



AOSIS



A scholarly contribution to educational praxis

Edited by

M.A. Mokoena ▪ I.J. Oosthuizen

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educational praxis**

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Peer review declaration

The Publisher (AOSIS) and the Editorial Board of its Domain Social Sciences, Humanities, Education & Business Management certify that the manuscript book was evaluated in a two-step review process: an initial selection review process by the Domain's international Editorial Board, followed by in-depth double-blind peer reviews by two specialists, then thoroughly revised by the corresponding author and the individual chapter authors, and verified by the Chief Editor of AOSIS Scholarly Publications. The external reviewers were selected by the Editorial Board as content experts in the field of educational praxis.

■ Research Justification

This publication contains original research targeting scientific specialists in the field of education.

Not only is the disposition of its research endeavours grounded on a philosophical basis, it is also embedded in the empirical. The research methodology of each chapter emanates from applicable philosophical assumptions in the form of an applicable theoretical and conceptual framework. The latter forms a firm basis for the application of sound empiricism. Both qualitative and quantitative empirical approaches were alternatively applied in the various chapters.

The content of each chapter was meticulously analysed before being finally accepted. In response to the call for chapters, 26 abstracts were received. After evaluation of these abstracts, 24 authors were granted the opportunity of submitting full manuscripts for evaluation. Subsequently the latter were submitted to a rigorous double-blind peer review process. These manuscripts were submitted to at least two or three specialist reviewers in their particular fields of specialisation. All of these review reports are preserved and kept for enquiry and assessment.

The content of the current book was chosen from a selection for a 2014 publication which did not obtain a subsidy from the DHET, titled *Nuances of Teaching Learning and Research*, published by AndCork Publishers. After careful re-evaluation, a much smaller number of chapters was selected, substantially reworked and considerably extended, after which the chapters were again submitted to a double-blind peer review process. Ultimately, of the 26 abstracts originally received only 10 were finally accepted as suitable for publication in the current volume. Finally, in terms of the requirements set by clause 6.12 of the Department of Higher Education and Training policy on reworked publications, this book now contains more than 50% original content not published before.

The content of this book adds to the body of scholarly knowledge in education. In his evaluation of the book, Acting Executive Dean, Faculty of Education and Training, Professor Akpovire Oduaran, made the following remarks:

To a large extent, the ideas put together in this book have come from data generated not just from literature found in books and journals but actual interactions with educators and the learning environment. So then, what the reader is offered in this volume is the articulation of ideas that have been interrogated, structured and presented in surprisingly simplistic and yet incisive and academically enriching content that can match the standards of scholarship that is available in the Western World. Yet, what makes this book so welcome, relevant and timely, is the fact that it is built around Afrocentric theories and practices such as one may find in imported literature.

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■ Final edition declaration

The Publisher (AOSIS) and the Domain Editorial Board certify that this scholarly work is a reworking of an earlier publication titled *Nuances of Teaching Learning and Research* published by AndCork Publishers (2014). Substantial new research has been done and at least 50% of the work has not been published before.

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List of abbreviations appearing in the Text and Notes

ADC	Academic Development Centre
ACE	Advanced Certificate in Education
CDE	Centre for Development and Enterprise
FET	Certificate and Further Education and Training
CoP	Community of Practice
CPD	Continuous Professional Development
CHAT	Cultural Historical Activity Theory
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statements
DESD	Decade of Education for Sustainable Development
DBE	Department of Basic Education
DoE	Department of Education
DAP	Developmental Appropriate Practices
DL	Distance Learning
ECD	Early Childhood Development
ECE	Early Childhood Education
ESD	Education for Sustainable Development
EMLO	Educational Management and Organisations

List of abbreviations appearing in the Text and Notes

FOER	Foundations of Educational Research
GET	General Education and Training
GAP	Global Action Programme
HEIs	Higher Education Institutions
ICT	Information and Communication Technology
IT	Information Technology
IEA	International Association for the Evaluation of Educational Achievement
LOLT	Language of Learning and Teaching
LTSM	Learning and Teaching Support Material
MST	Mathematics, Science and Technology
MSTS	Mathematics, Science and Technology Services
NBT	National Benchmark Tests
CAPS	National Curriculum and Assessment Statements
NCS	National Curriculum Statement
DEA	National Department of Environmental Affairs
NEEDU	National Education Evaluation and Development Unit
NEPI	National Education Policy Investigation
NPDE	National Professional Diploma in Education
NU	No Understanding
NGOs	Non-Governmental Organisations
NWU	North-West University
ODL	Open Distance Learning
PC	Partially Correct
PCK	Pedagogical Content Knowledge

List of abbreviations appearing in the Text and Notes

PDPs	Professional Development Programmes
RTOP	Reformed Teacher Observation Protocol,
SMTs	School Management Teams
SC	Scientifically correct
SITES	Second International Information Technology in Education Study
SDL	Self-Directed Learning
SLT	Social Learning Theory
SA	South Africa
SAQA	South African Qualifications Authority
SAFs	Specific Alternative Frameworks
SPSS	Statistical Program for Social Sciences
SCPS	Student-Centred Problem-Solving
SCK	Subject Content Knowledge
SI	Supplemental Instruction
TALPS	Test of Academic Literacy Levels and Test of academic literacy for postgraduate students
UNESCO	UN Educational, Scientific and Cultural Organization
UNEP	UN Environment Programme
UN	United Nations
UNICEF	United Nations Children's Fund
USA	United States of America
WIL	Work-Integrated Learning
ZFI	Zone of Feasible Innovation
ZPD	Zone of Proximal Development
ZPTD	Zone of Proximal Teacher Development

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Foreword

The Academic Development Centre of North-West University at Mafikeng Campus has come of age, when the volumes of academic publications it has sponsored are considered alongside the numerous effectively organised academic staff development workshops it has planned and implemented in the past five years. From very small beginnings, research, scholarship and publications have blossomed under the leadership of the Academic Development Centre. In my opinion this centre is transforming itself to become first amongst equals in the business of academic development practices aimed at staff and students.

It is therefore with great pleasure that I have agreed to write the Foreword to this book that is aimed at facilitating teaching and learning in South African education, and almost at all levels of critical application of relevant theories. This book is the accumulation of opportunities and challenges gleaned from the very rich experiences of authors drawn from the background of practical observations and a dogged search for relevant and current literature on the subject of teaching and learning.

To a large extent the ideas put together in this book have come from data generated not just from literature found in books and journals, but actual interactions with educators and the learning environment. So then, what the reader is offered in this volume is the articulation of ideas that have been interrogated, structured and presented in the form of surprisingly simplistic and yet incisive and academically enriching content that can match the highest standards of scholarship available in the Western World. Yet, what makes this book so welcome, relevant and timely is the fact that it is built around Afrocentric theories and practices such as one may not find in imported literature.

I have noted that tenacious issues discussed in this volume include learning readiness, pair programming and academic writing for postgraduate students, peer tutoring, teaching conceptual change in the physical sciences and environmental learning. These are issues that have been lightly treated in the available literature until most recent times, the understanding of which has great implications for the success of practices in our learning environment.

What makes this book assume an enriching and helpful value is the exploration of hotly debated issues like quality in teacher development programmes by open and distance learning mode, perceptual motor skills and scaffolding, and inquiry-based approaches in teacher development. In my opinion, teaching content and pedagogical knowledge stand on one leg unless the issues contained in this book are properly understood and applied in our various educational levels. I am quite convinced that this book should be a great and beautiful gift to all educational scholars, essentially because it contains a set of tools that could drive one towards becoming effective students, researchers and ultimately productive scholars in the field.

This book should assume the status of contributing towards promotion of the foremost mother profession in the entire world, only if it is placed in the hands of everybody – and that is what I recommend.

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04 August 2016

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Grade R learners' school and learning readiness from Bronfenbrenner's ecological perspective

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■ Introduction and background

After the 1994 first democratic elections in South Africa (SA), its nine provinces were each allowed to manage their departmental preschools in their own unique way. Gauteng Education Department closed all

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preschools in 2001 and reopened Grade R classes at primary schools about 10 years later. Unfortunately most of these teachers appointed in Grade R classes possess only the minimum qualifications required for this specialised job. North West province is one of the three provinces in SA that still supports the traditional preschools established by the Department of Education (DoE) in the 1970s and 1980s. This province also opened Grade R classes at primary schools.

