).

In the beginning of Phase 2 of the project, the challenge was to ensure that all schools in Mpumalanga were organised into clusters and to ensure that these clusters function effectively and efficiently so that there is an impact on classroom activities. Part of this 'effective functioning' of the clusters is the development and dissemination of science teacher support materials to the teachers. It is expected that the materials will be used as a focus for cluster meetings and eventually make their way into the classrooms. Here they are intended for use mainly by the teachers and eventually the learners, and in so doing, improve science teaching and learning.

This study focuses on the role of such learning support materials or teacher guides in science teaching and learning in South African classrooms. Specifically, the one aspect of the initiative that was of particular interest to me was the opportunities and challenges for teacher learning embedded in the processes of development of these science curriculum materials as part of the MSSI professional development programme. My working proposition was that the opportunities and challenges for teachers in the MSSI would be different from those arising out of a training workshop based on the training in and use of expertly developed materials that I had previously had the opportunity to attend as a teacher. This was because the MSSI teacher materials were to be developed in collaboration with and with input from school practitioners themselves with measured guidance from the (university) experts in this case.

1.3 SIGNIFICANCE OF THE STUDY

Over the years there have been professional development programmes based on developing learning materials. Research on these programmes typically focuses on a model of curriculum development where teachers are involved in piloting materials written by a team of 'experts' with a limited number of teachers (George and Lubben, 2002). This has often been the case in South Africa. In the mid-1980s, professional development programmes in the form of in-service education and training was the major strategy for introducing, for example, SEP materials into black South African schools with the aim of improving the quality of science education in the less privileged schools in South Africa (Rogan and McDonald, 1985). This was also the case for the Primary Science Project (PSP) (Harvey, 1999) and the Centre for the Advancement of Science and Mathematics Education (CASME) (Hobden and Draper, 1995). In these professional development programmes, teachers were trained in the use of learning support materials developed by 'experts'. Typically, the support materials are demonstrated and distributed at the teacher training workshops for use by the teachers in their classrooms.

So what makes the focus of the professional development of the MSSI different from the rest and why is it interesting to study? As a focus for the cluster-based professional development programme, learning support materials known as 'study guides' are collaboratively developed by small groups of MDE CIs supported by Japanese university experts, DCESs and staff from UP. While the DCESs, Japanese professors and the UP staff play a supportive role in the development processes, the issue of 'buy in' and 'ownership' by the CIs and CLs is considered to be of outmost importance. Hence their involvement in the development of the study guides is essential (Jita and Rogan, 2003). The CIs and CLs roles include the actual writing, brainstorming ideas for inclusion in the

guide and training pilot versions of the study guides in selected schools. It is these processes of materials development by novice developers but expert school practitioners and subject specialists that forms the major focus of this study.

In the preface to their book, Designing Professional Development for Teachers of Science and Mathematics, Loucks-Horsley et al. (1998) write of the gap between knowledge of meaningful and effective professional development and practice. One reason they suggest for the gap is the lack of 'rich descriptions of effective programmes constructed in various contexts addressing common challenges in unique ways' (Loucks-Horsley et al., 1998). Improving the quality of science teaching and enhancing the learners' skills in science and mathematics are the explicit goals of the MSSI and these goals are expected to be achieved through the professional growth initiative (Memorandum of Agreement, April 2003). It is the purpose of this research, therefore, to provide rich descriptions of the materials development processes within the MSSI programme and thereby contribute to the narrowing of the gap between knowledge and practice.

1.4 CONCEPTS USED IN THE STUDY

Professional development and professional growth

In the literature, there seems to be no clear distinction between the terms 'professional growth' and professional development' and in this study I use both terms. I use the term 'professional development' typically when referring to an organised programme or initiative. This may refer to organised teacher activities usually forming part of in-service education and training (INSET). I use the term 'professional growth' when it refers to the growth of a person in the field of their profession both inside and outside the traditional and organised 'professional development' or INSET programmes. For this study, the concept

'professional growth' means the 'opportunities offered to educators to develop new knowledge' (Loucks-Horsley et al., 1998). To understand to development of new knowledge, I draw on the theoretical perspective on learning which focuses on the integration and transformation of knowledge into meaning that is personally constructed (Campbell et al., 2001). The idea of learning as a construction of meaning is best expanded in the set of beliefs about knowing and knowledge known as constructivism (Tobin and Tippins, 1993). The constructivist theory of learning is not a single theory of how we learn but is rather a group of related views on how knowledge is constructed in the mind of the learner. It is based on a collection of assumptions about the cognitive processes by which we learn and is thus an important part of the conceptual framework for this study. This idea will be expanded in chapter 2 as part of my conceptual framework.

Learning support materials

Learning support materials has a wide range of definitions and includes print-based, electronic, physical, combinative, human and organisational materials (Vinjevold, 1999). The list of each kind of material under these headings is extensive. For example, print-based resources may be notes, documents, textbooks, newspapers, magazines, study guides, teacher guides, and reference books. Electronic materials transparencies include slide presentations, films, videos, audio tapes, and computer software. Although the South African Department of Education calls all of these 'teacher support materials', this study will focus on a single example of teacher support materials i.e. the printed activity-based materials. In the literature, these printed materials are referred to as 'curriculum materials', 'teaching support materials' and 'learning support materials'. This study will use the term 'learning support materials' to refer to all the printed activity-based materials which are used by teachers and learners in the classroom as the basis for learning science. In the MSSI professional development programme in particular, the term 'study-guides' is used.

These materials are the printed materials intended to be used by cluster leaders in the cluster workshops and teachers in their classrooms to assist in the teaching and learning of science. A document produced by the MSSI study guide co-ordinator (Rogan, 2003) set out the criteria for the intended guides. Each study guide is developed around a single topic and consists of four ingredients: An introduction to the topic, a sample scheme of work and a sample lesson plan; Materials to help teach each topic – especially the "new" aspects such as hands-on activities, the incorporation of societal issues and further student inquiry projects; How to assess learning for that topic based on the outcomes; Background knowledge and additional readings for the teacher on that topic. The study guides were developed for the following learning areas: Senior Phase Natural Science; Senior Phase Mathematics; FET Physical Science; FET Life Sciences; FET Mathematics (and in phase 2 Agricultural Science was added). Language is a key issue as it is envisaged that these study guides are to be used primarily by English Second Language (ESL) teachers and learners. For this reason, language used in the study guides is to be as clear and simple as possible, making sure that words that have more than one meaning are either avoided or clearly defined. It is understood that the activities presented in the study guides can be photo copied for learners and used by teachers in their classrooms (Memorandum of Agreement, April 2003).

The processes of development of the learning support materials are a key focus of this study. The Oxford dictionary defines the word 'development' as growth or evolution or the well-grown state of a product. In these processes of materials development, I have used the ideas of growth and evolution to mean a process which includes the brainstorming formulation of ideas, the preparation of a study guide outline, the gathering of resources for the study guide and finally the compilation of activities and information that goes into the teacher support materials.

Learners

The South African Revised Curriculum Statement (2002) refers to school children as 'learners'. This study uses this term in a broader sense i.e. learners refers to any person who is undergoing a process of learning. This study specifically addresses teachers as learners and the opportunities that are provided to them for professional growth and learning. When the text refers specifically to school children and not learners in general, the term 'school children' is used.

1.5 RESEARCH QUESTIONS

This study seeks to answer the following research questions:

1. What are the opportunities and challenges for teacher learning and professional growth that are created through the processes of materials development in the MSSI? This question will be explored fully by looking at the opportunities for teacher learning and professional growth in terms of:
   - Participation and ownership in the development processes, and
   - Building capacity for developing effective learning support material.
2. How can the opportunities and challenges to the material development processes in the MSSI be explained?

1.6 AIM OF THE STUDY

The aim of this study is to look at the processes of developing teacher support materials and to investigate the opportunities that these processes might provide for science teacher learning and professional growth. My research feeds into a much broader research initiative set up to contribute to a body of knowledge on the effectiveness of professional

development programmes in general, such as the MSSI. The study also seeks to contribute to the literature on improving science education, especially in the context of developing countries.

1.7 RESEARCH DESIGN

In order to answer the research questions posed, I needed detailed information from participants in the processes of materials development i.e. the MDE CIs and UP representatives. The data that I needed included the views and reflections of those involved in the processes. As a result of the type of data required to answer my questions, and guided by the literature on research methodologies (Bogdan and Biklen, 1992; Erickson, 1986; Cohen et al., 2002), a case study was chosen as the most suitable research design. This design will be elaborated on in chapter 3.

1.8 PLAN OF STUDY

1.8.1 Chapter 1 – Orientation and background to the study

This chapter orientates and justifies the study. It outlines the challenges faced by science education in South Africa in general, and in the province of Mpumalanga in particular. It puts the MSSI in context and explains how the project seeks to play a role in improving science education in Mpumalanga. Chapter 1 provides definitions of the key concepts used in the study as well as an outline of the research design.

1.8.2 Chapter 2 – Conceptual Framework and Literature Review

This chapter provides a conceptual framework for the study and a critical review of the literature read to place the study in context. It highlights the gaps in the literature and

shows how this study might address those gaps to improve science education in South Africa.

1.8.3 Chapter 3 – Research design and methodology

This chapter provides a discussion of the empirical research approach including the defence of the data collection instruments and techniques. Some aspects of the procedure such as the nature of the study, the method of data collection and analysis, and the issues of validity and reliability are discussed.

1.8.4 Chapter 4 – Report and Interpretive Commentary

This chapter presents the data collected in the study as well as a discussion about the development of teacher (study) guides and the opportunities for learning and growth that these processes provide.

1.8.5 Chapter 5 – Synthesis and Implications

This chapter synthesises the research findings and answers the research questions posed in chapter 1. Based on these answers, several recommendations are made, and questions for further study are highlighted.

CHAPTER 2
LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

The focus of this study is on the processes of developing teacher support materials within a professional development programme for science teachers and the opportunities and challenges for professional growth that these processes might create. An underlying assumption of this research is that inquiry-based, learner-centred and activity-based teaching and learning as envisaged in the South African Revised National Curriculum Statement (RNCS) is useful as a means of reforming science education and achieving the desired national educational outcomes (Revised National Curriculum Statement, 2002). This is because inquiry-based learning environments in science are considered essential to engage learners in actively constructing deep understanding of everyday science (Schneider at al., 2005).

The literature informing this study can be organised into several themes and it is these themes that will be explored in this review. The themes include: research on the role that learning support materials should and do play in teaching and learning; research on learning support materials and their development as part of professional growth both in South Africa and abroad; teachers as developers of learning support materials. The literature suggests that there is a need for more research on inquiry-based instructional materials developed to influence teaching practice. This review will show that programmes of this nature, especially in the South African context, are scarce. It is this gap in research that this study hopes to address.

2.2 CONCEPTUAL FRAMEWORK

As mentioned in chapter 1, the review of this literature will be from a constructivist perspective. Until recently, the accepted model in teaching was based on the assumption that knowledge could be transferred from the mind of the teacher to the mind of the learner, or that learning was a process of absorbing knowledge (Driver and Bell, 1986). This can best be understood as 'surface' processing of information, a theoretical perspective suggesting the use of strategies to memorise facts without meaning or organisation (Campbell et al., 2001). In contrast, contemporary constructivist perspectives on science education hold the view that knowledge cannot be transmitted to passive recipients (Tobin et al., 1994). Rather, knowledge is constructed in the mind of the learner. This view of learning is based on the assumption that learners are not passive recipients of information (Driver et al., 1994). A perspective best understood as 'deep' processing of information where there is the intention to gain understanding, and information is organised by integrating the knowledge whole and parts (Campbell et al., 2001). Or as Anderson and Mitchener eloquently put it,

> "Learning requires active involvement of the student in constructing meaning. Rather than just receiving more information, the learners must negotiate meaning with his/her learning community, make connections with the past understandings – modifying these prior conceptions if they are not accurate – and build understandings that are part of that person's personal conceptual framework. These new understandings occur in a learning community of context." (1994)

This theoretical perspective on learning can be developed to provide an understanding about the implications for teaching and learning in classrooms. Learning outcomes depend not only on what is taught but on what the learner already knows (Anderson and Mitchener, 1994). A learner's conceptions, purposes and motivations influences the way they interact with learning materials. This means, for example, that the observations that learners make as well as the interpretations of those observations are often different from

what may have been intended by the teacher. Individual learners may construct different or personal representation of phenomena they observe. Knowing this, it is necessary to reconsider assumptions about where learners start from in their thinking (Driver and Bell, 1986).

When engaging in teaching, we need to know that learning involves the construction of meaning as learners make links between what they already know and new knowledge presented to them (Anderson and Mitchener, 1994). Consequently, the meanings that learners make may not always be the meaning intended. The construction of meaning is a continuous and active process and as learners continually change their ideas as they interact with new knowledge, their thinking changes and evolves to accommodate new experiences (ibid). A learner's beliefs can influence the meaning they make of a situation.

Understanding the concept of learning for this study goes beyond school children as learners. By drawing on the work of Ball and Cohen (1996), I am able to add to my framework and include a perspective on teachers as learners within the context of developing materials. Ball and Cohen (1996) outline the role that curriculum materials can play in generating learning of both teachers and learners if the materials are properly integrated into a programme of professional development. These researchers distil five intersecting domains across which teachers work: that teachers are influenced by what they think of their learners; that they work with their own understanding of curriculum materials; that they fashion materials to design instruction; that they must be aware of the intellectual and social environment of the class; and that they are influenced by their views of the broader community and policy contexts in which they work (ibid). Curriculum materials thus constitute a significant context for teacher learning and teaching in science and other subject areas.

The concept of learning used in this study is determined by a complex interaction between firstly, the knowledge of a learner i.e. the pre-existing knowledge that a learner has, the meanings learners make of new knowledge, the organisation of that knowledge; secondly, the knowledge of the teachers which is determined by the intersecting domains across which teachers teach; and thirdly, the reorganisation of and addition to the knowledge of teachers through their own learning i.e. the professional growth as a result of the development of new teacher curriculum materials.

I have focused my literature review on a strand of research which focuses on inquiry instruction within a conceptual change framework for science teaching and learning (Driver and Bell, 1986; Driver et al., 1994). The role of inquiry in such an approach is to convince learners to change the ideas in science to be more in line with scientifically acceptable viewpoints. To achieve this, learning activities are carefully designed to show how learners' previous ideas may not account for observed phenomena (Keys and Bryan, 2001). Studies have shown that curriculum changes intended to achieve conceptual change have been effective in promoting the constructing and modification of children's ideas in line with dominant scientific viewpoints (Driver et al., 1994; Keys and Bryan, 2001).

The implications of a constructivist perspective and an alignment with conceptual change literature are that any learning support materials should directly aid learners in constructing meaning by getting actively involved in their learning, confronting prior conceptions, negotiating new understandings about science in a context that is both relevant and meaningful to the learners. A set of appropriate learning experiences thus have to be developed for the learner to challenge and change their conceptions. Tobin et al. (1994) suggest reflecting on two issues when developing those learning experiences: the actual

occurrence that can facilitate learning; and the learners' representation of his own prior knowledge to give meaning to new experiences.