Schools are graded by the DoE as Quintile 1, 2, 3, 4 or 5. Quintile 1, 2 and 3 schools are situated in poor socio-economic areas and get higher subsidies from the departments. Since 1998 Grade R (i.e. the last preschool year for informal stimulation) forms part of the Foundation Phase (Grade R – Grade 3), which is one of the phases of the General Education and Training Band. Grade R classes may be located at State-funded primary schools and independent schools as well as at community-based sites.

Annually approximately one million learners are admitted to Grade 1 in SA, of whom only about 50% previously had the privilege of attending a crèche, nursery school or Grade R before entering Grade 1 (Rademeyer 2001). Prof. Kader Asmal (a previous Minister of Education) wished Grade R to be compulsory from 2010 for every 5 to 6-year-old child, inspiring the DoE to commit itself to implementation of the preschool year as a priority in 2010. The goal was not reached and President Zuma (2009) later extended the implementation date to 2014.

Atmore (2012:6) reported that 2011 statistics indicated that 67% of 5-year-olds were enrolled in Grade R. This shows progress in terms of the Government's revised goal of making Grade R compulsory to all children before they enter Grade 1. Steady progress is thus being made and the target date for reaching this goal has been extended to 2019 (Republic of SA 2015:32).

Unfortunately, this progress is not true for training of teachers for Grade R classes. The Education White Paper 5 of 2001 on early childhood development (ECD) states that all accredited reception year teachers need to be registered as teachers, and that teachers who do not have specialised qualifications to teach the reception year need to undergo training programmes (DoE 2001:6).

There are not enough accredited reception year teachers in SA. According to the Education, Training and Development Practices Sector Education and Training Authority (2012:9), there are specified qualification levels for practitioners in the ECD sector, but up until 2012 these could not be enforced because of the large backlog in trained practitioners. The research findings of Bransford, Darling-Hammond and Le Page (2005:13) indicate that the qualifications and competence of a teacher impacts as much on the variation in learner achievement as the background and socio-economic status of learners.

According to the current National Curriculum and Assessment Statements (CAPS) there are certain assessment standards that should be achieved by the end of the Grade R year. A Grade 1 learner is expected to be physically, cognitively, affectively, normatively, socio-culturally and linguistically ready for a solid start to his or her school career (Powell 2010:27). Linguistic and cognitive readiness implies that a learner should understand the concepts used in the language of learning and teaching (LOLT) of the Foundation Phase. If learners are not school ready (Ladd, Birch & Buhm 1999; Lally 2010:18) they may suffer from learning problems in formal education. In SA it is generally known that the systemic assessment of Foundation Phase learners in Grade 3 has constantly proved the average performance of learners in Language and Mathematics to be less than 40% since 2001 (DoE 2011b:11).

The importance of school and learning readiness at the time that learners enter school is well established (see Abott-Shim, Lambert & McCarthy 2003:191). The purpose of this chapter is to report on the findings of the research that was carried out on the school readiness levels of Grade R learners in classes attached to primary schools in Gauteng and North West. To reach this aim, the chapter is structured as follows. It commences with a brief background sketch of the situation regarding ECD and early childhood education (ECE) in SA. This is followed by an outline of the conceptual and theoretical framework that serves as the basis of the empirical investigation, a discussion of the empirical research design, then the findings and a discussion thereof. The article concludes with recommendations.

The framework for this chapter is based on the Bronfenbrenner's ecological systems theory. The researchers kept this theory in mind to construct meaning of the complexity of the influences, interactions and interrelationships between the individual learner and multiple other systems that are connected to the learner from an ecological systems theory perspective (Landsberg, Krüger & Nel 2009:9).

■ ECD and ECE in SA

This definition for ECD can be discerned in the South African DoE's (2001) use of the term 'Early Childhood Development', namely as an umbrella term for the education of children from birth to at least 9-years-old, to grow and to thrive physically, mentally, emotionally, spiritually, morally, and socially. With regard to school grades, the ECE learning phase in SA covers the Foundation Phase, that is, Grades R to 3. Grade R is the year before learners in SA start formal schooling. Each of the nine provinces of SA approaches the problem to enable all 5 to 6-year-olds to attend a Grade R class in its own unique way.

During the ECD phase a learner should be enabled to understand the concepts used in the LOLT of the school that she or he will attend for the first time. Conceptual understanding is much more than mere (factual) knowledge. One of the problems in SA is that many Grade 1 learners do not receive instruction in school in their home language. Parents often choose an English medium of instruction school whilst they are Setswana- or IsiZulu-speaking. Often parents themselves have different home languages.

The problem is further compounded by the fact that there is an ever-widening gap in South African society between the achievement of previously advantaged learners and learners from disadvantaged backgrounds. Inequalities resultantly exist even before children start formal schooling (Lee & Burkam 2002). For instance, children from the previously disadvantaged areas do not as yet all have access to Grade R classes. The preschool year is also not yet funded by the Government, all of which means that many learners do not have the luxury of access to learning readiness programmes to help close the gap. The situation of the children is worsened by the fact that their parents often have poor parenting skills, which results in low parent involvement in their children's development and learning. Churches, charities and other non-governmental organisations (NGOs) provide day programmes for preschool children whilst their parents go to work.

The national DoE began to address this problem by making implementation of the preschool year (Grade R) a priority for 2010 (Mbeki 2008; Pandor 2005; South African Qualifications Authority (SAQA) 2007; UNESCO 2006). According to the 2006 UNESCO International Bureau of Education profile, around 500 000 learners were enrolled for Grade R classes in SA during 2005 (UNESCO 2006). The target for 2010 was to

have all preschool learners (approximately one million) enrolled for accredited Grade R programmes (UNESCO 2006). As mentioned, this date was later extended to 2014 (Zuma 2009). In the meantime, the DoE has been encouraging under- and unqualified ECE practitioners and teachers, especially those responsible for Grade R education, to acquire the necessary specialised, accredited qualifications (Pandor 2005).

The Department of Basic Education (DBE) gives guidelines in the CAPS for a day programme which should be followed at Grade R classes. The stipulation is that more or less one hour of free play should form part of a normal day programme. Furthermore, CAPS indicates that two hours per week should be given to structured movement and physical education as from 2012 (DBE 2011b). This includes coordination, spatial orientation, laterality and perceptual-motor activities, and is besides the one hour free play per day (DBE 2011a). In the schools visited for purposes of this research, these guidelines were not adhered to.

Developmental appropriate practices (DAP) are recommended for young children worldwide. DAP is grounded in research on child development and learning regarding educational effectiveness. This knowledge base provides teachers with knowledge about how children develop and learn at various ages and what approaches and conditions work best for them (Copple & Bredekamp 2009:33). This points to an informal approach and includes integration of movement, music and dance in the ECD stage.

■ Stages of ECD development in SA

SA went through stages of separate and independent development in ECD. For a long time in SA's history the Government did not make provision for the care and education of the young child. According to the National

Education Policy Investigation (NEPI) (1992:12), parents, communities, and welfare organisations initiated full-day care centres for mothers who were forced to work due to the socio-economic situation in the country. Standards for these care centres were only laid down in 1939 by the Nursery School Association of SA. Nursery schools were then seen as a supplement to the home, whilst crèches, which were full-day care centres, were seen as a substitute for the home.

Progress was made in this field in 1940 when the Committee of Heads of Education Departments recommended that nursery schools be seen as an adjunct to the national system of education (NEPI 1992:12). Welfare subsidies were given to all races to support crèches, but nursery schools for African children were not eligible for educational subsidies (NEPI 1992):

The result was that nursery schools, with trained teachers, became privileged middle-class institutions, while the crèches serving working-class children could only afford to provide custodial care, thus reinforcing white privilege and black disadvantage. (p. 12)

The nursery schools which received a subsidy were able to appoint qualified people, whilst the others only had sufficient funds to appoint unqualified caretakers.

The development of ECD in the previously Black community was, just like in the United States of America (USA), separate but inferior to that of their White peers. One of the problems in SA was that White and Black teachers were trained at separate institutions, and there was no quality assurance board to monitor the curricula across the various training colleges. Steyn, Steyn and De Waal (2001:29) confirm that there were great differences between the training of Black and White teachers.

The DoE (1995:66) cited the reason for most White teachers being better qualified than Black teachers as the historic legacy of past inequity. The minimum prerequisites for students at the different institutions

also differed. There was no quality control between the different colleges (Chisholm 2009:14). The newly elected Government of 1994 was faced with the incredibly big task of completely restructuring and rebuilding the education system and redressing the inequalities of the past.

Instead of just closing down the colleges with low pupil ratios, they were integrated with existing higher education institutions (HEIs), and on 01 January 2001 colleges of education were formally incorporated into existing universities and universities of technology (Chisholm 2009:15). This was done under the Higher Education Act, 1997 (Act No. 101 of 1997) and resulted in an emphasis shift from teacher training to teacher education (Gordon 2009:25). During that year the number of colleges was cut to half and the number of students reduced from 15 000 to 10 000. The incorporation was taken through a partnership between the DoE and the Council on Higher Education, which aimed to restructure the sector to enhance institutional capacity for all people in SA (Gordon 2009:11).

■ The need for Grade R teachers in SA

SA is in need of more qualified teachers for the preschool years (Pandor 2005). Well-qualified teachers for 5 to 6-year-olds are expected to lay a firm foundation for future learning success and contribute to the bridging of the existing achievement gap. Currently a huge demand exists for qualified ECD teachers and accredited ECD practitioners in order to ensure quality ECD teaching and learning.

In 2001 23% of all ECD teachers did not have any form of ECD qualification; 43% obtained ECD training through NGOs; 15% were under-qualified educators who received training in technical or teacher training colleges (M+2); only 12% of ECD teachers obtained an accredited

university ECD qualification (M+3 and more); whilst 7% of ECD teachers had qualifications in other fields, for example, nursing and social work (DoE 2001).

Teachers should be trained to be able to know how to create the best learning experiences for learners to go to the next level. Each learner presents the classroom teacher with a complex pattern of emotional, behavioural, linguistic, cognitive, motivational and physical developmental strengths and weaknesses. Successful teaching and learning cannot occur in the classroom when learners are hungry, cold, unhappy and not satisfied. Many children in SA grow up in poor circumstances with one meal per day.

The Government of SA realised that attention needed to be given to uplifting of the quality of teaching and ECD. The report of the National Development Agency showed that children in rural ECD centres are particularly vulnerable because they are often subjected to poor teacher: child ratios, poor infrastructure, poorly trained staff and no access to ECD training providers (Atmore 2012:36). Practitioners at these schools cannot leave their work to pursue professional teacher development. Apart from the implications for their own finances, the practitioners cannot leave the already struggling rural areas to suffer more because of the lack of teachers. North-West University (NWU) developed and implemented a distance learning Grade R diploma programme from 2011, and this fills a huge gap in the field of ECD.

The background sketched above gave rise to the following research problem: Do the Grade R learners in Gauteng and North West's primary schools achieve the required levels of school readiness, and if not, what obstacles do they encounter in the learning process?

To answer this question the following concepts need to be clarified.

■ **Early childhood education (ECE)**

In general, the term 'early childhood education' (ECE) refers to the conscious attempts of a group of people to effect developmental changes in children up to the age of school entry (Gordon & Williams-Browne 2004:7). In SA it also includes Grade R as the first year of primary education and hence concludes the phase with Grade 3. Regarding children's chronological age, ECE entails education up to the ages of 8–9 years.

Educators of children in this age group build bridges between the two worlds in a child's life, namely home and school. According to Gordon and Williams-Browne (2004:7), the basis of further learning is laid during this phase. During these years the child learns to walk, talk, acquire an identity, write and count. In later years the child uses these concepts and skills inter alia to master a second language, learn to communicate and negotiate, and to write and to do Mathematics (Gordon & Williams-Browne 2004:7). Although all countries have these elements in common, the age of entry into primary school differs as does the prescribed curriculum.

■ **Learning, education, school and learning readiness**

Several definitions of 'learning' are available, such as those of Hutchin (2007:151) and De Witt and Booyesen (2007:47), but that of Jordaan and Jordaan (1998) was found to be useful in the context of this research:

Learning is the name that we give to the process or processes that we assume to lay the foundation for perceivable behavioural changes in situations pertaining to exercise, teaching-learning and life experience. (p. 458)

Education, which includes the stimulation of children, commences at birth and includes all aspects of childhood: physical, emotional, social, intellectual

and spiritual. Education (including stimulation) is based upon self-discovery. Children learn through experience; it is therefore important that there be much stimulation and many challenges. Small children should be encouraged to explore the world; opportunities for stimulation should be provided from the baby years onwards (Davin & Van Staden 2005:5). Children develop and learn best in a physically and emotionally safe environment in which their basic physical and emotional needs have been met (Meier & Marais 2007:192). Readiness is bidirectional (Brewer 2007:300). A child does not merely grow into readiness but must be exposed to situations and carefully assisted by others to develop the necessary skills and ways of functioning.

School and learning readiness develops over a period of 6–7 years. If a child receives the right stimulation and exposure to discovering in free-play and certain learning opportunities during these years, cognitive and other skills could be acquired to make him or her school ready (Davin & Van Staden 2005:9). The success and degree of effectiveness with which he or she will master learning content in the formal teaching and learning context is determined by the learner's level of school and/or learning readiness. The learner, the teacher/practitioner and parents all play key roles in this process.

The content of preschool programmes is important. Lawrence Schweikhart (in Basson 2000), one of the designers of the High-Scope curriculum in the USA, avers:

School readiness means learning some other things – things that are not self-evidently 'academic', they're not reading, writing and arithmetic. They learn from toys, they learn from play, they learn from touching things and moving around, from their senses, from poking things to see how they react. (n.p.)

According to Pascal and Bertram (2011), the child should be actively involved in programmes which include large- and small-muscle development and coordination. The effect of movement programmes for

intervention purposes has been researched, and it was discovered that children's perceptual-motor abilities and learning readiness improved (Deli, Bakle & Zachopoulou 2006:9).

The educational inputs of parents regarding the development of their children's school and learning readiness during the preschool phase differ considerably (Wilkins 1986:15–16). There is little control over the activities of parents at home. Factors such as differences with respect to home circumstances, cultural-educational level of parents, the 'competence' for parenthood and many others are uncontrollable, difficult to raise, and divergent by nature.

Educationists realise that external factors such as parents, preschool programmes and the Grade R and Foundation Phase teacher each play a significant role in school- and learning readiness (Grobler *et al.* 1998:175). School readiness can then be defined as when a child's level of development on the physical, physiological, emotional and social level is so advanced that he/she is able to start with formal education and be able to adapt socially in a school environment (Brewer 2007:40; Landsberg *et al.* 2009:68). Learning readiness is when a child is intellectually and cognitively prepared and able to start learning in a formal school environment (Brewer 2007:40; De Witt 2011:170; Washington & Oyemade 1995:8). Learning readiness can be influenced by the knowledge of teachers, the teacher:child ratio, and the availability of teaching aids (also known as learning and teaching support material).

Perceptual skills and school readiness

Learners perceive the world through their sensory systems: vision, audition (hearing), gustation (taste), olfaction (smell) and by touching. Regardless of the particular sense being considered, however, the task of

perception provides the information needed to accomplish three functions: attending, identifying and locating. *Attending* involves determining what in a situation is worthy of detailed processing. *Identifying* involves recognising what we perceive. *Locating* involves specifying how far away the perceived object or event is and in what direction relative to the observer. All of these functions are performed with the goal of effectively guiding action (Siegler & Abibali 2005:143).

Clear perception and the ability to make meaningful interpretations form the basis of successful learning (Winkler, Modise & Dawber 2004:71). In the Foundation Phase, for instance, learners acquire certain perception skills like the development of laterality, body view, balance and spatial orientation. Children's sensory and physical interaction with the world in which they live is a perceptual and motor experience (Van Zyl 2004:147).

Perception, therefore, can be seen as the ability to observe, to distinguish, to have insight and to be aware of what is happening around a person (De Witt 2009:61; Landsberg, Krüger & Swart 2011:220; Slater & Bremner 2003). It refers to meaning which the brain attaches to information that is received through the sense organs (De Witt 2009:62) and constitutes the beginning of a person's experience of his or her environment.