I return here to the important contribution of learning materials and their development and the significant context for teacher learning that they provide. This is important as it influences how we design and organise professional development opportunities for teachers. Professional development initiatives such as the MSSI should be learner centred, should account for the knowledge and belief that teachers have, and should provide opportunities for participants to reflect on processes and products (Hawley and Valli, 1999).

2.3 LEARNING SUPPORT MATERIALS AND THEIR CONTRIBUTION TO TEACHING AND LEARNING

The current reform in science education, both abroad and locally, promotes inquiry-based teaching and learning to help learners develop a deep understanding of science concepts (Campbell et al., 2001; Schneider et al., 2005). However, teachers find implementing curriculum changes in the form of inquiry-based teaching and learning difficult. This may be the case even when they are supported by curriculum materials (Schneider et al., 2005). However, curriculum materials do have an important role to play in re-orientating classroom teaching towards inquiry approaches (Ball and Cohen, 1996; Ball and Feiman-Nemser, 1988; George and Lubben, 2002; Keys and Bryan, 2001). If such curriculum materials have a place in wide-scale curriculum reforms for teaching and learning, then their value when included in professional development programmes for teachers is of interest. More research is needed to explore the use and value of curriculum materials in the professional development of teachers, especially science teachers, in various contexts.

Using exemplary curriculum materials as a promising component of teacher development programme in Botswana formed part of a peer coaching programme (Thijs and van den Berg, 2002). The COAST study (Coaching to support science and mathematics teachers) explored the support needed to bring about effective peer coaching practices in schools in Botswana. The study was based on the assumption that peer coaching will be most effective if combined with exemplary curriculum materials and in-service education courses (ibid). The findings from the COAST study were, however, not conclusive. A sample of 120 teachers[7] from secondary schools in Botswana participated in the COAST in-service education courses. From this sample, eight mathematics and eight science teachers were selected for more in-depth data collection. The data collected from these participants concluded that the curriculum materials used in the professional development programme, did contribute to instructional improvement for the mathematics teachers[8] but not for the science teachers. However, as far as the implementation of the activity-based learning materials into practice was concerned, the science teachers in the study showed little or no transfer of ideas to their practice. The innovative method of teaching presented by the materials[9] was not seen by the science teachers as anything new and as a result, the teachers chose not to include them in their teaching. In their explanation of their findings, the researchers felt that perhaps the innovation aspects of the materials were not clearly reflected in the materials, even though the curriculum materials formed part of a professional development course providing the teachers with a clear understanding of the use of the innovation in practice. A second reason for the failure of the innovation could have been that while the literal intentions of the POE method were understood by the teachers, the teachers did not fully comprehend the deeper meaning of what the innovation intended (Thijs and van den Berg, 2002). The findings from the COAST study

[7] Sixty physics teachers and sixty mathematics teachers were selected for the sample
[8] This was understood to be the case because the materials filled a gap where there were no materials available for the mathematics teachers at the start of the project. In this case, it was assumed that any materials were better than no materials.
[9] Predict, Observe, Explain or POE

suggest that the transfer of ideas presented in the in-service program into classroom practice is not always straightforward (ibid).

As part of a general urban reform effort in Toledo, science materials that addressed content, pedagogy, and pedagogical content knowledge were designed to support teachers (Schneider et al., 2005). The materials were designed using the premise of project-based science (PBS). In PBS, learners engage in extensive use of learner-directed science inquiry supported by technology and collaboration. After a study on the how teachers actually used the materials was done and compared with the intentions of the developer, the researchers concluded that materials, if used in a careful way, can assist teachers in enacting reform-based teaching (ibid). The researchers found that the materials were most beneficial to teachers when the instructions were detailed, and support for teachers' thinking was lesson specific and consistent throughout the materials. A caution from the project, however, was that materials alone are not enough to reform educational practice. Together with materials, professional development is essential to help teachers plan for and reflect on their teaching practices (ibid). Teachers need to be given support on how to use materials as well as how to create the right classroom environments to encourage inquiry-based learning. Schneider et al. concur with the views of Ball and Cohen (1996) that learners' thinking and how to teachers should interpret the thinking should be an essential feature of curriculum materials.

Locally, curriculum reformers suggest that learning support materials should be seen as fundamental to the learning process (Revised National Curriculum Statement, 2002). According to the Department of Education (DOE), teacher support materials should among other things: promote critical thinking, logical reasoning and problem solving skills as essential life skills; promote an integrated approach to learning and encourage 'hands-on'

experiences; provide for a continuous progression of opportunities for development, allowing learners opportunities for gradual refinement of perception; take cognisance of individual differences and promote learner-paced learning; link content/ concepts/ knowledge/ understanding to skills and to values/ dispositions/ attitudes/ norms (DOE, 1998g, cited in Vinjevold, 1999, page 164). This list of criteria aligns the South African curriculum with an inquiry and activity-based constructivist context of ideas. How this vision plays out in South African classrooms is most extensively reported in “Getting Learning Right: Report of the President’s Education Initiative (PEI) Project” (Taylor and Vinjevold, 1999). The purpose of this group of studies was to provide a scientific basis for the future planning and delivery of educator development and support programmes in South Africa. The research focused on the South African school and classroom context, and interrogated issues of teacher practice, curriculum, and the use of teaching and learning materials, as well as the inter-relatedness of these matters in whole school development processes. While this report is now dated and regarded by some as conservative (Jansen, 2002), it is a useful synthesis of research on how teachers are using teacher support materials in the South African context at this time.

Vinjevold, in her chapter on Learning Materials (Vinjevold, 1999), cites a number of PEI studies that analysed the role of learning materials in South African classrooms. Crouch and Mabogoane looked at the role and use of textbooks in improving the quality of education in schools and according to them, apart from access to schooling, one of the most important factors in improving learning is the access to learning materials such as textbooks and stationery. Wickham and Versfeld investigated the role of texts in establishing good practices in the teaching of English in under-resources multilingual junior secondary classes in the Western Cape. Their main finding was that the individual teacher, rather than the materials used, determined the relationship between the materials and the

use of the materials. They also concluded that teachers did not always use the materials according to the material developer's vision. Baxen and Green's study examined the availability and use of learning materials in Grade 1 and grade 7 classrooms in the Western Cape. In their research, Baxen and Green observed that teachers made assumptions about the way in which materials mediate learning. According to them, teachers incorrectly assume that learners know how to use the materials to develop new knowledge after demonstration. Baxen and Green concluded that teachers provided learners with support of how to use the materials procedurally i.e. follow the instructions accurately, rather than conceptually i.e. how to use the materials to facilitate real learning and found no evidence of teachers instructing learners on why they were using the materials. They reported further that in many cases, teachers did not have a good sense of the relationship between learning goals and learning materials.

Some studies highlight some of the possible reasons why materials fail to impact in the way in which they were intended. Teacher educators and teachers often disparage text-books and prescribed learning materials of a similar nature (Ball and Cohen, 1996). In some instances, text-books and other materials are regarded as 'packaged information' and not used by good teachers (Vinjevold, 1999). A longitudinal study reported by Ball and Feiman-Nemser (1988) supports this notion. They investigated two separate teacher education programmes and suggested that the impression created by these programmes was that 'good teaching means creating your own lessons and materials' and teachers should avoid using text-books and teacher guides. Furthermore, teachers using learning materials do not always use them in the way intended by the developer such that they would achieve the conceptual goals stated. This is perhaps because teachers themselves are not always clear about the conceptual goals of the activities. Developers of teacher support materials assume that teachers will know how to use the materials in such a way

that learning will occur. The developers fail to take account of the teacher and of the fact that teachers themselves need to learn how to use new materials (Ball and Cohen, 1996). Teachers' own understanding of the material, their beliefs about what is important, and their ideas about teacher and student roles shape their practices. For these reasons, teachers change the material to suit their learners in such a way that there is a gap between what the developers mean to happen and what actually happens (ibid). Reeves and Long's investigation (cited in Vinjevold, 1999) of language-sensitive activity-based methodology in primary science teaching at the grade 7 level, led them to conclude that that in order for the conceptual goals of the learning programmes to be achieved, some key elements should be present: firstly, learning materials should focus on a few key conceptual goals and should address concepts, processes and skills in terms of incremental cognitive complexity; secondly, learning material should take into account the depth and breadth of teachers' current subject knowledge and should help bridge the gap between their existing knowledge and the needs of the curriculum; and thirdly, teacher support materials should explain scientific concepts clearly and explicitly (ibid).

There are studies that identify some features that contribute to the success of curriculum materials in education reforms (Dufresne et al., 1992a and 1992b; Hobden and Draper, 1995; Schneider et al., 2005). In Schneider's study (2005) for example, using the materials allowed teachers to give their students opportunities to plan and design investigations, discuss and contribute their own ideas, and participate in POE activities. The latter includes many activities which teachers tend to find difficult to implement as part of their day-to-day teaching practice (ibid). In Hobden and Draper's study (1995), they suggested that teacher support materials could be very effective in improving classroom practice and science learning if they were developed by teachers in collaboration with education researchers. Hobden and Draper argued that in order to bring about effective and

meaningful change, teachers would have to be directly involved in the development of the curriculum materials that they use in their own classroom and that the materials would be based on effective learning strategies if there was a process of collaboration between teachers and researchers (ibid).

2.4 LEARNING SUPPORT MATERIALS AND PROFESSIONAL GROWTH

International thinking seems to be converging on the importance of using curriculum materials in conjunction with professional development programmes, if such materials are to have any real impact on what happens in the classroom (Ball and Cohen, 1996; Schneider et al., 2005). According to these studies, materials have a much greater chance of impacting on teachers' practice, if teachers are trained in how to use the materials and support is given on an ongoing basis. A key issue in effective professional development programmes is the availability and design of adequate exemplary teaching materials and a more or less constant flow of new materials to facilitate and support teachers to implement any newly acquired skills and knowledge (de Feiter et al., 1995). The work of de Feiter et al. makes specific reference to the design of curriculum materials and the importance of introducing appropriate instructional materials to change teacher behaviour. According to these researchers, instructional materials should provide teachers with a clear explanation of the ideas and rationale behind the intended change (either in the curriculum or in teacher behaviour). These researchers further suggest that teachers need examples of what the ideas look like in the classroom e.g. written lesson plans or video footage of possible lessons (ibid). Teachers also need the opportunities to practice the intended change either in the workshop or in the classroom as well as the opportunities for structured feedback and informal exchange of experiences. Teachers also need follow-up support in adapting instructional materials or developing new ones (ibid).

Professional development programmes should include opportunities for teachers to learn about improved instructional practices through the use of curriculum materials (Schneider et al., 2005; Ball and Cohen, 1996). Curriculum materials can give teachers tools to enact reform in their classrooms (Schneider et al., 2005). In their research on the role of curriculum materials in teaching, Ball and Cohen (1996) suggest that while curriculum materials play and important role in teaching and learning, they might contribute more if teachers' guides included strategies to teach teachers how to listen to and interpret what learners say and anticipate what learners may think about instructional activities. Ball and Cohen stress the importance of the need to include information on student thinking in curriculum materials. Curriculum materials also need to support teachers' learning of content, by including in the materials a discussion about alternative representations of the ideas and connections between them (Ball and Cohen, 1996). Curriculum materials should also focus on how to improve teaching. According to Keys and Bryan (2001), there are factors beyond the inclusion of learners' ideas in materials that contribute to their effectiveness. Keys and Bryan say that teachers who use inquiry-based teaching must have a rich and deeply developed understanding of science content, student learning, the natures of science and ways to engage learners in investigations (ibid).

While Ball and Cohen (1996) stress the importance of using materials as part of professional development aimed at improving a teacher's ability to teach, they caution that this approach to curriculum materials and their development needs a lot of work. If students' ideas are going to be included in the materials, you need to find out about what students think. Rather than thinking of materials as something for students and the teachers guide as an instruction manual for teachers, both would have to be considered as territory for teachers' learning (ibid). This approach would require imaginative design and inquiry but would be able to offer teachers more opportunities to learn in and from their

work. Curriculum materials could offer concrete examples of what student work might look like, what reasoning might underlie students' work, and what other teachers have done in similar situations (ibid). To some extent, the suggestions made by Ball and Cohen (1996) provide inspiration for this study i.e. the notion that teacher support materials can be seen as opportunities for teacher learning and not only as learning tools for learners in the classroom. This idea provides the basis for using teacher support materials as the basis for professional growth, not just as something to be handed out at workshops for teachers to use in their classrooms.

To move in the direction of making curriculum materials more effective in promoting learning, I looked at the research on teaching strategies within a conceptual change framework for science teaching and learning. Within this framework, activities should convince learners to change their ideas in science to be more in line with scientifically acceptable viewpoints. Hobden's work on problem tasks in science (Hobden, 1998) summarises the strategies that can be used to adapt traditional problem tasks to develop conceptual understanding in science. According to the work of science educationists, teachers should expand routine problems into broad problems with a set of structured questions to allow the learners to understand the entire situation (Schuster, 1993 cited in Hobden, 1998, page 227). The questions are designed to guide students to the relevant aspects of the problem. The focus is on a qualitative understanding of the problem, rather than just a problem of getting numerical answers. Teachers must encourage learners to use multiple representation of a problem such as qualitative descriptions and diagrams rather than just numerical representations when solving problems (van Heuvelen, 1992 cited in Hobden, 1998, page 227). There should be an emphasis on a qualitative understanding of problems before using mathematical calculations. To promote an understanding of the problem solving strategies, learners must be given the opportunities

to reflect on the problems after the teacher has done them. This can be done by giving learners detailed written solutions to problems (Sweller, 1989 cited in Hobden, 1998, page 227). The emphasis should be on understanding the problem as a whole, rather than just understanding the mathematics and memorising steps in the solution. Added to these strategies, Mason (1992) suggests that learners should be provided with techniques for developing extensively linked schema. This can be done by introducing learners to concept mapping as a tool to represent knowledge in concept networks.

2.5 TEACHERS AS DEVELOPERS OF LEARNING SUPPORT MATERIALS

The design of learning support materials is one of the oldest strategies for attempting to change classroom practice and improve science education (Ball and Cohen, 1996). Current research on teacher thinking suggests that teachers are active curriculum creators, rather than just curriculum implementers who make instructional decisions based on a complex system of beliefs and knowledge (Keys and Bryan, 2001). Teachers are active decision-makers and what they believe will significantly affect how they teach and how they use inquiry-based teaching methods (ibid). When teachers are instructed to implement a curriculum, their own beliefs about the natures of science and student learning may in fact be obstacles to the intended curriculum, which may in turn inhibit reform. There is currently a need for research on inquiry-based materials that have been designed by teachers rather than researchers, or teaching materials that are truly collaboratively developed by teachers and researcher with teachers contributing at least as much to the design of the materials as the researchers (Keys and Bryan, 2001; Hobden and Draper, 1995).