The motor aspect links up with perceptual development because small children are active and by nature enjoy movement. Young children experience sitting still as difficult because their muscle movements are still uncontrolled to a degree. Consequently, it takes effort and concentration for a young child to sit still because it requires muscle groups to coordinate as well as to synchronise with aspects of balance (Goddard-Blythe 2005:420). Perceptual-motor development usually refers to the ability to receive and interpret information and to successfully react to

sensory information. The perceptual part is seen as the 'receiving part' of the information, whereas the motor part is described as the 'execution part', thus the reactive movement which must be executed (Capon 1983:8; Johnstone, Ramon & Magee 2010).

Theoretical perspective: Bronfenbrenner's ecological model

In the 1970s Bronfenbrenner developed a complex ecological model that explains the direct and indirect influences on a child's life by referring to the many levels of environment or context that influence a person's development. He suggested that it is helpful to conceive of the environment or social context as 'a set of nested structures, each contained inside the next like a set of Russian dolls' (Landsberg *et al.* 2009:10) and therefore interrelated. A key component of Bronfenbrenner's model is the understanding that children are also active participants in their own development, and the environment therefore does not simply impact on the child (Landsberg *et al.* 2009:13). Children's perceptions of their context are central to understanding how they interact with their environments. The way they perceive their circumstances influences the way they respond to their human and physical contexts.

The Bronfenbrenner model is an example of a multidimensional model of human development (Landsberg *et al.* 2009:10). It suggests that there are layers or levels of interacting systems resulting in change, growth and development, such as physical, biological, psychological, social and cultural. What happens in one system affects and is affected by other systems. In other words, relationships amongst causes are reciprocal and multifaceted. Multidimensional models are useful in describing development as well as the complex, casual processes involved in many other kinds of change.

■ Problem statement and aim

As stated before, development, perceptual and other developmental skills can be influenced by the environment, like learning and home environments, parents, teachers, society and national and provincial policy. The main purpose of the research reported in this chapter was to investigate from Bronfenbrenner's ecological perspective if Grade R learners in Gauteng and North West's primary schools achieve the required levels of school readiness, and if not, what obstacles they encounter in the learning process.

The aim of the research was to determine if Grade R learners in Gauteng and North West's primary schools achieve the required levels of school and learning readiness, and if not, what obstacles they encounter in the learning process.

The rest of the article is structured to describe the empirical design, findings, discussions and recommendations.

■ Empirical research

■ Research design and method

A school readiness test was done with Grade R learners from primary schools in Gauteng and North West, and observations at the schools were undertaken by the researchers. The school readiness tests provided quantitative data, and the observations provided qualitative data. A quantitative and qualitative *ex post facto* survey was done.

■ Research instrument for North West and Gauteng

The Susan Le Roux school readiness test was used as a measuring instrument because it tests a variety of perceptual abilities and also contains

a motor element. It is registered with the Human Sciences Research Council (Sonnekus & Le Roux 1995).

For the quantitative part of the investigation, the school readiness of the participants in North West was assessed by means of the registered Susan le Roux Group Test for School Readiness that determines the level of development in different areas of development. The test consists of sub-tests, one each for visual perception (visual discrimination, perception of shapes, foreground/background perception, sharp visual perception, incomplete drawing of a person, Gestalt perception, visual memory, visual sequencing), spatial orientation (position in space, sense of direction, midline crossing), number concept (counting of concrete objects, quantities and proportions), language and experience (emotions, abstract thinking, memory), draw-a-person (a universal test to determine at what stage of mental development a learner is), auditory perception (auditory discrimination, auditory memory, auditory sequencing), fine motor coordination (fine motor skills, dexterity, maze, writing patterns) and gross motor development (Le Roux 2010). According to Le Roux's standards, an average mark of less than 49 out of a maximum of 75 (i.e. 63%) indicates that a child is not yet school ready (Le Roux 2010).

Also as part of the qualitative research, analyses were done of the school readiness profile of learners in the selected schools in Gauteng and profiles were drawn up of the training of teachers and/or practitioners involved in those schools.

Observations as quantitative data were documented whilst visiting the schools to organise for assessment of school readiness levels of learners. Observations were made of Grade R class set-ups, focusing on teaching activities and aids, equipment, playgrounds and apparatus.

■ Sampling

In both cases Le Roux's school readiness test was used as a guide to determine the Grade R learners' perceptual and motor skills.

In North West Grade R learners from Quintile 3 and 4 ($N = 48$) took part in this experiment. An availability sample of Grade R learners was drawn out of two schools from deprived areas. The group of children tested in this study were growing up in home environments without much stimulation. The schools are not far from one another, with nearly the same environment, school set-up and inadequate apparatus and teaching aids. The languages of instruction of these schools are Sesotho and Setswana, and are spoken by one of the authors. A school-readiness test was administered amongst 48 Grade R learners (21 boys and 27 girls).

In Gauteng learners participated from Quintile 1 to 5 schools ($N = 114$). Two districts (Pretoria and Vereeniging) in the Gauteng Province were selected for the survey, that is, a district in the north and another in the south of the Province. Pretoria schools represent learners from a city and Vereeniging learners represent a large urban town. The participating learners were selected by their teachers ($n = 114$) using the age and gender of learners as criteria. The learners were between 5½ and 6-years-old, and 6 boys and 6 girls were selected per school. Some schools selected 12 learners and some schools had fewer learners because of absenteeism. The survey was done to investigate the profile of the Grade R classes at primary schools representing all five quintiles in the two districts of the Gauteng Province.

■ Data collection

The participants were prepared for a certain time and date as arranged with the principal, and according to the age requirements indicated

specifically for the test. One particular primary school (name withheld) did not select the learners as requested, and as a result the assessment activities were not completed on the same day. The researcher had to go back to the school on a later date to complete the assessment activities.

In both cases the learners completed the workbook for the Susan le Roux school readiness test with the guidance of the researchers in accordance with prescribed guidelines. Since Grade R children have a limited attention span, the test was divided into two sessions with a break in between. The researcher in North West (with knowledge of Sesotho) could explain the test to the learners in their mother tongue.

■ Ethical considerations

Permission to do the research was acquired from the university under whose auspices the research was done (from both the Research and the Ethics Committees). Permission was also received from the Director of the Gauteng DoE and North West DoE.

Permission to conduct the study at the primary schools was obtained in advance from the school principals involved, teachers and parents and/or guardians of participating children. Parents and caretakers of Grade R children also signed a consent form that their children could participate in the investigation. Participation was voluntary and the results of the test were treated as confidential.

■ Trustworthiness

The previously mentioned Le Roux test is deemed to be trustworthy. It is a standardised test, registered at the HSRC in 1992. The test is widely used

in Grade R classes to assess the levels of school and learning readiness of children. The assessments were done by university researchers as well as ECD departmental officials attached to two districts in the Gauteng Province.

The reliability of the measuring instrument was established by calculating the Cronbach alpha coefficient of the scores of the North West learners. An overall value of 8.0 for the eight component tests confirmed the reliability of the test (Field 2009:675).

■ Data processing and analysis

The school-readiness tests were marked according to the guidelines of the test. Quantitative data were captured and processed by the Statistical Consultation Services of the universities in SA to which both researchers are affiliated by means of SAS statistical software (STATISTICA 2016). Descriptive statistics (means and standard deviations) and percentage frequencies were calculated.

■ Findings at the Gauteng schools

All the participating learners managed to complete the test administered to them on the first visit to the school by the researcher. They enjoyed it very much, although most of them were tired towards the end of the day. Ex-model C schools (i.e. the historically more advantaged schools) did not experience problems with language, but township schools (i.e. the historically disadvantaged schools) did. The District Officials who assisted the researcher in conducting the school-readiness test had to translate to learners in the LOLT of the school.

The school-readiness profile of learners in Gauteng was calculated as a percentage per quintile. Table 1 shows the overall average results of all the learners in each of the subtests, starting from Quintile 1 to Quintile 5 schools in both districts.

According to the data reflected in Table 1, not one of the five groups of Grade R learners from different quintiles that were included in the sample scored at the desired level of 63% or more. This means that not one of the five groups were school ready as a group. Some individuals did indeed score 63% or more, which indicates that they were school ready.

Table 2 gives the numbers of learners in each of the quintiles that achieved below and above the minimum score of 49 out of 75 for the school-readiness test.

Table 3 shows the profiles on the training of teachers in the selected schools in Pretoria and Vereeniging.

TABLE 1: Achievement of learners in quintiles as percentages.