Teachers in Trinidad and Tobago for example, participated in a professional growth programme using the development of context-based resource materials as the basis for the programme (George and Lubben, 2002). Typically in professional development programmes teachers are involved in piloting materials written by a team of 'experts'. This programme, however, focused on a 'participatory model' (ibid) where the teachers developed their own learning resources for use in their classrooms. The intervention was intended to stimulate professional growth and while the teachers remained constrained by the examination-orientated system, the teachers reported that the experience 'empowered them to be more critical practitioners' (ibid). This study reported partial success in curriculum reform through the participatory development of learning support materials.

Research interrogating the value of teachers as developers is reported by Ball and Feiman-Nemser (1988). Their study focused on textbooks and teachers' guides and examined the value placed on teachers developing their own teacher support materials. The teacher in-service programmes that they studied revealed that the prescribed textbooks were often presented as insufficient and that teachers were encouraged to supplement the textbooks by developing and using their own materials. Ball and Feiman-Nemser (1988) discussed the problems that new teachers have with this expectation and conclude that new teachers often lack in depth knowledge of any subject area to develop useful learning materials. Furthermore, the novice teachers also lack the knowledge about children and are just starting to develop pedagogical orientations and skills. To develop ones own materials, they suggest the need for a flexible understanding of the content knowledge as well as ideas about how children might learn this knowledge which is a challenge even for highly experienced and knowledgeable teachers (ibid).

Teachers' responsibility for the design and development of materials and learning programmes in South Africa is now widely assumed (Vinjevold, 1999). This is evident from the South African RNCS (2002) regarding the roles of teachers. The competencies teachers are expected to have and practice in their teaching include the design of original learning programmes and teacher support materials that take into account the learning needs of the learners as well as new approaches to teaching and learning. These materials should allow learners to overcome barriers to learning (Department of Education (1998b) Norms and Standards for Educators cited in Vinjevold, 1999). We now know that learning support materials can play a significant role in educational reform. We also know that teachers, as curriculum developers rather than curriculum implementers are well positioned take on the role of developers of materials. What we need to find out is how processes of developing materials might proceed and what opportunities they can provide for professional growth for teachers. Unfortunately, research on local programmes involving teachers as developers of teacher support materials is very scarce.

2.6 CONCLUSION

Research seems to speak with one voice on the importance that learning support materials can play in curriculum reform. There is also agreement on the need for professional development programmes to be an integral part of the use of learning support materials and the need for teachers to participate in the development processes. Where there is not agreement are the features of materials and professional development programmes that would make the inclusion of learning support materials into a teacher's repertoire of practice on an ongoing basis. While some studies report limited success in teachers using materials in the way in which they were intended, most of those reviewed suggest that success has been inadequate. There is also a lack of research attention to

the processes involved in teachers participating as the developers of materials, and the impact of these processes of their own professional growth and curriculum reform. This study seeks to address that gap in the literature by investigating the opportunities and challenges for teacher learning and professional growth that are created through processes of materials development. The research is conducted as part of an innovative professional development programme, which includes the development of learning support materials by curriculum implementers. Perhaps curriculum implementers can be seen as a middle point between teachers and experts as developers of materials. Curriculum implementers are selected because of the knowledge they have of the classroom environment while at the same time, as teacher leaders are able to assist with teacher learning. This is seen as an important compromise in the programme where the ultimate goal is to get the teachers fully involved in the materials development processes.

> "If the boundaries of curriculum design and development were reconsidered and redrawn, curriculum materials could offer more opportunities (for teachers) to learn in and from their work." (Ball and Cohen, 1996)

An important issue for this study is to explore whether the MSSI intervention can help to redraw those boundaries and offer teachers a chance for professional growth through the processes of developing learning support materials.

CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION

This study was based on an interpretive research design involving a case study approach. Qualitative data collection techniques and procedures were used. The interpretive research paradigm is characterised by a concern for the individual and endeavours to understand the subjective world of that individual (Cohen et al., 2002). It is the name given to a group of research approaches including qualitative, participant observer, and case study research where the researcher attempts to understand and interpret what is happening from within. In this chapter, I show why this design was best suited to answering my research questions, followed by a description of the tools used to obtain data and the data collection procedures. In addition, I outline the steps followed in the analysis.

3.2 RESEARCH DESIGN

This study sought to investigate and understand the processes involved in developing teacher support materials. In particular, it sought to identify the opportunities and understand the challenges that the development processes presented for professional growth of teachers and teacher leaders in the MSSI. It was an investigation of a case of materials development within the broader professional development initiative of the MSSI. The development of materials took place primarily in a workshop setting consisting of a small number of participants. I needed to know how the workshop was set up, who controlled the activities, what the participants did in the workshops, what the participants expected to happen at the workshops and most importantly, what actually happened. I was

interested in observing what the participants were doing, how they interacted and what the final product of the development processes were. By observing the processes, speaking to the participants and making field notes of the workshops, I was able to get a deep understanding of the opportunities and challenges of the processes of developing the materials. Faced with the challenge of collecting the necessary data to conduct my investigation, and guided by the literature on the research design (Cohen et al., 2002; Merriam, 1998; Stake, 1988; Yin, 1988), I selected a case study as the most suitable research design.

As this was a small study, and I was the only researcher, a case study was ideal as it allowed me to position myself as the primary instrument for collecting data (Merriam, 1998). The real strength of this study is that it allowed me to gain access to the processes in the natural setting of the workshops at which the development of materials took place (ibid). This then gave me better insight into not only what is happening, but why it is happening.

3.3 RESEARCH ROLES

For the purposes of this study, I adopted the roles of direct observer, participant observer and interviewer.

Direct observer and Participant observer – Observations are a valuable source of data in case study research as they afford the researcher the opportunity to collect 'live' data from 'live' situations (Cohen et al., 2002). This allows a researcher to discover things about the context of the situation and personal knowledge about the participants that participants might not be willing to speak about in a formal interview (ibid). I assumed the role of direct

observer in some CI and CL training workshops and adopted a semi-structured approach to observations (ibid). This meant that while I had an agenda of issues I wished to observe, the data was not always gathered in a pre-determined or systematic manner. In some instances, it was only upon observations of certain phenomena that I decided the significance of those observations for my study. My study sought to investigate opportunities and challenges in a development processes, and so throughout my observations I looked for critical incidences. In some instances, the incident may have only been observed once but was still recorded as important evidence. In these instances, I believe that the incident revealed an important insight into the situation being observed (ibid).

In some workshops, my role as researcher went beyond dispassionate observer and instead I took on the role of a participant observer. Participant observation is a special means of observation whereby the researcher is not just a passive observer instead takes a variety of roles in the case situation and may even participate in the events (Yin, 1988). This type of observation provides good opportunities for collecting case study data, and as I was invited to participate in the materials development workshop, this way of collecting data was the most appropriate. Participant observation allowed me to get a viewpoint of participant inside the case, rather than external to it (ibid). This viewpoint proved to be invaluable in portraying an accurate picture of the case under investigation. I was aware that participant observation may also produce potential bias on the part of the observer and there were times when I became involved in the group as a supporter rather than as an objective observer of phenomena (ibid). There were also times when the role of participant became much greater than the role of observer and valuable data may be overlooked as potential times for note taking and question-raising may have been lost. Despite these problems, the role of participant observer was best suited for the case under

investigation and the gaps in the observation data were filled in through interviews with other participants and stakeholders after the materials development processes.

Interviewer – Interviews are an essential source of case study information (Yin, 1988). Interviews give participants (interviewer and interviewee) the opportunity to discuss their interpretation of what they experience and observe and to express their own point of view (Cohen et al., 2002). The purpose of my interviews was to gather data about why things were done in a particular way and to better understand participants' opinions about the processes and products of the development workshops. I chose to conduct focus interviews (Yin, 1988), which followed a set of pre-determined but semi-structured questions conducted in a conversational and open-ended manner (Cohen et al., 2002). This allowed me to add questions about issues that arose unexpectedly during the interview and to follow up on issues that the interviewee felt needed to be expanded. In some cases, I returned to the participants to ask additional questions that arose from reading the interview transcriptions. In some instances the interviews were conducted with small groups and in others with individuals, depending on the availability of participants and the time allocated for my research within the project.

3.4 SELECTING THE CASE

This research was conducted as a case study of the processes of materials development within the MSSI project. Within this case, I observed three different development workshops. The MSSI was chosen for my study because of its position within the Joint Centre for Science, Mathematics and Technology Education (JCSMTE), which allowed me easy access to the project and participants. It was also chosen because I have had an interest in materials development processes for many years based on my experiences as

a qualified science teacher. I was also, for the purposes of the MSSI, a subject specialist in GET and FET science and was brought into the process to fulfil this role. I was considered by the other members of the development group primarily as a science subject specialist with the additional task of conducting some research. While I explained to each group at the start that I was doing research on the processes and would be asking them a few questions during the workshops, my role as participant surpassed the role as researcher.

3.5 DATA COLLECTION PROCEDURES AND STRATEGIES

Within the MSSI case, I studied 3 separate materials development workshops. A table (Table 1: Data Collection Event and Products) is given showing the workshops and meetings that I attended, the other participants in the workshops and meetings and the data that was collected at each stage.

Table 1: Data Collection Events and Products

Date	Place	Event	Product (study guide)	Role of researcher	Participants	Data collected
1. July 2003	UP	CI GET development workshop (workshop 1)	• Forces	Participant observer	3 UP staff (including myself) 1 CI	Personal reflection Study guide document
2. Feb 2004	UP	CI FET development workshop (workshop 2)	• Chemical interactions • Matter and materials • Waves (not complete)	Participant observer	1 UP Staff (myself) DCES 4 CIs	Personal reflection Interview with organiser Study guide document
3. Feb 2004	UP	Interview and follow-up interview	-	Interviewer	Development workshop organiser	Transcribed interview
4. March 2004	Middleberg	CI Training workshop Science FET group	-	Participant observer	10 CIs UP representative	Video recording Field notes Power-point presentation form DCES Questionnaire responses from CIs
5. April 2004	Middleberg	CL Training workshop	-	Observer	28 CLs	Video recordings Transcribed interview
6. May 2004	KwaMhlanga	Cluster meeting	-	Observer	26 Cluster members 7 CLs	Video recordings Post-cluster meeting questionnaire responses Field notes
7. May 2004	KwaMhlanga	Cluster meeting	-	Observer	38	Video recordings Field notes
8. Jan 2005	UP	CL development workshop (workshop 3)	• Vectors (later became Physics)	Participant observer	FET DCES 2 UP staff (including myself) 3 CIs	Video recordings Group Interviews
9. Jan 2005	UP			Interviewer	Assistant workshop organiser	Transcribed interview
10. Feb 2005	UP			Interviewer	Study guide developer and editor	Transcribed interview

The case study research spanned 2 years and covered a number of workshops in that time. Some of the workshops were attended by the same people while others were attended by different people in each case.

My involvement in the initiative started when I was invited as a subject specialist for the development workshop held at the University of Pretoria in July 2003 (item 1 on data collection procedure table). I was interested in developing materials and this seemed like a good opportunity to get involved in a professional development programme. At this point, I had no formal research questions, just an interest in the processes of developing materials and how this initiative would be different from others that I had been involved in previously. The workshop was a gathering of CIs with UP staff added for subject knowledge and I participated in the group developing materials for the GET Senior Phase on 'Forces'. The workshop was scheduled for 3 days and on completion, the CIs returned to their official work stations within the MDE and I was given the job of compiling the draft documents, editing them and producing a workable study guide including pictures for training at a CI training workshop. With no formal questions at this stage, I reflected on the study guide that was the product and the processes of developing it as I had observed it. This reflection was the basis for the formulation of my research questions.

In February of the following year, I was again invited to a CI development workshop held at the university (item 2). This time I was invited to join the science FET CIs who were tasked with the job of developing three study guides. Except for the one CI that had participated in the previous development workshop and I, these participants were all new to the process. Also participating in the workshop was the MDE Science DCES, although he was only able to attend one of the three days. Without the DCES, the team consisted of me and 4 CIs. With more focused research questions, I reflected on the processes as a participant and

studied the study guides that were produced at the end of the workshop. I also interviewed the organiser of the development workshops to get his views and expectations of the processes and the product (item 3). That interview was transcribed and based on that transcription, I did a follow-up interview.

The MSSI programme relies on a cascading model of information dissemination. A small group of CIs and CLs (about 15) are selected by the MDE and invited to participate in the development processes. These CIs typically would have just returned from a study tour in Japan hosted by JICA officials. These CIs are then expected lead the training of all the CIs in the province on how to use the materials in cluster leader workshops. In March 2004, the CI training workshop was held in Middleberg and I attended this workshop, this time as an observer (item 4). The workshop was attended by the CIs (approximately 80) in the province but the group that formed part of my case study was the group of 10 CIs responsible for FET science. These CIs were to be trained in the 'chemical interactions' and 'matter and materials' study guides. The 'matter and materials' study guide training was done by the university representative responsible for organising the development workshops and the 'chemical interactions' study guide training was done by a CI. This CI had participated in the development of the guide. The study guide on 'waves' was not developed enough to be used in training. At the start of the workshop, I gave each of the 10 CIs in the FET group a short questionnaire. All CIs responded on the first part (before the workshop) but only 4 responded on the second part (reflection after the workshop). The questionnaire was open-ended and designed to elicit short responses from the participants. The questions were confined to the expectations of the participants of the workshop, as well as whether their expectations were met. I was interested in whether the participants had the same expectations as the organisers. I also video recorded the training, studied the power-point presentation given by the Mpumalanga science DCES at

the beginning of the workshop, and took field notes throughout the workshop. I attempted to conduct a group interview with the CIs at the end of the workshop to get their opinions on the processes including their expectations but the noise level in the room was too high and the quality of the recording was so bad that no usable data was obtained. Data for this part of the study was obtained from my observations of the video recordings, my personal notes and personal memories of the interviews.

At the Middleberg CI training workshop, dates for CL training were set. I decided to follow the group of 3 CIs from the larger group of 10 FET Science CIs who would be organising the training in the KwaMhlanga sub-region. This was because the training was to be done in Middleberg and this was the training centre closest to the University of Pretoria where I was based. The CL training workshop was held in April 2004 in Middleberg and was attended by 28 CLs, led by 3 CIs (item 5). The 3 CIs who had been trained at the CI training workshop the previous month were now responsible for organising the workshop and training the CL in how to use the study guides over two days. I attended this workshop as an observer and video recorded the proceedings of the training. I also did a group interview with the CLs at the end of the workshop as well as one interview with one of the CLs at the workshop. The group interview was captured on video-tape and the individual interview was transcribed. While this training workshop and the cluster meetings were not directly part of the development processes, it was important for me to attend these workshops to gain insight into the full process of dissemination of the materials.