Learners	Quintiles (%)					Total average (%)
	Q1	Q2	Q3	Q4	Q5	
Achievement	49.18	41.63	53.32	49.94	51.70	49.00

TABLE 2: Numbers achieving below and above minimum score – learners in Quintiles 1–5, Gauteng.

Quintile	Below min. 49	Above min. 49	Total (n)
Q1	13	11	24
Q2	18	3	21
Q3	5	16	21
Q4	10	14	24
Q5	9	15	24
Total (N)	55	59	114
Total (%)	49%	51%	100%

TABLE 3: Training of teachers.

Location	Quintile	Training of teachers
Pretoria	1	$N = 3$: Level 1 ($n = 2$); and Level 4
	2	$N = 1$: Level 4
	3	$N = 2$: Level 4 and 5
	4	$N = 3$: Level 1, 4 and no training
	5	$N = 2$: Teacher's diploma but not in pre-primary.
Total	Q1–5	$N = 11$
Vereeniging	1	$N = 2$: Both Level 5
	2	$N = 2$: In training and Level 1
	3	$N = 1$: Level 5
	4	$N = 1$: Level 4
	5	$N = 1$: Level 4
Total	Q1–5	$N = 7$

In the Vereeniging district schools 5 teachers out of the 7 had Level 4 and 5 training. Only one had Level 1 training and one is still busy with her Level 1 training (Vereeniging, $n = 7$). In the Pretoria district 3 teachers had Level 1 training; 1 does not have any training at all and 2 teachers have teaching diplomas, but not in pre-primary education. Four teachers have Level 4 training and only 1 has Level 5 training (Pretoria, $n = 11$).

Findings at the North West schools

Although the learners ($n = 48$) that formed the sample for the research in North West had already attended Grade R for 6 months, not a single one of them had reached the level of school readiness by the time the test was administered. The group of children assessed in this study was growing up in a deprived environment with poor stimulation. The approach to Grade R was also still too formal in these schools and very little time was given to movement development.

Table 4 shows the scores recorded by 48 children in the school-readiness test.

Discussion

It is clear that these learners coming from deprived circumstances had to contend with several barriers in Grade R and did not reach school readiness, a prerequisite for entering Grade 1.

TABLE 4: Overall scores recorded by 48 children in the eight component tests for school readiness.

Test	\bar{x}	SD	Minimum	Maximum	Total score subtest	Minimum prescribed score	Children who meet pass mark requirements [%]
1. Visual perception	11.25	3.23	1	17	26	19	0
2. Spatial orientation	3.45	1.07	2	6	9	6	2
3. Number concept	2.94	0.95	1	5	6	3	75
4. Language and experience	3.48	1.11	0	5	11	5	19
5. Drawing human body	1.06	0.67	0	2	3	2	25
6. Auditive perception	3.79	1.11	1	6	9	6	4
7. Fine motor ability	2.52	1.25	0	5	7	4	23
8. Gross motor coordination	1.44	0.87	0	3	4	2	52
Test total	29.93	6.46	9	43	75	54-59	0

\bar{x} , average; SD, standard deviation.

Perceptual motor skills are closely related to the development of body image, coordination and visual as well as auditive/auditory perceptions. Perception is the beginning of a person's experience of his or her environment and living world, and children's sensory interaction with the outside world is thus a perceptual motor experience (Grove & Hauptfleisch 1978:12; Landsberg *et al.* 2009:370). Perceptual motor skills play a crucial role in school and learning readiness. The following skills tend to develop through these skills: spatial and temporal awareness, awareness of depth and form, background/foreground discrimination, listening ability, auditive and tactical discrimination and tactile memory.

The research reported in this article focuses on a connection between the stimulation children receive and their level of school readiness. If children were given sufficient time to play, small and gross motor coordination should improve and develop. A further reason for the poor test score recorded in this study might be that teachers had not been adequately trained to teach Grade R as well as a lack of resources, teaching aids and playground equipment (LTSM).

Of the eight subdivisions of the test, the children achieved the best learning readiness score in number concept (75%). This relatively good result might arise from the numerous work sheets on numeracy and counting sessions completed in class by teachers. The weakest performance was in visual perception, spatial orientation and auditive perception. The poor results achieved in visual perception could possibly be ascribed to the fact that these children had grown up in deprived environments, without stimulation, without books, magazines or any other written material. Few deprived areas have libraries, and children in these areas are seldom if ever exposed to educational toys. Teachers in

classes (Gr. R – Gr. 3, for children aged 5–9 years) sometimes have educational toys and equipment in their classes but do not know how to use these.

A possible effect of poor visual perception is that these learners might experience problems when beginning to read. Overall poor perceptual development could lead to later barriers in reading, spelling, writing and mathematics achievement (Grove & Hauptfleisch 1978:17; Landsberg *et al.* 2011:371). Not being school ready in time (Brewer 2007:153) could lead to learning obstacles in and for these learners, which in turn might result in poor school performance.

Observations of researchers

The researchers reached consensus from their observations as qualitative research on the following matters and circumstances that contribute to the situation concerning Grade R education in primary schools and the phenomenon of learners not being school ready:

- A contributing factor in Quintile 1 and 2 schools in SA is the high numbers of learners in Foundation Phase classes – from 40 to as high as 82 learners, with one teacher without a class assistant.
- Books from the Government are provided, but not enough for all the learners. There was an absence of LTSM at most of the primary schools in the North West and Gauteng provinces of SA.
- The development and stimulation learners are supposed to get through play is limited.
- Especially in the rural areas, the DBE builds Grade R classes and equips them with the necessary educational toys, apparatus and LTSM. However, the teachers do not use the educational toys as part of the teaching and learning programmes in their classes.

- The problem that still exists is that there are not enough appropriately trained Grade R teachers to fill all the vacancies. Furthermore, primary schools who get Grade R classes are not provided with the opportunity to appoint Grade R teachers because the DBE does not create Grade R posts at the schools where the new Grade R classes are built. If there is an extra teacher she is usually appointed to teach a Grade R class without experience or appropriate training.

■ Recommendations and reflection on the researchers' experiences

Since the focus of the researchers was on perceptual development and school and learning readiness of Grade R learners in Gauteng and North West's primary schools and the obstacles they encounter in the learning process, various recommendations can be made:

Teacher training and in-service training should be addressed. The 4-year BEd Foundation Phase degree covers Grade R to Grade 3, but the Level 4 and 5 diplomas for Grade R practitioners are not acceptable for this important phase. People with such a qualification cannot be employed by the DoE. A major problem, therefore, is that some teachers in practice do not seem to have adequate training, knowledge and experience of teaching young children in the informal way that Grade R teaching requires. Continual professional development for teachers is therefore necessary, especially for those teachers placed in Grade R classes without appropriate initial training.

Workshops and short courses can be conducted to demonstrate and practice skills based on a play-based programme. Grade R teachers need to know what the use and benefits of different educational toys are and how and when to use them. Emphasis needs to be on the set-up of an informal

classroom with different areas; for example, block construction, fantasy corner, reading corner and a creative area. Furthermore, Grade R classes at primary schools need to have a separate fenced playground with enough apparatus like jungle gyms, swings, a sandpit and a water play area.

It is important to follow a Grade R day programme as prescribed by the CAPS and not the timetable as for the other Foundation Phase classes (Gr. 1–3). Grade R classes should follow a semi-formal Grade R programme with less emphasis on completing worksheets. The focus should be on free play, exploring the environment and creative activities.

Principals of schools with Grade R classes should find appropriately qualified educators to teach the learners at this crucial time of their lives with regard to stimulation and development. In cases where teachers without appropriate training and/or experience have to be appointed for Grade R classes, they should undergo in-service training in order to be informed about the correct pedagogy and their professional duties.

Despite the fact that the DoE provides a list of the minimum apparatus required and provides the required apparatus to primary and nursery schools with Grade R classes, playgrounds and outside play equipment for Grade R learners are insufficient and inappropriate.

Interventions to catch up on backlogs should be offered to contribute to the school readiness of learners when they start their formal education in Grade 1 (Blythe 2006:421).

■ Final findings

The research described in this chapter was carried out through an interpretivist paradigm to get a better understanding about the phenomenon around Grade R learners in SA. Interpretivism was also used

to get insight into which educational, social and environmental factors could be contributing to the situation. An interpretation of the results of the school-readiness test was made to determine the level of learning readiness of the learners from different quintile schools in Gauteng and North West provinces (Jansen, in Maree 2010:21). Against the introduction of ECD and ECE in SA and the conceptual/theoretical background, empirical research is reported into the current situation in a sample of preschools in Gauteng and North West provinces of SA.

Although the National DoE established Grade R classes at primary schools, some of the classrooms are not well equipped, and neither are there qualified Grade R teachers. The result of this was that even though these children already attend Grade R, most of them never reach the level of school readiness. The approach to Grade R is still too formal in schools and very little time was given to developmental activities and different perceptual skills development.

Despite the fact that there are huge differences in the socio-economic status of Quintile 1 and Quintile 5 schools, there were no significant differences in the achievement scores of learners in the different quintiles. According to this finding, socio-economic status and surroundings do not seem to make a difference to school readiness. The common factor shared by all these schools is the level of training possessed by their teachers. Training level may therefore arguably be regarded as one of the key factors to the attainment of school and learning readiness by their Grade Rs.

A study of related literature shows that in the USA well-trained educationalists are able and follow an approach to education based on knowledge about how children learn and develop. From the literature it is clear that children develop and learn best in a physically and emotionally safe environment, in which their basic physical and emotional needs are

met (Meier & Marais 2008:192). This essential knowledge should also be part of teachers' training and in-service training in SA.

There is clearly a need for better qualified teachers for learners in the preschool years in SA. A well-grounded training programme for teachers of 5–6-year-olds will lay a firm foundation, ensuring the future learning success of these learners and contributing to the bridging of the school-readiness achievement gap. Teachers with Level 1, 4 and 5 training should only be allowed to be assistants to trained pre-primary school teachers. As Copple and Bredekamp (2009) of the National Association for the Education of Young Children state:

Excellent teachers are intentional in all aspects of their role. The position statement identifies these roles as: creating a caring community of learners, teaching to enhance development and learning, planning curriculum to achieve important goals and assessing children's development and learning. (p. 34)

Parents should receive guidance in being involved in the stimulation of their small children. They should be informed of the importance of the above-mentioned principles and the importance of these in the classes of their children. Parents should also be advised not to send their children to Grade 1 too early.

■ Conclusion

According to Bronfenbrenner's theory of eco-systemic systems, the bio-ecological contexts in which learners find themselves influences their development (Landsberg *et al.* 2009:12). Consequently, deprived environments have an effect on learners who are exposed to these circumstances and this might result in shortcomings in their general development. If learners do not receive sufficient stimulation, their free play will be limited, and if they lack necessary educational

appliances and resources, their school readiness might be disadvantaged (Bronfenbrenner 2005:201; Donald, Lazarus & Lolwana 2002:36).

The researchers kept this theory in mind to construct meaning for the complexity of the influences, interactions and interrelationships between the individual learner and multiple other systems that are connected to the learner from an ecological systems theory perspective. Learning and school readiness can be influenced by the training and knowledge of teachers, the teacher: child ratio, the availability of teaching aids (also known as LTSM) the school and class as learning environment, the support and stimulation from parents and the community, and also the national ECD policy and implementation thereof in provinces and schools.

In the light of Bronfenbrenner's theory of eco-systemic systems, the above-mentioned factors have an influence on Grade R learners and are possible reasons for the backlogs and shortcomings in their performance in the school-readiness test. Bronfenbrenner's theory of eco-systemic systems shows that the bio-ecological contexts in which learners find themselves influence their development (Landsberg *et al.* 2009:12). The main factor preventing participants in this study from achieving school readiness seems to be the level of training of teachers in their classes.

The findings flowing from this research should inspire not only the Gauteng and North West DoEs but also the DBE to, amongst others, create more sustainable, enriched and empowering learning environments for Grade R learners to promote school and learning readiness.

When Grade R children commence their formal school programme before they are ready to learn or are prepared for schooling, they might experience barriers to learning later in their school careers. The possible cognitive backlogs within these children create various problems (De Witt 2009:315).

■ Chapter 1: Summary

Different factors in South Africa (SA) contribute to deficiencies regarding school readiness of Grade R learners. Perceptual motor development and other developmental skills can be influenced by learning and home environments, parents, teachers, society and national and provincial policy. The main purpose of the research reported in this chapter was to investigate the school and learning readiness of Grade R learners in SA from Bronfenbrenner's ecological perspective. In SA *early childhood* is an umbrella term for the period from birth to nine years of age, with different subdivisions according to age groups. Grade R children are between 5 and 6 years old, finding themselves in a semi-formal set-up in a Grade R class, either at a primary school, nursery school or in some informal settlements at a crèche. This period of time is critical to the development of fundamental movement and perceptual skills. The researchers focused on Grade R children from Gauteng and North West provinces in this research. Le Roux's school readiness test was used as an instrument to determine the participants' perceptual skills that indicate their school and learning readiness. The test determines the learner's visual perception, spatial orientation, number understanding, language and language experience, perceptual and fine and gross motor coordination skills. Statistical analysis revealed low scores of the learners from the two provinces according to the criteria of the test. School readiness is a major indicator of learning readiness and success in primary school and even later.

The role of pair programming in enhancing capability amongst learners

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■ Introduction

In South Africa Information Technology (IT) can be taken as a school subject from Grade 10 to Grade 12. According to the Curriculum and Assessment Policy Statement (CAPS) document, IT considers the actions that deal with the solution of problems through rational as well as computational thinking (Department of Basic Education (DBE) 2011). This includes the physical and non-physical elements for the electronic transmission, access, and handling

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of data and information (DBE 2011). About 60% of the outcomes of this subject consist of programming skills in an object-oriented programming language (DBE 2011). Only a limited number of learners take it because of the higher-order thinking skills required to solve programming problems. What learners do not realise is that Computer Science provides the knowledge and skills for current technological developments, and that in a technology-driven world it serves as an entry-point to many other disciplines (Cohen & Haberman 2007). Higher-order thinking skills also open doors by enabling learners to meet present and future challenges (Ramos, Dolipas & Villamor 2013). According to the South African CAPS (DBE 2011) IT focuses on, amongst others, activities that deal with logical thinking, problem-solving and the development of computer applications through the use of different development tools.

Most introductory programming courses allow little or no collaboration, which deprives learners of the opportunity of learning from others and sharing their knowledge, prohibiting them from achieving meaningful learning (Plonka *et al.* 2015). Urness (2009) states that using collaborative efforts in programming courses is more realistic because in industry software is also developed in collaboration as opposed to the solitary programming that is taught in most programming courses. Learners working together in a group are able to share and clarify ideas (Webb *et al.* 2014), which leads to improved learning, particularly of cognitive skills such as critical and creative thinking (O’Flaherty & Phillips 2015).

Critical thinking enhances learners’ ability to deal with the overwhelming amount of available information and changing technologies that they are faced with (Kalelioğlu & Gülbahar 2014). Critical thinking is encouraged by debate, which promotes understanding in preparation for collaboration between learners (Noddings 2015). In groups, dialogue

emerges that enable learners to identify their limitations (Kost & Chen 2015). Three components emerge from discussion, namely, working collaboratively, exploring interpretive questions that activate prior knowledge and reflecting on discussion (Kost & Chen 2015).

In view of the fact that cooperative learning strategies are designed, amongst others, to motivate students (Fernandez-Rio *et al.* 2016) help their retention of key ideas (Tsay & Brady 2010) and, that is, increase their depth of learning (Tsay & Brady 2010) and time on task higher-order thinking skills (Johnson, Johnson & Stanne 2000), one could expect group work and especially pair programming to be used more frequently in IT classes. Working in groups cooperatively, especially on tasks thought to be difficult, will empower students and reduce the anxiety surfacing when they have to struggle on their own (Zulu 2011).

According to Willis (2007), some learners experience high stress or anxiety when asked to do something that they perceive as difficult. When stressed, there is a significant reduction in the neural activity into the brain (Willis 2007). If the brain is in a normal, relaxed state it receives information as sensory input; thus when learners take part in engaging activities, like cooperative learning groups, there will be nothing blocking the flow of information (Willis 2007) and better learning will take place. This proves Krashen's (1982) well-known theory that learning that is associated with positive emotion or enjoyment is retained for a longer period of time.