At the CL training workshop, the dates for the cluster meetings were decided. At this workshop, the CLs in the KwaMhlanga sub-region decided to pool their efforts and combine the regions cluster meetings into one large meeting. Instead of each cluster of about 6 schools meeting with one CL, there would one large meeting led by the 7 CLs

from that region (item 6 and 7). The leadership of the cluster meeting would be divided between the CLs with each being responsible for a few of the activities from the study guide. The cluster meetings were set for 4 consecutive Wednesday afternoons, from 1pm until 3pm each afternoon. This would give a total of 8 hours of training for the teachers on the study guides. I attended the first two of the cluster meetings in May 2004 as an observer but the second two were cancelled owing to other departmental scheduled meetings for all teachers. The first of these two meeting was only attended by 28 of the possible 49 teachers because some schools had not received their invitations to the workshop in time. The second meeting the following Wednesday was attended by 38 teachers. This time they had all received the notice. At the end of the meeting, I gave the members of the clusters an open-ended questionnaire to complete. The questionnaire was designed to elicit short responses from the cluster members regarding their expectations of the meeting and their impressions on the value of such a meeting for improving their teaching practice. Only a few minutes were needed to complete the questionnaire and 32 of the possible 38 members returned the questionnaires. This was done because there was no time officially allocated for gathering of research data in the meeting and time was limited. They were designed to get an overview of opinions from the participants rather than in-depth answers. I intended to schedule in-depth interviews with participants to probe more deeply the insightful responses but because the last two cluster meetings were unexpectedly cancelled, this did not happen as planned. At the two cluster meetings, I video recorded the meetings and took field notes during the meetings.

The development and training process within the MSSI is organised on an ongoing basis with rounds of development and training continuing throughout the project. For each of these development workshops, new CIs are invited so that each group of CIs that has returned from the Japan study tour will share their resources collected in Japan at the

development workshops. These resources are to be the starting point for development of the study guide. The next round of materials development started in January 2005 and I was invited as a subject specialist for the science FET group (item 8). This group consisted of the Mpumalanga Science DCES, one UP representative who attended for the first day (brought in to the workshop as a subject specialist and employed to compile and edit the study guide after the workshop), me as a subject specialist, and 3CIs. One of the CIs had attended the development workshop held in February of the previous year. The group was to develop a study guide on vectors using the resources gathered in Japan as a starting point. The workshop was video recorded. I attended this workshop as a participant observer, interviewed the science FET group as a whole at the start of the workshop (including the DCES) and interviewed 2 of the CIs who had participated in the workshop immediately after in had finished on the final day. The person who was supposed to organise the workshop was not available to organise it so two UP staff members stood in as organisers and I interviewed one of those 'organisers'. A few weeks later, I interviewed the member of the group who had attended for the first day and who had compiled the final version of the study guide. All these interviews were transcribed. For each interview conducted, I adopted a semi-structured and open-ended approach. I had a list of questions that I wanted to ask but was able to deviate from my questions and add additional questions when necessary.

It was at this point that I felt that I had gathered enough data for me to understand the processes of developing material and to extract opportunities and challenges within the processes.

I felt that I had enough evidence to answer my research questions which are:

1. What are the opportunities and challenges for teacher learning and professional growth that are created through the processes of materials development in the MSSI? This question will be explored fully by looking at the opportunities for teacher learning in terms of:
   - Participation and ownership in the development processes, and
   - Building teachers' capacity for developing effective learning support material.
2. How can the opportunities and challenges to the material development processes in the MSSI be explained?

3.6 DATA ANALYSIS PROCEDURES

This study sought to investigate the processes of materials development as part of a professional development programme. With the ultimate goal of answering my research question, I systematically searched and arranged the interview transcripts, field notes, documents, personal reflections, and notes based on video recorded data to increase my understanding of them and to enable me to present what I have (Bogdan and Biklen, 1982). My analysis involved organising the data, synthesising it and looking for patterns, and discovering what is important and what is to be learned (ibid). I started the organising by constructing a table (below) to show the types of data that were collected to answer each research question.

Table 2: Relationship between research question and type of data collected

Research Questions	Interviews	Observations	documents	Self-reflection	Video recordings
1. What are the opportunities and challenges for teacher learning and professional growth that are created through the processes of materials development in the MSSI? This question will be explored fully by looking at the opportunities for teacher learning in terms of: • Participation and ownership in the development processes, and • Building capacity for developing effective learning support material.	√	√	√	√	√
2. How can the opportunities and challenges to the material development processes in the MSSI be explained?	√	√			

A case study was chosen as the most suitable research design and a qualitative understanding of the data was selected as the most appropriate way of analysing and interpreting the data. I watched the video recordings of the workshops that were taped over and over, transcribed and read all the interviews that were conducted, read the documents that I had obtained pertaining to the organisation of the workshops, and read all the field notes that were taken during the study. I searched the data for regularities and patterns and categorised the data into themes (Bogdan and Biklen, 1982). For written transcripts, this involved using different colours for different themes. For example, as I read and watched the data, I noticed that the issue of 'time', or in some instances 'not enough time', was raised on a number of different occasions by different people. I then re-read all the data and highlighted all the occasions that the issue of 'time' was recorded, checked the frequency of this issue in the data and started to get a picture of how important an issue it was. I looked at the issue of time and began to interpret it in the context of an opportunity or a challenge to the development processes. I then made an assertion about the issue of time and selected evidence from my data to support and refute my assertion. I also looked for critical incidences in my data. This method of

analysis was repeated until I had sufficient themes and evidence to make assertions to answer all my research questions.

3.7 LIMITATIONS OF THE STUDY

The MSSI is a large project both in terms of geographic size and time frame. In terms of geographic location, it covers the whole of Mpumalanga and has organised all schools in the province into clusters. For the purposes of my study, I participated in the development workshops that occurred at the university and for convenience, chose to attend the cluster meetings in the sub-region closest to the university. In terms of time, the MSSI presently is divided into two phases with the three years of phase 1 complete and phase 2 expected to continue until 2006. I came into this project at the beginning of the second phase and so was not part of the processes that occurred in the first phase. Because of the time frame of the initiative, the process is constantly changing and so the opportunities and challenges arising out of my study may not necessarily be the same for other studies conducted at other times during the initiative. Despite all this, I believe that the data gathered from this study reveal some opportunities that can be built on in the future and challenges that need to be addressed by project organisers at this stage of the initiative.

3.8 VALIDITY AND RELIABILITY OF THE STUDY

The validity and reliability of a qualitative study can be confirmed by establishing that the research findings and hence interpretations based on those findings are credible (Lincoln and Guba, 1985). For this study, this was done in a number of ways. Firstly, as a participant and an observer, I was invited to three development workshops. This allowed me to spend a prolonged period of time in the development workshops which gave me

opportunity to learn about the research context, minimise distortions and build up trust between the participants and myself (Ibid). Most participants in the workshops considered me to be part of the MSSI project and my presence over the two years allowed me to interact with the participants on a formal and informal level.

Validity and reliability was further established by the use of triangulation in collecting data (Cohen et al., 2002, Lincoln and Guba, 1985). Triangulation is a way of improving the probability that findings and interpretations will be found credible by, for example, using different methods of data collection (Lincoln and Guba, 1985). In this study, workshops activity was observed, participants were interviewed before and after the workshops, and all workshop proceedings were video recordings. In all cases, interviews were accurately transcribed and in some cases, I returned to the interviewee to ask additional questions that the first interview had failed to establish answers to. Field notes were taken during the workshops and the video recordings served to remind me of interactions that I had failed to fully record during the workshops.

CHAPTER 4
THE DEVELOPMENT OF TEACHER (STUDY) GUIDES AND THE OPPORTUNTIES FOR LEARNING AND GROWTH

4.1 INTRODUCTION

In this study, I used the MSSI professional development programme as a context to investigate a case of learning support materials development. I sought to understand the nature and quality of opportunities for teacher learning and growth as well as the challenges embedded in such a process. I used observation and interview data collected from three separate materials development workshops, as well as a cluster (teacher) leader workshop and 2 (teacher) cluster meetings. My presentation and analysis of the data is based on the evidence gathered, and is organised around five main themes, namely (1) who participates in the development processes and how they participate, (2) the opportunities for ownership embedded in the processes, (3) the organisational constraints and how these affect opportunities for professional growth, (4) time factors and how these influence the opportunities for professional growth, (5) the processes of the cascade model and how it influences participation, ownership, and capacity building. Using these themes, at the end of the chapter I engage a discussion designed to answer my research questions, namely:

1. What are the opportunities and challenges for teacher learning and professional growth that are created through the processes of materials development in the MSSI?
2. How can the opportunities and challenges to the material development processes in the MSSI be explained?

4.2 WHO PARTICIPATES IN THE DEVELOPMENT PROCESSES AND HOW THEY PARTICIPATE

At the end of phase 1 of the MSSI, the collaborating parties (JICA, MDE, and UP) agreed to work together for another 3 years in MSSI phase 2 (Memorandum of Agreement, April 2003). In phase 2, the production of "distributable materials" in the form of "subject content materials for systematic use in training activities, especially at the cluster and school levels" is a key part of MSSI (Memorandum of Agreement, April 2003). There was a decision at the start of phase 2 therefore to provide the cluster meetings with the focus that had been lacking in phase 1. This focus was to be study guides for use in the cluster meetings and in classrooms. A member of the MSSI steering committee explained:

> Our impression in the case of some clusters is that they are getting together because they are supposed to be getting together, they are told to get together (by the department) and … the main item on the agenda was a) what's for tea and b) when do we meet again. So we (MSSI) wanted to provide some kind of materials in the hands of the cluster leaders so that when people came to the clusters, they could go back saying 'I really got something now… its really useful, I'm going to be sure I'm at the next cluster meeting because I don't want to loose out on the kind of help and support we are getting.' We would hope, then, that the ideas that the teachers get at the cluster meetings are taken and used in the classroom. We've made it clear that we are more than happy if they take the activities in the study guide and photocopy them and use them in their classes. It's in that way that we hope then that the project will begin now to have some kind of impact on the classroom. (interview)

This interview with the steering committee member of the MSSI showed a clear commitment from MSSI to ensure that the cluster meetings played an important role in increasing the focus of all teachers in the MSSI to improving science education in their classrooms, and that the development of learning materials was an integral part of that commitment. Another member of the MSSI steering committee, had raised the concern that just giving teachers ready made materials to be used in the classroom may prevent the educators from developing capacity in materials development

themselves (Minutes for MSSI Coordinator Team, January 2001). The solution suggested at the same meeting was that the then Heads of Departments (some of whom later became Cluster Leaders) should be trained to develop their own materials for use in their classrooms. This opened up the opportunity within the MSSI to focus the teachers' professional development programme around the processes of developing learning support materials. In the same interview referred to earlier, the steering committee member confirmed this new focus on using materials development to create opportunities for teacher learning and growth when he said:

> What the department (MDE) wanted was to have the CIs and hopefully at some stage the Cluster leaders involved as a way of empowering them and as a way of professional development. The writing of these materials was seen as professional development. (interview)

This data suggests that the leaders of the MSSI project saw the learning support materials as more than just a product for teachers to use. They saw them more as an opportunity to make an impact on the professional growth of the participating teachers. In 2003, a discussion document entitled "The Production of Study Guides in MSSI Phase II" (Rogan, 2003) outlined the project guidelines in respect of the learning materials development processes more clearly. The buy-in and ownership of the Curriculum Implementers (CIs) and Cluster Leaders (CLs) was considered to be of "utmost importance" (Rogan, 2003) hence their involvement in the development of the study guides was "essential" (ibid). This understanding of ownership was further affirmed in an interview with the materials development coordinator when he said:

> If you are taking material that you have ownership in, that you understand, that you helped develop, you'll do a much better job at the HoD level of presenting them and getting others enthusiastic about it. (interview)

The data makes known his belief in the link between participation and ownership. The ownership suggested in this interview begins with the participation of CIs and CLs in the

Japan study mission[10] where they develop the initial draft modules which form the starting point for the development of the teacher (study) guides. The CIs/CLs returning from Japan join a group of about 20 other CIs and UP representatives, brought together for two or three days for the process of developing the materials that were started in Japan further, and consolidating them into a study guide (Memorandum of Agreement, April 2003). This group of CIs is divided up into subject specific groups and in July 2003, I took part in the (physical) science group as a participant observer. During my participation, I probed deeper into the theme of (teacher) participation to investigate the extent to which their participation creates opportunities and/or challenges for professional learning and growth.

The opportunities for professional learning and growth through the materials development workshops are created through small group interactions and collaboration. The expected participants are subject specialists invited by UP, a MDE official (DCES), and the CIs. The workshop format allows a small group of participants to work collaboratively for an intensive period of 2 to 3 days to share ideas and resources in the development of classroom activities. The DCES is expected to provide leadership and subject content expertise, and brings with him/her knowledge of the school classroom and MDE policies. The UP participants are selected to participate for their subject content knowledge and their materials development experience. The CIs are expected to add value with their in-depth knowledge of the Mpumalanga classrooms and to keep the processes focused on the needs of the teachers. Arising from the group collaboration, opportunities for subject content knowledge and pedagogical content knowledge discussions are expected to create opportunities for professional growth. Evidence of the extent of participation was gathered over the three workshops I attended in my capacity as a subject and materials development 'expert' commissioned by the University of Pretoria (UP).

[10] The study mission is discussed in more detail later in this chapter on page 68.

The first development workshop that I participated in was the GET Senior Phase science group developing the study guide on 'Forces'. I will refer to this workshop as workshop 1[11]. This science group had one CI, one university staff member (science subject specialist), the husband of a university staff member (science subject specialist not involved in education), myself (invited as a science subject specialist). As a team we together assembled and developed activities for the 'Forces' study guide. The CI that had participated in the development activities on the first day was unable to attend the workshop further, as was one other UP representative owing to other work commitments. On the second and third day of the workshop, individual members of the science development group worked individually on their own contributions to the guide. The study guides are, however, intended to be developed collaboratively, and the development process is designed to allow for additional contributions to be made to the study guide from CIs not participating directly in the writing workshops. That is, the final draft is made by the writing team that is assembled for the development workshops, and it is then circulated and discussed further by a larger group of CIs at a follow-up CI workshop. These processes are designed to increase voice and ownership in the product.

In February of 2004, I participated in a second development workshop organised at the University of Pretoria. I will refer to this workshop as workshop 2. The product of the science group at this workshop was expected to be three study guides: Waves; Matter and Materials; Chemical Interactions. For workshop 2, the CI participation in the science group had increased. There were four CIs in the group, one of whom had been in the previous round of development, the DCES for science who attended for half of one day and contributed some ideas to the 'Waves' study guide and myself (science subject specialist).

[11] Details of data collected at the workshops are given in Table 1, page 36.

The third round of study guide development in this case study took place in January 2005. I will refer to this workshop as workshop 3. The FET science group attending the workshop was attended by 3 CIs, one of whom had attended workshop 2, the science DCES (who had participated in workshop 2), two subject specialists (one with the additional task of compiling and editing the final study guide and myself). The attendance of the DCES in the development workshops increased over the three workshops with no attendance for workshop 1, some attendance for workshop 2, and full attendance for workshop 3.