Previous research in two South African provinces (Mentz & Goosen 2007) indicated that a low percentage of IT teachers actually implemented any form of group work in their classes. Participants raised several problems regarding the implementation of group work, and this led Mentz and Goosen (2007) to conclude that teachers were uninformed on how to implement cooperative learning, especially pair

programming, in their classes effectively. They are therefore unaware of the advantages of cooperative learning with regard to capability development.

Although research on pair programming with Computer Science students in tertiary institutions is well documented and indicates a certain degree of learning gain as well as a favourable change in the students' and lecturers' perceptions after using pair programming, only limited research on pair programming in high schools could be found. Liebenberg (2010) researched South African high school girls' perceptions of IT after the implementation of pair programming in the subject; it transpired that the girls' enjoyment of programming, their view of the subject and of a career in IT had changed positively. Werner and Denner (2009) examined pair programming in middle schools in the USA and the degree to which it could promote or undermine effective problem-solving. No research could be found regarding teachers' attitudes, beliefs and perceptions about pair programming as a capability development tool for high school students in South Africa (SA).

We now contend that with the correct implementation of pair programming as a teaching-learning strategy teachers would agree that pair programming could be a useful capability development tool for IT learners. To defend this claim, we present three sets of evidence: a discussion of findings regarding the journals kept by teachers whilst implementing pair programming; the findings flowing from open questionnaires completed by teachers before training to implement pair programming and also after the six-month implementation; and lastly, the findings flowing from interviews with teachers after having implemented pair programming for six months. The report of the research findings begins by presenting the conceptual-theoretical framework on which the

study was based and then outlines certain implementation guidelines. This is followed by the research methods, results, recommendations and final conclusion.

■ **Conceptual and theoretical framework**

□ **Pair programming as teaching-learning strategy**

Pair programming first originated as one of a group of agile software development methods used in industry, where solutions evolved through collaborative teamwork. The reported successes in industry motivated the application of pair programming as a teaching-learning strategy. Pair programming as a teaching-learning strategy has been described as two learners working at one computer, sitting side by side, and collaborating on the same programming task (Anderson & Gegg-Harrison 2012; Vasanthapriyan, Tian & Xiang 2015). One learner performs the task of 'driver' operating the keyboard and mouse, and the other performs the role of the 'navigator', being in control of the resources continuously examining the work of the driver, suggesting strategies and alternatives to solve the problem, and being actively involved in identifying tactical and strategic deficiencies in the work (Anderson & Gegg-Harrison 2012; Shaw 2009; Williams *et al.* 2008).

The success of pair programming as a teaching-learning strategy at tertiary level is well documented. Anderson and Gegg-Harrison (2012), Kavitha and Ahmed (2015), Braught, Wahls and Marlin Eby (2011) as well as Carver *et al.* (2007) regard pair programming as an effective pedagogical tool as it bolsters course completion and pass rates, contributes to greater persistence in Computer Science-related majors and improves the enjoyment of programming. Pair programmers also produce better designed programs.

As mentioned in the introduction, research on the implementation of pair programming in high schools is limited and, if unaware of the advantages thereof, teachers are often reluctant to change their teaching strategies.

Implementation of pair programming in high schools

One of the reasons for the success of the pair programming strategy for teaching programming skills can be found in its collaborative nature. Collaborative learning, which can be regarded as embedded in the social constructivist theory (cf. Onwuegbuzie, Johnson & Collins 2009), implies interaction, combined completion of a task and the sharing of each other's resources (Chizhik 2010; Liaw, Chen & Huang 2008). It promotes higher-level thinking and communication skills and fosters meta-cognition (Breed, Mentz & Van der Westhuizen 2014; Lee 2014; Urhahne *et al.* 2010).

Student pairs in a collaborative environment tend to use problem-solving methods to extend ideas that are acceptable to both, justify their reasoning by acknowledging opposing interpretations, learn from each other's mistakes and receive critical feedback from proposed ideas (Webb *et al.* 2014). Barber, King and Buchanan (2015) state that learners can support one another, enabling them to take risks, make mistakes and ask for help when solving problems. This proves to be much more effective in promoting learning than a teacher simply providing the answers.

Collaborative learning can be a valuable method of teaching and learning computer programming (Teague & Roe 2008), as problem-solving forms a key part of Computer Science and more specifically of computer programming. It also offers opportunities for students to engage in meta-cognitive activities (Werner & Denner 2009). The navigator's role of

monitoring and reflecting on the problem-solving process (Bryant, Romero & Du Boulay 2008) is part of a set of meta-cognitive activities which could result in better learning, understanding and ability to transfer knowledge to new situations.

Pair programming is more than simply allowing students to work in pairs. According to Bryant *et al.* (2008), the navigator and driver not only have special roles but also have to rotate these roles regularly and communicate with each other. Programming in pairs urges the learners to talk, which by itself can result in improved understanding (Bryant *et al.* 2008). It can almost be seen as a type of 'cognitive off-load', which helps to free up working memory. Bryant, Romero and Du Boulay state that many programmers have reported instances where they have had 'eureka' moments whilst explaining something to someone else.

Mentz, Van der Walt and Goosen (2008) find that pair programming based on the elements of cooperative learning, namely positive interdependence, individual accountability, face-to-face promotive interaction, good social skills and group processing, can serve as an effective teaching-learning strategy for mastering computer programming at tertiary level. Effective implementation of pair programming depends on teachers and facilitators taking note of the implementation guidelines for such programming. The learning process should be structured very carefully, especially in high school. Learners need to know precisely what pair programming is all about and what is expected of them in such an environment. The teacher should never assume that the learners will figure out what to do when they have to program in pairs. Learners may think that the idea is to divide the work equally, each working by themselves (Williams 2007). Learners need to be taught the roles of the drivers and navigators, how to meet individual responsibilities, share resources, set

goals, communicate, listen effectively and resolve conflict where necessary (Williams & Kessler 2000). In general time constraints are a common problem for all teachers (Crompton 2014), but in pair programming time constraints serve as motivation and create a sense of urgency in the pair, thereby promoting active learning (Mentz & Goosen 2009).

The teacher should set mechanisms in place that will force both members of the pair to be actively involved in the learning process and ensure that no one is having an easy ride on the other's back or completely withdraws or, alternatively, dominates the situation. This could be done through the implementation of peer and self-assessment strategies as well as by providing opportunities for learners to demonstrate their work to the class. Setting clear and mutual goals for the pair is important to foster positive interdependence (Mentz *et al.* 2008).

The teacher should constantly be available for help, support and assessment (Mentz *et al.* 2008) and to see to it that roles are regularly switched (Williams 2007). After the completion of a task, learners need to reflect on how well they cooperated and how they could have improved their collaboration (Mentz *et al.* 2008). Class discussions on how learners solved their programming problems and which methods they applied to reach a solution could result in greater insight and understanding, and might also serve as another learning opportunity.

Studies at tertiary level indicate that skills levels and/or personality types can be used as criteria for creating pairs (Begel & Nagappan 2008; Salleh *et al.* 2009), but Williams and Kessler (2003) as well as Chong and Hurlbutt (2007) are convinced that when pairs move around and everyone gets to work with everyone else, even more and faster learning occurs because it helps to distribute the code knowledge across the whole class.

Teachers are often unaware of the guideline to implement pair programming and simply ask students to work on an assignment together, which may be the reason for the negative experiences of the implementation of group work reported by Mentz and Goosen (2007).

The capability approach

According to the *Concise Oxford English Dictionary* (2011:208), a capability is the power or the ability to do something. The discussion above abounds with words and phrases that embody such a power or ability, for instance the ability to persist, perform better, discuss a problem, interact with others, share (resources), reach higher levels of thinking, communicate, learn from mistakes, transfer knowledge, take responsibility, listen effectively, resolve conflict, foster creative interdependence, cooperate and collaborate with others. These abilities should all be brought home through education, which is why we referred to the method of pair programming as a pedagogical tool.

This view ties in with Nussbaum's (2000) capability approach. Education (in this case) should focus, she insists, on the development of human capabilities, which are central human functions, that is, what people (in this case learners) are actually able to do and be. Pair programming is therefore not simply a teaching method or technique, but is 'informed by an intuitive idea of a life that is worthy of the dignity of the human being' (Nussbaum 2000:5). As with all forms of pedagogy, it should be aimed at the good of the learners and at enhancing their quality of life; it should be pursued for each and every learner, treating each as an end and none as a mere tool to the ends of others. In this regard Nussbaum (2000) and Sen (2009) agree that individual advantage is judged in the capability approach by a person's capability to do things he or she has reason to value.