My data suggests that the participation in the three workshops making this case study was variable. Participation by the MDE leadership improved over the three workshops with the DCES being present for one day in workshop 2, and for the full workshop 3. CI participation also increased over the three workshops with 4 CIs and 3 CIs attending for workshops 2 and 3. Participation was therefore not consistent over the three workshops although there is evidence of improvements. Invited as a subject specialist for each workshop, I was the only member of the group to attend all three workshops, and one other CI attended for workshops 1 and 2. Upon further probing, I found that this change of participating CIs was a deliberate decision on the part of the MSSI steering committee. The agreement was to give as many CIs as possible the opportunity to participate in the Japan study mission and therefore the opportunities for professional learning and growth (Memorandum of Agreement, April 2003). The result of this decision was that while the development processes created opportunities for professional growth through the collaborative interaction at the workshops, these opportunities were constrained by the fact that the beneficiaries only received a single opportunity to participate actively. These CIs did, however, have other broader opportunities to continue their structured learning during the CIs workshops designed for “additional input” into the study guides. The latter

opportunities are a bit different and probably less rich in terms of the opportunities they provide for participation and ownership.

Beyond trying to understand about who participates, workshop 3 allowed me to probe more deeply the contributions of the participants during the workshops, and the impact that these workshops have on the opportunities for professional learning that are created. On the first day of workshop 3 in the science group, the discussion focused on how to develop activities that encouraged problem-solving skills or more specifically, those that addressed Natural Science Learning Outcome 1[12] of the new National Curriculum (National Curriculum Statement, 2003). Learning Outcome 1 (LO1) is stated as "The learner is able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts" (National Curriculum Statement, 2003). Activities addressing this outcome should allow learners to use process skills such as planning, observing, gathering information, comprehending information, synthesizing information, generalizing, hypothesizing, communicating results and findings. It is expected that learners will be encouraged to make scientific inquiries by asking relevant and appropriate questions, solve problems by identifying and analyzing problems that focus on technology, the environment and society and designing procedures to reach solutions (National Curriculum Statement, 2003).

In the following extract that is typical of the conversations in the workshop, the group is engaged in a discussion about the activity that the two participating CIs had brought along from Japan. It was placed on the table as a starting point for developing activities and as

[12] As of 2006, there are 3 learning outcomes assigned to FET Physical Sciences. The other two are: The learner is able to state, explain, interpret and evaluate scientific knowledge and can apply it in everyday contexts (LO2); The learner is able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic, environmental and human development (LO3).

suggested by the CI, the activity could be used in the study guide. The DCES leading the group during the writing workshop suggested that the activity was a standard text book activity and as such, should be reworked into an activity addressing problem solving as required in LO1. Line numbers are given on the right for easy reference in the discussion which follows.

DCES	You know the learning outcome practical scientific inquiry and problem solving skills. Where is that coming in here? (Referring to the vector activity presented by the I) Can I suggest this … this is something (referring to vector activity) which is … is any conventional textbook experiment, right? This is what the teachers have, and this is what the teachers do in a grade 11 classroom now. Am I right? (gets general agreement from the group). Now from this same exercise, or from the same topic, can we move and design an activity which would encourage problem solving skills? … Maybe the question is "how can we convert such an activity to a problem solving activity"?	1 2 3 4 5 6 7 8
CI	Maybe I have to take us through the process of … let me just say the way we approached this thing (referring to time spent in Japan), you know what happened was that we started off by demonstration … I took two learners … or three actually … to outline different forces on one in the same direction. So I suppose this one (referring to one vector in the activity) is applying a force of 7N in the direction south, this one, 5N in the direction south. Then I said "what is the combined effect?" Then it was 12 in the direction south. Then from there I changed the whole scenario. Then the two people were applying different forces, say similar forces. We changed the direction such that the forces would be at an angle to one another. Then we asked them to predict what the answer would be. So that's basically the whole point. That was the starting point (referring to the lesson that he gave in Japan using the activity that had been developed). Now, there is a problem to be solved. Then hence, we asked them (the learners) to apply different forces that are at an angle to one another. Then from there, try to find the resultant of the 2 forces. So we gave them directions as to how to do that. So that at the end of it all, they would have to compare their answer with their prediction. So that's what transpired. We never started by … you know once you … we never said "this is what you are going to do, and this if the formula, there it is, then you just put them together then Wallah! You've got the resultant force.	9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
DCES	I do agree but my question is did they solve a problem?	26
CI	Well I think they did. Because they are supposed to find the resultant of two forces that are acting at an angle to one another … each other. So I think in doing that they applied the parallelogram law of vector addition. So there was the problem to solve. They could not add them mathematically.	27 28 29 30
DCES	And how would they find it?	31
CI	Unfortunately, we had to prescribe. Because we wanted them to use parallelogram law with the addition. And I think there is another way of doing it, which can be safer.	32 33
DCES	That is the whole point I'm talking of.	34
Subject specialist	There is a different way to approach this whole developing materials. The one thing is to say "these are the outcomes we want the kids to achieve, 1, 2 and 3 and this is what they are. And … vectors is just a context to develop those outcomes (Tom nods)." So let's say we want to develop problem solving, how can we use vectors to develop problem solving (Tom nods) we can do this, this and this. How can we use vectors to develop investigations, we can do this, this and this. What we typically have been doing is we've been saying "this is vectors, and we must cover this, this and this in vectors." Ok, activity one, we do it and if you try and throw in an outcome, like for example you try and throw problem solving onto this activity (referring to the vector activity under discussion) it doesn't work necessarily. If we had said "we want to develop problem solving, we must make correction to this activity to develop problem solving" … this is not a good problem solving activity, this is a good investigation activity. So we can start off by saying "we want to develop the outcome of investigations, how can we change this activity to focus on	35 36 37 38 39 40 41 42 43 44 45 46 47

	getting the kids to do investigations."	48
DCES	When we are talking of problem solving skills … the problem solving skills mean that they should identify a problem, they should make a hypothesis, then they should design a method to address to problem or to solve the problem. And then they do it. They plan an investigation, Ok … they plan. But that is taken out of this thing now … Ok you are planning for them … but I don't say they aren't doing any problem solving. During the course of that investigation, they measure … the observe, they measure, they take the data record the data, they manipulate the data … so that part is there. So that's problem solving skills even there. I agree with you, but not only that problem solving is taken in one activity … but one thing that is not there is 'to plan'.	49 50 51 52 53 54 55 56 57
CI	As Sue is pointing out, the rationale behind the whole lesson was not to solve a problem, but we wanted them to conduct and investigation. And then communicate and present information, so that basically the whole idea. But if then we put in the question of problem solving then we'll have to change the whole thing.	58 59 60 61
DCES	You see, I'm not asking the people who go to Japan to … … nobody is on trial (apologising for apparent accusation, general chuckle). What we are trying to do is to write the activity, by the study guide, that will address also problem solving skills …… so how best we can do that, that is where we have to put our heads to work. So … how many activities do you think we … I will go for Vusi's suggestion. We can split them into a series of activities. The first activity will be … I don't know how you want to come to it. We can go for your suggestions.	62 63 64 65 66 67 68
Subject specialist	My suggestion as a way of doing it would be to look at the text book or whatever reference book we have and look at the sort of topics that we would need to cover in vectors. So presently, being able to draw a parallelogram is prescribed knowledge, they need to be able to do that. So I would say let's go through vectors and see what content they are expected to cover. Then I would go through the outcomes and say there are the three main outcomes. Which of these activities or which of these lessons would lend themselves to covering that particular outcome? So this is the prescribed section of content that they need to do, and conducting an investigation is also a prescribed outcome. So how can we use this activity to develop a good activity on conducting an investigation? And then if we look at the other topics of vectors, which one of them lends themselves well to problem solving? And develop an activity … a problem solving activity around it. Because the way I see it, different topics … or different sections of vectors would lend themselves better to different outcomes.	69 70 71 72 73 74 75 76 77 78 79 80 81
CI	Yes, lets identify topics that we need to cover …for us to cover in vectors. Then from there, we consider our learning outcomes, problem solving ….	82 83

This extract shows a rich interaction between the participants in the group. Firstly, the participants are examining a given activity for its possibilities and ability to lend itself to achieving a particular set of outcomes (problem solving). The participants first disagree on the merits of the activity and engage each other on how they see the task as a possibility for achieving LO1 (lines 17-19). The value of the workshop format to learning and growth is that the discussion is free flowing and not regulated by the different positions (hierarchical) held by the participants in the organisation. They engage as participants of equal standing in this case and as such, opportunities for learning through participant interaction are evident.

Lines 26 to 33 suggest that all the participants do not have a good grasp on the concept of 'problem solving' and lines 49 to 51 indicate the valuable contribution that the DCES was able to make in helping the participants grapple with the concept. The extract shows that while some participants have a tentative understanding of the concept of 'problem solving' as explained in the South African National Curriculum Statement, others were able to create the opportunity for professional growth through guiding the discussion. Lines 35 to 39 and 72 to 81 show critical interventions from the subject specialist. She directs the participants towards a particular direction in development strategy, without dominating the discussion. The subject specialist becomes an integral part of the conversations and participates in the co-construction of the knowledge with the teacher leaders. Lines 81 and 82 suggest that the discussion was cut short as the CI chose to accept the suggestion unchallenged and to some extent the opportunities for further discussion and professional growth were prematurely curtailed.

4.3 OPPORTUNITIES FOR OWNERSHIP

Workshop 2 in particular provided me with the opportunity to investigate the issue of opportunities for ownership embedded in the processes of developing the learning support materials. It also revealed the constant dilemma between ownership and quality of the product. As a participant in workshop 2, I experienced the dilemma differently from the organiser. I was concerned about the quality of the final study guides and questioned the workshop organiser about his views on the quality of the study guides that had been produced. His response was:

> I think the quality is fairly good. You know, there is always a balance between the ideal and what can be produced in a setting like that and also one has to look at the ideal, and what is really suitable for the clusters and for the classrooms. So it would be quite feasible to produce material of higher quality in the sense that the cognitive level is higher but which would not really be useful and I think the CIs do probably have a better sense of what will go over in the classrooms and what will go over in the clusters. So I think the kind of activities that they came up with, are probably the realistic ones…. they're probably just right. (interview)

This extract shows the MSSI commitment to ownership of the product. It suggests that value is placed in the leadership role of the CIs with the teachers in the classrooms. It suggests that while quality might be slightly compromised, the value of ownership in ensuring classroom access was considered very important. A critical incident during workshop 2 supports this view.

> Critical Incident: A CI had developed an activity. In the activity, she had given instructions for the learners to do research on a topic and then present their ideas. She had given a number of options for presentation including using a power point presentation. Based on my experience in the classroom both as a teacher and as a developer of materials, I felt that firstly giving too many options for presentation was not a good idea and that introducing the option of using a power point presentation was completely inappropriate as we were writing for rural schools with little or no equipment. I felt that this part of the activity should be reworked. I assumed that it was my call, as the subject specialist, to do so and changed the activity to read in a much simpler way. When the CI re-read the activity, she was offended that I had changed her activity and insisted that it be changed back to the way she had written it. I approached John regarding who had the final say in the materials and he suggested that I allow the CI to take ownership and structure the activity as she wanted. (field notes)

The incident highlighted for me the struggle between myself, invited as a subject specialist pushing for a product of high quality based on some research-based strategies for improving science, and another participant (CI) who took ownership of the activity as a MSSI team player. My feelings of frustration at this incident had been experienced by another subject specialist who had participated in the Biology group in workshop 1. At the end of the development workshop she commented to me during an informal conversation that she thought the product was, in her words, "so bad" that she did not want her name to

appear on the guide. These two incidents show how different participants in the processes might have different understandings of the professional growth opportunities and had not 'bought-in' to the programme in the same way as the CIs.

Discussing the workshop and the study guides that were produced with the CIs at the end of workshop 3 certainly gave the impression that they felt a sense of ownership. One CI after workshop 3 suggested that he was happy with the product. He said:

> I think we are producing a good product. The reason is we don't … we didn't stick to the books. … From the brainstorming from the discussions that we had, we were able to come up with something new which I think it's a good challenge to teachers. It will be interesting to them. (Interview)

I probed his response further and asked in particular about the suitability of the study guides to the schools for which they were developed. These schools are far apart, typically poorly resourced, often without the basic requirements such as water and electricity. This means that learning materials developed for these classrooms should allow for English Second Language (ESL) teachers and learners with limited access to resources. The CI commented that:

> Since what we have … the activities that we have prepared, they don't need a lot of apparatus to be bought, then it means that most of the schools, even the schools that are disadvantaged, they are not having much equipment, they can be able to do this, that is why I am saying that it will be easier for educators to use it in the schools. To make one example, the last activity that we have done, of the … where the learners themselves have to make a plan how they can investigate whatever. Which I think it can improve science in the classroom. (interview)

The comments illustrate his belief that the study guides are suitable and relevant to the classrooms in the province of Mpumalanga. The processes of teacher (study) guide development bring together participants with extensive subject knowledge as well as participants who are an integral part of the MSSI and its goals. The evidence presented

earlier shows that the workshop format creates opportunities for rich interactions between these different participant which sets in place the ground work for professional learning and growth opportunities. However, there remains a tension between the expectations of the different participants as their understanding of such concepts and frameworks as 'buy-in' and 'ownership' may differ. This raises the issue of quality verses ownership and the extent to which quality can be sacrificed without compromising on ownership.

4.4 THE EFFECT OF ORGANISATIONAL CONSTRAINTS ON PARTICIPATION AND OPPORTUNITIES FOR PROFESSIONAL GROWTH

Throughout the three materials development workshops that inform this case study, evidence of organisation issues emerged to raise concerns about opportunities for professional growth that the development process was designed to create. For example, at workshops 3, the agriculture writing team did not arrive because the department had failed to inform them of the workshop in time. When I attended a cluster leaders' training workshop, I asked one of the CLs about his views on the departmental organisation with regards to disseminating information about meetings and professional development workshops. He explained the problems of communication as follows:

> They (the department officials) tell you, you must be there 10 o'clock for a certain meeting. Sometimes you get the note that you must be there yesterday, and you get it today. Really! At 9 o'clock this morning you get the notice 10 o'clock there's a workshop somewhere. You can't miss it. You have to leave your class. There's no time to organise for it. (interview)

His comments and tone of voice during the interview showed his annoyance at the departmental lack of proper organisation and the frustrations that resulted from it. He felt that his classroom practice suffered as a result and I sensed his disapproval. This sentiment was not uncommon among many of the participants in the MSSI project with whom I spoke informally to about this issue.

In all three workshops there was no participation by CLs or teachers in the development process. I was puzzled by this omission and upon investigation I discovered that in 2002, the MDE had placed a restriction on attendance of workshops by teachers during school hours (Memorandum of Agreement, April 2003). This meant that even though the steering committee had decided in 2001 that CLs and educators should be involved in the production of the materials (minutes of meeting, January 2001), their attendance was not possible as the writing workshop took place during school hours. This was despite the fact that the MSSI was a project "conceived and promoted by MDE" (Memorandum of Agreement, April 2003). At workshop 3, one participating CI commented:

> Even though, what I'm going to say is a bit controversial because we need teachers, what I would suggest is that when we develop them, we can involve at least one or so educator. One educator or so, so that they can also say what their experience is in class. But I know that that is not possible because we do this when the schools are running then that is not an easy job to do. But all the same I think it will be easier if we are involving the educators … at least one educator, so that he can come with a suggestion which are relevant to the schools … the school situation because we (CIs) are not at schools any more and we know what is happening in schools but we don't have the first hand information as they (teachers) do. (interview)

His use of the term 'controversial' suggested that it was a sensitive issue to discuss. As mentioned earlier, CI participation was expected to focus the development on relevant classroom activities. His comment that 'we need teachers …we don't have the first hand knowledge as they do' indicates his understanding of the issue that teacher participation was an on-going debate within the MSSI, especially in the view of its commitment to teacher contribution and ownership. It is clear, however, that MDE policies mitigate against active participation by teachers and cluster (teacher) leaders in materials development. A clear opportunity for teacher learning was therefore missed during some of these materials development workshops. Later I will discuss the various other attempts to engage teachers with the MSSI materials.

Evidence from workshop 3 relating to the development of the 'Vectors' study guide suggested that continuity between the development process and the product was affected by these organisational issues, which challenged opportunities for professional growth. For this particular workshop, the person compiling the guide was present for one day of the possible 2-day workshop (field notes) owing to other prior work commitments. I enquired about the apparent organisational challenges. The writing workshop had been shifted from a previously date agreed on by the MDE. The dates had been shifted to accommodate MDE officials and unfortunately the invited subject expert was not able to make the necessary adjustments to his schedule at such short notice. This limited his participation in the development process with the consequence that he was not able to share in the discussions that took place throughout the workshop. Since these discussions were designed to inform the focus of the activities in the study guide, it was not surprising that the final study guide produced at the end of this workshop did not reflect the ideas developed during the workshop. When asked why, he said:

> There was somebody by the name of Joe. I told him that he should have everything so that I can have them (activities) as long as I know exactly what is happening at this moment. So, but I didn't get anything at that time. Joe told me that Thandi will give me … when I looked for Thandi I didn't get her … I was going to Mpumalanga … those people (CIs) wanted their things (activities) that was prepared there. And those things were not there. And Tim phoned me to prepare something … and I was not knowing exactly what to prepare. I asked him and he said "No, all that you have done, you should just patch up". I said I do not have anything. He said I should just prepare anything and those people (CIs) said they were not the things that they had prepared. It was tough. (interview)

The evidence suggests a lack of effective leadership and communication between participants. Each member of the group assumed that it was somebody else's responsibility to make sure that the editor remained in the loop with regards to the workshop discussions. The outcome was that no draft activities reached the editor and without any guidance, the editor assembled a study guide on 'Mechanics' instead of on

'Vectors'. When probed as to what he resources he used to develop the study guide, he said:

> **Interviewee**: (Referring to his own resources) I mix everything.
> **Interviewer**: You took material that you already had?
> **Interviewee**: (Nods) Because usually, especially physics, I'm having a lot of things (referring to his own materials) … But I do not just … I check relevance and so on and then try to change them." (interview)

This evidence highlights the disparity between the intended and the actual processes of materials development. This subject specialist confirmed that the activities used in the study guide were taken from his own collection of resources that he had collected over the years. They were gathered from his previous experience in science education and materials development and changed to fit the study guide requirements. The CIs who had participated in the development workshop were understandably annoyed with these organisational constraints. After reworking the study guide, the final product was entitled "Physics Guide", had the four activities that the development group had developed during the workshop, and an additional five activities that the editor added from his own resources. This process of development reflected some of the flaws in the development processes with respect to the MSSI commitment to ownership as proposed by the MSSI steering committee.

4.5 THE INFLUENCE OF TIME ON OPPORTUNTIES FOR PROFESSIONAL GROWTH

Interrogating the evidence collected over the 3 workshops revealed that time was an issue during the professional development and growth sessions. The MSSI steering committee had agreed on a workshop format with 3 days set aside for the development of activities. I questioned the organiser of workshops 2 and 3 on the issue of whether the 3-day workshop was sufficient time to develop a study guide. He replied:

> One is the old story of putting up the circus tent. If you've got three hours to do it, you'll do it in three hours. If you've got five days to do it, it'll take all of 5 days. So it partly, you do what you can in the time that you've got. I think 3 days is in some ways insufficient. I think it was sufficient to get to the point that we did. And I think we got to the point in most cases where the ideas were there, people had made their contributions, and from there on the process really needed an editor to run with it. To pick out the mistakes, to format it, to get the illustrations in, and so on. So yes, we could have done with longer. Basically the time we had was all that the department could really afford. (interview)

This comment suggested that working within the MDE time constraints, the time allocated was indeed adequate for the purposes. While the organiser had suggested that time was indeed enough to produce a product, evidence from workshops 2 and 3 suggested that this was not always the case. In two of the study guides, the assigned editor took on a much greater role than intended because of time constraints. In the first example, the goal for workshop 2 was to develop three study guides, namely 'Waves', 'Chemical Interactions', and 'Matter and Materials'. The 'Matter and Materials' study guide was written solely by the editor without input from CIs or teachers. This was the case because the objective of developing three study guides in one 3-day workshop proved to be too big a task. With time limited, dividing the work among the small team was decided by the group to be the most appropriate way to proceed. As mentioned earlier, the 'Vectors' study guide (which became the 'Physics Guide') of workshop 3 had five additional activities developed by the editor added to the guide. The limited time at the workshop meant that the group only partly developed four activities. These four activities were not sufficient to make a complete study guide.

The evidence in this study suggests that a three-day workshop limits the collaborative contributions that the CIs and other participants are able to make to the learning activities, and ultimately the study guide. It further points to the interesting dilemma about how best to use that time to create opportunities for professional learning and growth. Again it would

seem that limited time tends to mitigate against substantive collaboration and significantly impact on the opportunities for professional learning that the group development process was designed to promote.

As discussed earlier, progress in the science group on the first day of workshop 3 was slow. Participants themselves suggested that 'time' was a constraining factor. This was confirmed by the DCES leading the science group when he reported back at the start of the second day by saying:

> We (science group) found actually the time available to us was very short. Actually because we brainstormed what was done in Japan and then what would be done and focused on … so that was then …(inaudible) … After that we started working on the activity as such. We could hardly get in one hour. So ..uh … even to complete a sequence of activities connected with one topic, to introduce the related aspects to it was too little. So what we did yesterday was just the outline. (transcript from feed-back session)

He had indicated that the group had yet to develop any activities but had rather spent the time working through the outline of the study guide. In workshop 3, the frustrations of development on the first day of the workshop were also discussed by the Biology group. A member of that group explained it as follows:

> I had a confusion yesterday when … at three o'clock when somebody said we had to prepare two lessons because I was under the impression that we refined the one we did in Japan. Because we realised … Barry indicated that that was an introductory lesson and then in our deliberations we were trying to put more flesh into it and coming up with materials that could be used for enrichment. (report-back session, January 2005)

It is clear from this quote that for some members of the groups their expectation was that the processes would allow them to cover the material in-depth rather than rush through to the next activity to complete the process. There were indeed, at various times, contradictory expectations for the participants. While everyone recognised the study guide development processes as a great opportunity for the practitioners to enhance their

subject content knowledge (SCK), the frustrations of having to produce an output of sufficient quality by the end of the three-day meeting period were always evident among the leaders of the sessions. A more in-depth and critical evaluation of the issue of 'lack of time' provided me with a better understanding of the issue. In a reflective comment, one of the workshop leaders from the University of Pretoria, for example, discussed the challenges on the participants SCK:

> Another challenge is the whole content knowledge. Some of the CIs realise that their content knowledge is inadequate and they are put in a situation where their content knowledge is challenged. And as a result, … in this morning's meeting … that is why some of them just focused on the lesson, on one lesson. Because my thinking was that if they have to go further than that, then their content knowledge will be challenged and it might embarrass them, the CIs. (interview)

It is noteworthy that while this Workshop Leader recognised the challenges confronting the teachers with regards to the inadequacies of their SCK, she was equally frustrated by their inability to make progress beyond a discussion of one lesson during the entire day of the workshop. The dilemma of trying to encourage a rich discourse about subject matter among the teacher leaders in the context of trying to come out with a tangible product (the teachers' guide) became evident throughout the workshops. All the subject groups found themselves having to grapple with this tension in the given time frame.

4.6 THE FEATURES OF THE CASCADE MODEL

4.6.1 The influence on participation and ownership

MSSI relies mostly on the cascading approach for materials development and for providing professional growth opportunities (Memorandum of Agreement, April 2003). A small group of CIs is invited to Japan on a study mission. These CIs participate in the group materials development workshops upon their return from Japan. These CIs then train all the CIs in the province on the study guides, who in turn train the CLs in various regions. These CLs lead the teachers at cluster meetings in their local area. I was concerned about the use of a cascading model for information dissemination. In an interview, a steering committee member explained:

> There certainly have been questions (about the cascade model), and in the end it's probably the only realistic model given the resources and the size of the province. One also has to define the cascade model. Some definitions of the cascade model which have been really discredited have been one shop workshop at the top level, and then one level down you have that one shop workshop repeated, and then again repeated and so on down the cascade. Then if that is the cascade model, and that is often what is meant when people criticise the cascade model, what we are doing is not strictly the cascade model. There is an ongoing support for clusters. (interview)

As he discussed in this interview, the feature which makes this model different from traditional cascade models is the on-going cluster-level professional development. In the MSSI model, the CIs are expected to work with CLs at the level of cluster meetings to ensure that information dissemination comes with professional support.

The steering committee member discussed with me the how phase 2 differed from phase 1 and how phase 2 would ensure that the cascade model operated better. Phase 1 of MSSI created a province-wide structure for school-based professional development and

organised and trained CIs. Phase 2 intended to have a greater impact on classroom instruction by among other things, “empowering cluster leaders on material development adoptable for use in classroom situations” and “empowering cluster leaders on professional development and personal development” (Memorandum of Agreement, April 2003). Phase 2 also aimed to make this structure function effectively and efficiently as a system so that there will be a major impact in the classrooms in terms of enhanced instructional capacity of the teachers and improved science comprehension of the learners (Memorandum of Agreement, April 2003). In order to ensure the use of learning materials in the classrooms, it was necessary to create a supporting mechanism for school-based professional development activities closer to the schools (Memorandum of Agreement, April).

The MSSI steering committee met in July 2003 and had agreed at that meeting that preference for participation in the Japan study mission would be given to CIs who did not go the previous time (minutes of meeting, 2003). It is the CIs returning from the study mission that form the key participants in the materials development workshop. About 2-3 CIs[13] participate in the development process at the development workshops held at the university. These CIs train 10-15 science CIs in Mpumalanga as part of a large CI training workshop. These CIs then lead about 40 CLs at a CL training workshop in the use of the study guides. At the CL training workshop, a CI could be involved in training the Cluster Leaders without having received training in Japan or having participated in the development process. Each CL has 6-10 teachers in their cluster, depending on the region in Mpumalanga and the CLs use the study guides as a focus for leading cluster meetings. This highlighted for me the contradiction between participant in materials development and

[13] This data has been collected from the Physical Science group only.

implementer of developed materials. One questionnaire response from a CI after the training workshop wrote:

> I wish these workshops were given to all the affected teachers because the amount of input that may filter down to the teachers will not be more than 20% of what we got here. In short, the classroom teacher is not gaining much in the process to make the workshops more effective and worthwhile. (questionnaire response)

Investigating the opportunities for professional growth that are created through the processes of developing learning support materials, and the extent to which CIs, CLs and teachers are given the opportunity to participate needs to be re-examined. This lack of participation has obvious implications for the 'buy-in' on the processes and products as envisaged by the MSSI. I questioned a steering committee member about this issue and he responded:

> I guess one has to see if the ownership is there in the long run. Another factor is that it comes with an MSSI tag. It is seen to be part of a project, rather than something that comes from outside. It hasn't got Japan written on it, or university of Pretoria, or Juta's books or whatever. That's another level of ownership that 'here's materials that belongs specifically to this project. It's ours because we're part of this project'. (interview)

The comments in this interview highlight the on-going dilemma between fulfilling the goals of participation and ownership and the goal of addressing the province-wide need for educational reform. While a modified cascade model has been adopted as the only 'realistic model' (interview), it challenges the MSSI's ability to the influence teachers on an individual level.

4.6.2 The influence on capacity building

In the context of this study, a key feature of capacity building is training and the role that training can have in developing ability and competence in a particular area of knowledge

and skills. Looking beyond the Japanese involvement in the MSSI, the CIs and CLs are expected to play a key role as developers of their own learning materials. The CIs play a central role in the training process, both in the training that they receive on the Japan study mission and the training of the CLs that they lead. The Japan study mission offers CIs and CLs opportunities to upgrade their subject content knowledge and skills and gather educational resources for the development of learning support materials (Memorandum of Agreement, April 2003).

The study mission is a 6-week visit to Japan funded by JICA and hosted by Hiroshima University and Naruto University of Education. About 10 CIs/CLs visit Japan for each study mission, accompanied by a UP expert who serves as an advisor. The purpose of the group's training is three-fold: (1) to learn about the experience of Japan in the filed of education, particularly its in-service training system for teachers; (2) to upgrade the knowledge and skills of the CIs/CLs in science; (3) to develop a programme of material development for implementation at the cluster level (Memorandum of Agreement, April 2003). Two of the six weeks is spent on the materials development programme. As only a few participate in the study mission on each occasion, on their return they are expected to share their material development work and resources from their Japan experience with other CIs at a 5-day provincial-level training workshop (Memorandum of Agreement, April 2003) and at a later stage, use the materials to train CLs.

As a participant in workshop 1, I was concerned about the lack of resources offered as a starting point for the development of the 'Forces' study guide. After the development workshop, I questioned the organiser on this issue and he commented on the resources brought back from Japan, saying:

> Ever since the first study missions in Japan, the curriculum material, the material that could potentially be used by teachers were developed as part of the mission to Japan, and very often that team who went to Japan would come back with quite a thick document, very little of which in the end got passed on to the other CIs and none of which, or hardly any of which ended up in classrooms. (interview)

In phase 2, the CIs returning from the study mission before workshop 3 came to the development workshop with one activity that had been developed in Japan. One organiser of workshop 3 expressed surprise at the lack of resources that the CIs returned with as she had been on the tour and was witness to the large amount of resources that the CIs could have gathered.

> And there were lots of text books, and most of those texts books were actually South African text books. I didn't even know that there were so much good text books in South Africa. Because they don't have English books in Japan so they had a lot of new books from South Africa and some physics books from America. So all of those books were piled. On top of that there were hand-outs that were given. … my first surprise yesterday (at the development workshop) was that those people come out with nothing. They just came with nothing. (interview)

This comment suggested that over the three workshops of this case, there was no real change in the collection of resources. At workshop 3, the DCES leading the science group commented on the contribution of the materials prepared in Japan to the development process:

> You see the problem what we have seen, and anyway the team will tell us, what they reported in the Physics group, was that their focus in the Japanese training period was mainly on lesson study, and with the material … for example in physics, what the team gave us was maybe half an activity. Not even a full activity because that activity cannot be presented here as such, because it was … what was written was perfected in the form of a demonstration. So it should be something by way of demonstration. That is how they presented it. It was suitable to the presentation there. And that all what we could get. So as far as the study guide materials is concerned, the materials that were prepared in Japan were too far less, as far as the study guide is concerned. (group feedback discussion)

This conversation revealed the complexity in the link between the Japan study mission and the development workshop at the university. Providing CIs with the abundance of resources in Japan seemed to have little impact on the quantity of resources used in the development of materials at the university. It also showed that there remains a question of whether the time spent in Japan on 'lesson study' provided suitable groundwork for the development activities expected of the CIs during the development workshops.

To fully understand the influence that the modified cascade model has on capacity building, it is necessary to interrogate the role of the leaders throughout the processes. Despite a commitment to on-going support at all levels of the cascade, leadership changes hands at each stage of the training. UP staff and CIs train at the CI training workshops, CIs train at the CL training workshops, CLs train at the cluster meetings. Workshop 2, the CI training workshop, CL training workshop and cluster meetings following workshop 2 suggested that as the leadership changed, the contributions of the leaders to the professional growth of the workshop participants also changed. To illustrate this point, I followed one activity from the 'Matter and Materials' study guide from development through to the presentation at the cluster workshops. For each of these, I recorded aspects of the presentation with a particular interest in the importance that the presenter placed on the activity.

I developed the 'Matter and Materials' study guide during workshop 2 and observed as one of the activities in the study guide was used as a training activity at three different workshops. The complete activity is shown in Appendix 1.

The first workshop was the CI training workshop in which a university subject specialist presented the activity to a group of 10 CIs. The second was when one of those CIs used it

to train a group of about 40 CLs at the CL training workshop a few weeks later. And the third was when it was presented to the teachers at a cluster meeting lead by one of the CLs that had participated at the CL training workshop. In each case, extracts from the conversations have been presented to show the different interpretations of the activity and what it was designed to achieve with learners. Each of these extracts was taken from the reflection session after this activity was done.

My notes as a developer of the activity

> The activity was designed to introduce learners to scientific investigations as part of addressing LO1 of the new curriculum. Some issues that the activity was designed to address were: (1) How to make a hypothesis; (2) How teachers in poorly resourced classrooms can improvise (Stones of a known mass could be used instead of the traditional mass pieces. The idea was that each teacher would make for himself or herself a set of carefully measured stones. These needed to be done in small increments. This could be done at a teacher centre when there was access to a balance. The teacher would then keep these stones as her personal set of masses to be used in any investigation that needed a measured mass instead of relying of expensive mass pieces); (3) Some criteria of a good investigation (dependent and independent variables should be identified); (4) Science and society (Paying for plastic bags - could initiate a debate about how it reduces the environmental impact of plastics or just make the poor people poorer?) – taken from field notes

These reflective notes suggest that the developer had a particular focus for developing this activity. The activity was designed to address LO1 (National Curriculum Statement, 2003) within the context of plastic bags.

Extract from a discussion at CI training workshop which formed part of the reflection after conducting this investigation the entire reflection took about 30 minutes

> **Leader discusses conducting a fair test using this activity**: I think in any task, there will be various factors, which will be influencing the results. So a fair test means that you have to control some of the variables involved. So what are the variables which are to be controlled, what are the variables which we vary now and see? That should be specified. That is our number one step. So in this particular case, the learners must specify how many different types of plastics are investigated …. 1, 2, 3 … number 1. Number two, if it is to be a fair test, how are they comparing the different plastics. Are they taking just any piece? So they are specified, isn't it? For this experiment, you must cut the same area for the strip … the same width and length for the strip, isn't it? The area is specified, or the same area is used, number 2. And then, anything else … (opens it to the group).

> **Further discussion about the criteria for the rubric**: I think that you mention the dependent and independent variables, which would be 'different plastics have been tested by hanging different weights on them'. That's really what it's about but it's not controlling the other variables….. the main variables to control are the length and the width. That's the same, and the position of the hole is the same. I think those are the obvious important controls. There was another method which I think no one here controlled. And that is 'how long do you hold it before it breaks?' because some I them I think that it would have broken if you had held it for another 10 seconds. But you put it down and said ok, it didn't break. I think that's another one which could be added. For a really excellent plan … 'we are going to hold it for 20 seconds and if it hasn't broken in 20 seconds, then it ok'. But some people held it for a second and said its ok, and some held it and were about to let it go and suddenly it broke.

This short extract was taken from part of the 30 minute reflection session after the activity. Although the developer of the activity did not present the activity, the focus reflected the intended outcomes. The leader in this case clearly had the same focus on LO1 and organised the reflection around the issues associated with an investigation. One important aspect of the reflection was the need to assess investigations and how rubrics could be used.

Extract from CL training workshop covering the entire reflection. It took 4 minutes.

> **CI**: We have done this activity … when you are at school, you can give this specific topic … (inaudible) … where learners can conduct their own investigations. For this one … (inaudible)… it activates as working in a team, and then know how to record, and make a conclusion. And then you have noted the different strengths of the different plastics, though as I mentioned earlier, we have to look at the composition of each plastic. But now from my observation, during the course, for example from this group (pointing to one group of CLs who had conducted the investigation), you take one piece (referring to plastic). You start with a very big weight (referring to stone). [General disagreement from group]
> **CL**: No, we started with the smallest.
> **CI1**: You started with the smallest? Because if you take a bigger stone earlier, you cannot tell the intervals of the stress on the plastic until it breaks. You will give the wrong conclusion if you make that variable. So which one is the strongest? (Asks all groups, and two groups give a different answer). So now we note that different materials have got different strengths because of their composition. And then we had another … who wants to make any comments on this activity?
> **CI2**: Ladies and gentlemen. What do you think of this experiment?
> **CL**: For the amount of time that you use for this experiment there is very little knowledge. All you've shown them is the different strengths of materials. So I would not use it.

This section reflects the entire reflection session after completing the activity. The first notable difference is the much reduced time spent on the reflection. The CI

highlighted the importance of using the stones in the correct order and reminded the participants that they should note the different strengths of the plastics. The final comment made by one participant "For the amount of time that you use for this experiment there is very little knowledge" suggests that the intentions of the activity were misinterpreted by the CLs owing to inadequate explanations from the leaders (CIs) as to the goals of the activity. This is turn was probably as a result of their own inadequate understanding of the intentions of the developer.

Consider another example, which is an extract from cluster meeting. This time the activity was lead by a CL.

> **CL introduces the activity:** What we are going to do is we are going to take different types of plastics, and then we are going to cut them in the same line, and then from there we need hooks, each and every group will have one hook, and there are different sizes of stones there. Each and every group will take maybe 5 or 4. And actually, we (refers to cluster leaders) were supposed to measure those stones but unfortunately our mass measurement does not take those stones (referring to size) it just takes small stones unfortunately. And then from there, because we are having another three different types of plastics, you cut them in the same length, you make an open …(inaudible) …and then we tie a stone with a rope and from there we take a rule plastic and from there we check whether the plastic will tare off. Then from there you'll start with a smaller stone, then with that size, with that size (indicates getting larger). If the stones don't tare that particular plastic, then after completing all the stones, you are going to double them until that plastic is cut off. I hope that I'm well understood. Then from there we will determine what types of plastics, which ones are the stronger than the others. (groups started collecting the plastics and stones). Cluster leader continues to talk while teachers are collecting their things. Before we do this, remember we must hypothesise. Before we do the experiment, we must say which one will be the stronger than the other one and which one will be the weakest.
>
> **After the activity, the CL led the reflection**.
> One teacher from each group reported on their findings. They indicated which plastic they expected to be strongest, and which in fact was as a result of their investigation. All four groups reported different results. There was a brief discussion that followed.
> **CL:** We have found our results are different in different groups. What could be the reason?
> **Teacher:** Stones.
> **CL:** The size of the stones.
> **Teacher**: Also it could be the make. I will say the properties. Because we are not sure are they of the same atomic structure.
> **CL:** OK. And how can this help. How can we help the learners? Because this is going to be part of the curriculum and suddenly you are going to be doing the strength of plastics, and the learners says "how does this help me?"
> **Other CL:** And especially nowadays because we are buying those plastics.

Teacher: Every day we use plastics. Our learners don't have bags to carry books to school. So the learner must be able to know if I use this bag for these books, this plastic will hold for 2 weeks, 2 months, whatever. If I use this one, it will just break and all the books will be on the floor. One example.
CL: Another one?
Teacher: Maybe because plastics are bought, then when they go to different shop in the Plaza, KwaMhlanga Plaza, they should know from which shops they should buy plastics. Because they go shopping at A and B and C, and they are selling different plastics. So if you want to buy a plastic that lasts, you have to know exactly from which shop you must buy plastics.
CL: Alright. (Moves on to next activity)

This extract is the entire introduction before the activity as well as the reflection after the activity. This final presentation of the activity at a cluster meeting suggests that the outcomes of the activity to develop scientific investigation skills had been replaced by a focus on how strong the different plastics are and where you should buy your plastic bags from to get the strongest bag. What is missing from this presentation of the activity is the focus on LO1[14], the aspects that make a good scientific investigation, and effective improvisation strategies.

As can be seen from the three extracts and discussion given above, the interpretation of the activity and how to use it to improve science learning was altered in each case. As the developer of the activity, it was my belief that the value of the activity was significantly eroded as the leadership changed hands in the cascade model. The final presentation held very little resemblance to the original intention of the activity. It was designed to engage learners in an investigation to develop skills around scientific investigations i.e. LO1 (National Curriculum Statement, 2003) as mentioned earlier, but was interpreted as a predominantly LO2[15] (ibid) activity by the CIs and CLs.

[14] LO1: The learner is able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts
[15] LO2: The learner is able to state, explain, interpret and evaluate scientific knowledge and can apply it in everyday contexts.

4.7 DISCUSSION

The MSSI offers all teachers and teacher leaders in Mpumalanga the chance to participate in a province-wide professional development programme. This is done through the organisation of all its schools into clusters for ongoing professional support supported by CIs and lead by CLs. In an effort to get all CIs in the province involved in the development processes, all are given a chance to learn from the Japanese study mission experience and subsequent development workshops and as such, repeat participation in the development of materials is limited. Within the present case study, it is evident that CL and teacher participation in the development processes has yet to be established. This can be explained through a combination of departmental organisational challenges and departmental regulations prohibiting the attendance of in-service workshops during teaching time. Despite some erratic participation, the development workshops do in fact provide a context for opportunities for professional learning and growth. It is the effective combination of department officials, university subject specialist and CIs, which allow for groups discussions rich in subject and pedagogical content knowledge.

Ownership is a central feature of the MSSI professional development initiative. By getting CIs, CLs and teachers to participate in the development of the study guides and subsequent training processes, it is hoped that teachers and teacher leaders will buy in to the initiative and adapt their teaching practises to include the learning activities in the teacher repertoire. Participants in the processes are committed both to the processes and the products and show a belief in the value that teachers will place on the study guides. However, constraints such as poor organisation, limited time to produce a high quality product and to engage in professional growth opportunities often collaborate against giving participants the level of ownership that is intended.

As the MSSI is a province-wide professional development initiative, the cascade model has been adopted as the only feasible model of information dissemination. A variation on the traditional cascade model means that the MSSI can offer CLs and teachers the professional support of CIs at each stage of the cascade. Despite this, leadership of the process changes hands at each level and as such, the quality of leadership is eroded with each level of the cascade. This can be explained by the inadequate level of subject and pedagogical content knowledge of many of the participants in the process. This conclusion is supported by a recent study by Jita and Ndlalane (2005) investigating the subject matter knowledge of teachers and teacher leaders from the same professional development project. They concluded that the subject content knowledge "is grossly inadequate and lacking in the fundamentals of physics required for mastery of these topics." (2005).

The poorly resourced classrooms of MSSI are not unique to Mpumalanga and are typical of many developing countries. This raises the question of selecting CIs and CLs as the best possible choice of materials developers given the evidence to suggest their poor subject knowledge, lack of expertise in developing learning materials and apparent lack of exemplary materials and other educational resources as a starting point for development. This study raises the question about who has authoritative knowledge about the Mpumalanga classrooms and hence who should play a key role of developer of learning support materials to achieve the goals of the MSSI. It is obvious that a number of players, properly balanced in their subject knowledge and expertise including their classroom experience would be the preferred combination for materials development. As discussed in this case study, the question of how to manage and balance participation by the various stakeholders and players is not always easy and straightforward.

The real test of the relevance of the MSSI learning support materials for teacher development and growth is yet to be established. The potential of these study guides to improve science teaching and learning in Mpumalanga classrooms has not been sufficiently established either. Development of effective learning materials requires repeating research and development cycles (Stern and Ahlgren, 2002) in which students' responses are used for the basis for revision and refinement of the learning materials (Ball and Cohen, 1996; Stern and Ahlgren, 2002). This defines the next challenge for the MSSI project holders.

CHAPTER 5
SYNTHESIS AND IMPLICATIONS

5.1 INTRODUCTION

The purpose of this study was to investigate the opportunities and challenges that are created in the processes of developing learning support materials. The Mpumalanga Secondary Science Initiative (MSSI) was used as a context for studying these opportunities and challenges. More specifically, I sought to understand better the processes of materials development as they occurred in the subject area of science and how these processes provided teachers with various opportunities to learn and grow in their subject content knowledge and pedagogical content knowledge and the challenges embedded within. The findings in the study may not be generalizable to other development processes, or even to other subject areas within the MSSI project, but readers might find ways in which these findings begin to identify some common issues which may be applicable to other settings. It is hoped that this study can lead to a better understanding of the processes of teacher learning and practice change.

In this chapter I provide a summary of the findings and discuss the implications for future professional development programmes using materials development as a key strategy for providing opportunities for teacher development and growth. I conclude with some recommendations for further research.

5.2 SUMMARY OF FINDINGS

The Mpumalanga Department of Education (MDE) has found itself in a situation of unacceptably low pass rates in science. In response to this challenge, the MSSI was conceived and is supported financially by the Japan International Cooperation Agency (JICA), and professionally by the University of Pretoria (UP).

Professional development projects are expected to play an important role in on-going education and training for science teachers in South Africa. There is a growing body of literature on the possibilities that learning support materials offer for teachers' professional development and growth (Ball and Cohen, 1996; Ball and Feiman-Nemser, 1988; de Feiter et al., 1995; George and Lubben, 2002; Loucks-Horsley et al., 1998). Furthermore, the many attempts to get teachers to incorporate 'expertly' developed materials in their teaching have raised serious questions of suitability and relevance for the classrooms in which those teachers teach (George and Lubben, 2002). It is on account of these developments and recent literature that the MSSI project adopted an innovative professional development project of materials development in which the ultimate 'consumers' of the learning materials, the Curriculum Implementers (CIs) and Cluster Leaders (CLs) acting in their capacity as teacher leaders in Mpumalanga, were invited to participate in the processes of developing the teacher study guides/learning materials. The study sought to understand how such a potentially innovative process of teacher growth through the development of learning materials worked in practice and the nature of the opportunities and challenges for teacher learning that it created. The findings of this study can be summed up in the following five critical contentions:

First, the study has established that the materials development processes of the MSSI provided numerous opportunities for professional learning and growth to the participants. The study has identified several structures and processes through which such learning opportunities are created within the MSSI project. The six week study mission to Japan provided teacher leaders with the opportunity to enhance their subject content knowledge and materials development skills. These opportunities were created though an intensive content enrichment and materials development skills programme lead by Japanese university professionals. The training that the teacher leaders received while in Japan set in motion the process of developing learning support materials relevant to the Mpumalanga classrooms by the teacher leaders themselves when they return. This is done so because these teacher leaders are assumed to be more informed about what the teachers and learners need in their unique Mpumalanga classrooms.

Second, the 3 day workshop format chosen as the most appropriate format for developing the study guides provides the teacher leaders a chance to work in collaboration with university subject specialists and deputy chief education specialist in their subject. The small groups provide an opportunity to pool resources and an environment for rich verbal interactions between teacher leaders and subject specialists.

Third, in addition to the opportunities created through the MSSI, evidence collected in this study suggests that the processes of teacher growth and development are not always smooth and properly conceived within the project. There are several challenges that tend to mitigate against the potential for sustained learning and growth by the teachers and teacher leaders. For example, the poor organisation and management of the MSSI processes by the Mpumalanga Department of Education at various times resulted in inconsistent participation of teachers and teacher leaders in the development processes.

While MSSI is committed to teacher learning and growth through materials development processes, it is clear that there was a half-hearted attempt in that some of the internal departmental structures and policies worked against these stated intentions.

Fourth, the cascade model of knowledge dissemination means that any opportunities for professional growth through the process of materials development are seriously challenged. As the leadership in the process changes hands at each stage of the cascade, even the modified cascade model with the on-going support of the CIs throughout is not sufficient to maintain a reasonable quality of instructional leadership.

Fifth and perhaps the most significant challenge to this process of developing effective learning support materials is the inadequate subject content knowledge of participants in the processes. The professional development growth opportunities offered through the study mission to Japan as well as those offered in the development workshops appear to be insufficient to achieve a level of subject content mastery by the developers necessary to produce relevant and effective learning support materials.

5.3 THE CONTRIBUTIONS OF THIS STUDY

Professional development programmes in South Africa in the past have typically focused on piloting materials developed by experts. Programmes such as SEP (Rogan and McDonald, 1985), the PSP (Harvey, 1999) and the CASME (Hobden and Draper, 1995) are a few. In these professional development programmes, teachers were trained in the use of learning support materials developed by ‘experts’ demonstrated and distributed at the teacher training workshops for use by the teachers in their classrooms. Criticisms about relevance and appropriateness of these materials has shifted the focus to involving

novice developers in the process with the aim of increasing the 'buy in' and 'ownership' in the product. It is hoped that this study will make the MSSI programme organisers aware of some of the constraints that might challenge this model of materials development and professional growth. On a broader level, this study contributes to the literature on using learning support materials as a major feature in the design of future professional development programmes in South Africa. It has provided a rich description of a process of developing learning support materials in an attempt to close the gap between knowledge of meaningful and effective professional development and practice (Loucks-Horsley et al., 1998).

At the start of this study, we knew that the process of developing learning support materials could provide an opportunity for professional growth and development of participants. We did not, however, know how the processes would unfold and how the processes could specifically be used to enhance professional growth and development of participants. This study has revealed some specific areas of opportunity for professional growth that this materials development process provided. It has also revealed some constraints that significantly inhibit the realisation of those opportunities.

5.4 THE WAY FORWARD

There are two areas in particular that this study did not address and these might provide a way forward. The first is that the group of science teacher leaders participating in the science development group was studied as a unit. This study did not look at participants in the development processes individually and the specific benefits that participating in the processes might offer them for their own professional growth. The second is that the study has provided a good understanding of the development processes but has not yet

extended our knowledge to an understanding of the product i.e. the study guides. It is these guides that are expected to be the driving force in education reform in Mpumalanga classrooms and as such, their value and effectiveness as learning support materials needs to be investigated.

References

Anderson, R. D. and C. P. Mitchener (1994). Research on Science Teacher Education. Handbook of Research on Science Teaching and Learning. D. L. Gabel. New York, MacMillan Publishing Company**:** 3-44.

Ball, D. L. and D. K. Cohen (1996). "Reform by the book: What is - or what might be - the role of curriculum materials in teacher learning and instructional reform?" Educational Researcher **25**(9): 6-8, 14.

Ball, D. L. and S. Feiman-Nemser (1988). "Using Textbooks and Teachers' Guides: A Dilemma for Beginning Teachers and Teacher Educators." Curriculum Inquiry **18**(4): 401-423.

Bogdan, R. C. and S. K. Biklen (1982). Qualitative Research for Education. Massachusetts, Allyn and Bacon.

Campbell, J., D. Smith, et al. (2001). "Students' Perceptions of Teaching and Learning: the influence of students' approaches to learning and teachers' approaches to teaching." Teachers and Teaching: theory and practice **7**(2): 173-187.

Chisolm, L. (2000). South African Curriculum for the Twenty First Century: Report of the Review Committee on Curriculum 2005. Pretoria**:** Chapter 4.

Cohen, L., L. Manion, et al. (2002). Research Methods in Education. London, Routledge Falmer**:** 181-190.

deFeiter, L., H. Vonk, et al. (1995). Towards More Effective Science Teacher Development in Southern Africa. Amsterdam, VU University Press.

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

Department of Education (2003). National Curriculum Statement Grades 10-12. Pretoria, Department of Education.

Driver, R., H. Asoko, et al. (1994). "Constructing Scientific knowledge in the classroom." Educational Researcher **23**: 5-12.

Driver, R. and B. Bell (1986). "Students' thinking and the learning of science: a constructivist view." School Science Review **67**(240): 443-456.

Dufresne, R. J., W. J. Leonard, et al. (1992a). Research-based materials for developing a conceptual approach to problem-solving in science. Workshop on Research in Science and Mathematics Education, Cathedral Peak, South Africa, SAARMSE.

Dufresne, R. J., W. J. Leonard, et al. (1992b). Designing instructional materials for promoting conceptual understanding. a informal workshop. Physics Department, University of Natal.

George, J. M. and F. Lubben (2002). "Facilitating teachers' professional growth though their involvement in creating context-based materials in science." Journal of Edcuational Development **22**: 659-672.

Harvey, S. (1999). "Phasing science InSET in developing countries: reflections on the experience of the Primary Science Programme in South Africa." International Journal of Science Education **21**(6): 595-609.

Hawley, W. D. and L. Valli (1999). The Essentials of Effective Professional Development: Handbook of Policy and Practice. Teaching as the Learning Profession. L. Darling-Hammond and G. Sykes, Jossey-Bass**:** 127-150.

Hobden, P. (1998). The Role of Routine Problem Tasks in Science Teaching. International Handbook of Science Education. B. J. Fraser and K. G. Tobin, Kluwer Academic Publishers**:** 219-231.

Hobden, P. and K. Draper (1995). Teachers as Researchers : Encouraging Practical Inquiry to bring about Change in Classroom Practice. SAARMSE : Third Annual Meeting, Cape Town.

Hobden, P. A. (1999). The Context of Problem Tasks in School Physical Science. Department of Education. Durban, University of Natal.

Jansen, J. (2002). Getting Teaching Right? Changing Patterns of Teacher Education in South Africa. K. Lewin, M. Samuel and Y. Sayed. Pretoria.

Jita, L. C. and T. C. Ndlalane (2005). How much do science teachers know? SAARMSTE, Windhoek, Namibia.

Jita, L. C. and J. M. Rogan (2003). The Role of the Univeristy of Pretoria in MSSI Phase 2. Pretoria, University of Pretoria.

Keys, C. W. and L. A. Bryan (2001). "Co-constructing Inquiry-Based Science with Teachers: Essential Research for Lasting Reform." Journal of Research in Science Teaching **38**(6): 631-645.

Lincoln, Y. S. and E. G. Guba (1985). Establishing Trustworthiness. Naturalistic Inquiry, Sage Publications**:** 289-331.

Loucks-Horsley, S., P. Hewson, et al. (1998). Designing Professional Development for Teachers of Science and Mathematics, Sage Publications.

Mason, C. L. (1992). "Concept Mapping: A tool to develop reflective science instruction." Science Education **76**(1): 51-63.

McDevitt, D. (1998). "How Effective is the Cascade as a Method for Disseminating Ideas? A Case Study in Botswana." International Journal of Educational Development **18**(5): 425-428.

Memorandum of Agreement (April 2003). MOA between Japan International Cooperation Agency and Authorities Concerned of the Government of the Republic of South Africa on Japanese Technical Cooperation for the Project on Mpumalanga Secondary Science Initiative Phase 2.

Merriam, S. B. (1998). Qualitative Research and Case Study Applications in Education. San Francisco, Jossey-Bass.

Rogan, J. (2003). The Production of Study Guides: Discussion Document - MSSI Phase 2. Pretoria, University of Pretoria.

Rogan, J. M. and C. Aldous (2005). "Relationship between the Constructs of a Theory of Curriculum Implementation." Journal of Research in Science Teaching **42**(3): 313-336.

Rogan, J. M. and M. A. Macdonald (1985). "The In-Service Teacher Education Component of an Innovation: A Case Study in an African Setting." Journal of Curriculum Studies **17**(1): 63-85.

Schneider, R. M., J. Krajcik, et al. (2005). "Enacting reform-based Science Materials: The Range of Teacher Enactments in Reform Classrooms." Journal of Research in Science Teaching **42**(3): 283-312.

Stake, R. E. (1988). Case study methods in educational research. Complementary methods for research in education. R. M. Jager. Washington, DC, American Educational Research Association.

Stern, L. and A. Ahlgren (20002). "Analysis of Students' Assessments in Middle School Curriculum Materials: Aiming Precisely at Benchmarks and Standards." Journal of Research in Science Teaching **39**(9): 889-910.

Taylor, N. and P. Vinjevold, Eds. (1999). Getting Learning Right: Report of the President's Education initiative Research Project, The Joint Education Trust.

Thijs, A. and E. van den Berg (2002). "Peer coaching as part of a professional development program for science teachers in Botswana." International Journal of Educational Development **22**: 55-68.

TIMSS (2003), see http://nces.ed.gov/pubs2005/timss03/

Tobin, K. and D. J. Tippins (1993). Constructivism and as referent for teaching and learning. The practice of constructivism in science education. K. Tobin. Washington DC, American Association for Advancement of Science Press**:** 3-22.

Tobin, T., D. J. Tippins, et al. (1994). Research on instructional strategies for teaching science. Handbook of research on science teaching and learning. D. L. Gabel. New York, MacMillan: 45-93.

Vinjevold, P. (1999). Learning Materials. Getting Learning Right: Report of the President's Education Initiative Research Project. P. Vinjevold and N. Taylor. Johannesburg, The Joint Education Trust: 163-184.

Yin, R. K. (1984). Conducting Case Studies: Collecting the Evidence. Case Study Research - Design and Methods. California, Sage Publications: 78-98.

APPENDIX 1

Worksheet Activity: Which plastic is the strongest?

Different materials have different properties. We use different plastics for different things depending on these properties. In this activity, you will investigate the strength of some different plastics.

This is what you will need for this activity:

- Different types of plastic (shopping bag, plastic milk bag, cling wrap, black garbage bags and any other plastics that you can find at home)
- 4 different size food cans with different weights (for example a tin of cat food, tin of baked beans, tin of tuna, tin of soup, etc.)
- String
- A metal hook in the shape of a "S" (bend some wire if you don't have a hook)
- A pencil and some paper to write down your observations and results

This activity is for a group. Get into groups of about 4 or 5 learners and put all the plastics that you have collected in the middle of the table. Look at what the other members of your group collected.

The first investigation

1. Hold up a plastic bag to the light.
2. Look carefully at the grain of the plastic. You should see faint lines running in the same direction.
3. Slowly stretch the plastic in the direction of the grain. What happens? Discuss this in your group.
4. Now stretch the plastic against the grain. What happens? Discuss this in your groups.
5. On your own, write down your observations. Include the differences that you notice between the two different stretches.

Make a prediction

Look at each piece of plastic and think about which piece you think is the strongest. Discuss this as a group and give a reason for your answer.

The second investigation

This is what you must do:

1. Cut strips from each piece of plastic (about 3 cm wide and about 15 cm long).
2. Tie a piece of string around each tin of food. Make a loop on the one end. This loop will let you hang the tin on the "S" hook.
3. Hold up one end of a plastic strip and hang the lightest can to the other end using the "S" hook.
4. If the plastic does not tear, hang the next heaviest tin to the hook.
5. Make a note of the heaviest tine that the piece of plastic can hold before it breaks.
6. Do this again with all your samples of plastic and note the heaviest tin that each piece of plastic can hold before breaking.

Putting your results into a table

These tins of food should have their weights printed on them. If they do not, try and find a scale to measure the weight of each tin.

Sometimes, results are easier to understand if they are in a table or a graph. Draw a table to show what weight each piece of plastic can hold before breaking. Here is an example of what your table might look like.

Plastic	Heaviest tin held	Maximum weight held
Black plastic bin bag	Tin of baked beans	422g
Checkers shopping bag		

Your conclusion

Which plastic is the strongest? Was your prediction correct?

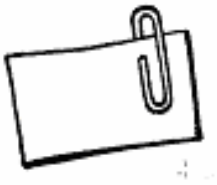
Understand what is happening

Plastics are made out of long molecules called polymers. Polymers are lots and lots of repeating units connected together into chains. The "grain" that you saw when looking at the plastic in the light shows the direction of the polymer's chain. Pulling against the grain forces the chains to re-organise in the direction of the pull. Most plastics are strongest when they are pulled *with* the grain. How much strain a plastic can take is called *tensile* strength.

Answer this question

1. Different plastics are chosen for different uses depending on their tensile strength and other properties. For example, cling wrap is thin and very stretchy. This allows you to stretch it over a bowl and make the container airtight. This is useful for keeping food fresh. Can you think of any other instances where bags of different tensile strength are chosen for a particular use? List a few.

<u>Notes to teacher</u>



The day before starting this activity, get the learners to bring as many different samples of plastic that they can from home. Bring some your self in case they do not collect enough. The discussion at the end of the activity can be aided if you get the learners to bring some old shopping bags (the thin bag that used to be considered the countries national flower) and some new thicker shopping bags (the type that you pay for).

Also get them to bring tins of food of different weights. If each learner brings one piece of plastic and one tin of food, there should be enough for the activity.

For the last part of the activity (things to discuss in your groups), get the learners to write their answers to one of the questions and hand it in. This can be used as an assessment task.