The capability approach, therefore, can be used as a normative framework for the evaluation and assessment of human well-being (De Haan, Hirai & Ryan 2016).

Based on this conceptual and theoretical framework, an investigation was launched to establish whether teachers viewed pair programming as a teaching-learning skill that could contribute to greater capability development in their learners.

■ Research design

■ Method

A predominantly phenomenological-hermeneutic method was employed within a qualitative research setting (Creswell 2014), amenable to recording teachers' experiences and perceptions of the pair-programming phenomenon. The researcher believed that people are constantly constructing interpretations of their world, which should be taken into consideration in any social research. These interpretations should be clarified in order to understand human actions and ideas (Babbie & Mouton 2011).

■ Sampling

The population consisted of all the IT teachers ($n = 24$) in a specific province in SA. At a provincial meeting of these teachers at the beginning of the academic year, they were informed about the research, and five¹ of them were purposively selected by the researcher on the following grounds:

1. Note: since very few learners take IT in senior classes in South African schools, the pool of teachers available for study was quite small.

- One teacher from each of the four different provincial regions.
- At least one teacher from a top-performing school.
- At least one teacher from an underperforming school.
- No previous experience with pair programming as teaching-learning strategy.

Ethical considerations

Permission to conduct the research was granted by the provincial Department of Education (DoE), the principals of the selected schools, as well as by the ethical committee of the university under whose auspices the research was undertaken. Informed consent was given by all participating teachers. We assured the participating schools and teachers that the information obtained throughout the research process would be treated in a confidential manner and that they would in no way be disadvantaged. They were also reminded that their participation is completely voluntary and that they could choose to opt out of the research process at any given time. We adhered to this by not naming any of the schools or teachers involved, by respecting their answers and opinions, and by treating the information in a confidential manner intended for research purposes only.

Intervention

The five teachers underwent a two-hour individual pair-programming training session before they started implementing pair programming in their Grade 10 IT classes. Training was given by a computer programming facilitator/researcher with many years of experience in the implementation of pair programming in teaching and learning. Each teacher received a training manual that could be consulted after the training session.

The training and the manual were designed according to the guidelines discussed earlier. The training placed special emphasis on how the principles of cooperative learning could be applied in the implementation of pair programming.

■ Measuring instruments

Before the training session teachers' initial perceptions of group work in general as well as their preferred method of teaching were determined through an open questionnaire on their expectations regarding the impending implementation of group work in their IT classes. During the six months' implementation of pair programming, they were expected to make a journal entry on a weekly basis after each pair-programming session. We specifically asked them to reflect on positive and negative experiences, challenges, solutions and the implementation of pair programming in their classes.

After the implementation period an open questionnaire was completed again and semi-structured interviews were held with all of them, where we initially asked what their experience with pair programming in their classroom was. This prompted further discussion and led to follow-up questions for clarification, which enabled us to get a broader picture of their perceptions and experiences of pair programming, especially pertaining to the advantages and disadvantages, and the extent to which it could be seen as a pedagogical tool for the capability development of their learners.

■ Data analysis

The data were analysed and interpreted by means of axial coding. Axial coding is used when a large number of codes given to phrases need to

be grouped into themes and/or categories (Babbie & Mouton 2011). A number of themes were identified from the data and grouped into categories and patterns to reveal certain interrelationships or linkages amongst the patterns, categories or themes.

■ Results

■ Open questions

When asked about their preferred method of teaching programming skills before commencing pair programming, the participants said that they prefer giving assignments to individual learners rather than having learners work in groups. They argued that group work was time-consuming, that learners needed to understand programming principles, that assessment was too difficult in groups, and that individual attention could be given when learners worked independently. They also mentioned that only some of the learners (usually the high achievers) did all the work when working in groups, and complained about discipline problems and a lack of time. They believed that learners needed to work on their own to really learn how to program.

Only one teacher initially indicated that she or he preferred group work as learners could help one another. Interestingly, the same teacher also declared that they never applied group work in the class as this always resulted in chaos. It was clear from the open responses to the initial questionnaire that these teachers did not often apply group work and that they did not have training in the application of group work. Consequently, they did not adhere to the principles of cooperative learning and had no real understanding of the value of cooperative learning as a capability

development tool. The following quotes represent their viewpoints at that stage:

‘I prefer that learners program individually.’

‘I am not sure if everybody is working in a group.’

‘It is total chaos ... not all learners participate in the group work activities.’

‘It took too much time.’

After the 6 months of implementing pair programming, the teachers were asked to complete the open questionnaire again. Where the majority of them said that they prefer individual assignments when asked about their teaching preference before the implementation, afterwards only one teacher still preferred individual work on programming tasks – but also admitted that group work, and specifically pair programming, helped learners understand programming concepts. Everybody said that they used pair programming in their classes on a regular basis. It was clear that they applied pair programming in such a way that the initial complaints about group work had dissipated. No one complained about discipline problems, time constraints or assessment problems:

‘Pair programming helps with the acquisition of new knowledge ... and programming skills.’

‘It is important for learning of programming skills ... they share their knowledge and learn to communicate effectively.’

‘Pair programming saves time because learners work actively and complete assignments faster.’

According to the results of the questionnaire, teachers’ perception of group work in general was somewhat negative before the pair-programming training. After the six- month implementation period their overall view was more favourable towards pair programming as a teaching-learning strategy. Their responses also attested to the fact that they had become more sensitive to the issue of capability development in their learners.

Journals

Two visible patterns emerged from an analysis of the aforementioned journals. Table 5 shows that teachers' views and experiences of pair programming were positive. They declared pair programming to be a successful teaching-learning strategy, effective for introducing new or difficult programming concepts. Not only did learners gain from this strategy with regard to enjoyment, enthusiasm and motivation for programming, there was also evidence that their academic achievement improved as a result of pair programming. Despite the fact that measuring improvement in the learners' academic achievement was not within the scope of this research, and therefore no evidence could be provided by teachers to prove that any improvement of academic results could be ascribed to the implementation of pair programming, their journals seem to point to a greater sensitivity regarding capability development in their learners.

The teachers also had more teaching time due to the fact that learners were more focused, more motivated and hence reacted faster on assignments. Learners' active involvement in class activities was one of the main advantages mentioned by teachers.

The negative experiences that teachers had were almost all recorded during the first 2–3 weeks of implementation; they used phrases such as 'at first ...' and 'in the beginning'. Reference to 'some learners' indicated that the majority of learners did not have negative experiences. However, one of the teachers admitted that she did not adhere to all the cooperative learning principles during the application of pair programming; it was therefore not surprising to learn that not all of her learners fully participated, they depended too much on their partners, and high achievers were reluctant to take part. Interestingly enough, it was the same teacher

TABLE 5: Patterns, categories, themes and quotations from qualitative data analysis of the journals.

Pattern	Category	Theme	Some quotations from teachers	
Positive experiences	Learners (according to teachers)	Attitudes	'Pair programming motivates learners to be actively involved during class time' 'Learners are most positive after first pair-programming experience' 'It is enjoyable for learners' 'Learners are enthusiastic to work in pairs'	
		Communication	'They did a lot of explaining.' 'They show new techniques and shortcuts to each other.' 'They are confident in asking questions.'	
		Collaboration	'Pairs work well together.' 'They helped each other.'	
		Productivity	'They work faster in pairs.' 'Save valuable teaching time.' 'They are motivated to complete assignments in the specified time.' 'Learners learn at own pace.'	
		Learning gain	Academic achievement	'Learners perform better in individual tests after pair programming.'
			Teaching strategy	'It is a successful teaching-learning strategy for acquisition of programming skills.' 'I quickly learnt the ability of learners in the class.' 'I have more time to help the slow learners.' 'It is effective to introduce new or difficult concepts.'
			Class atmosphere	'Relaxed class environment.' 'Promotes learning.' 'No discipline problems.'

Table 5 continues on the next page →

TABLE 5 (Continues...): Patterns, categories, themes and quotations from qualitative data analysis of the journals.

Pattern	Category	Theme	Some quotations from teachers
Negative experiences	Learners' attitudes and behaviour	High achievers	'At first high achievers are worried that they are not going to achieve the same high marks in a pair and therefore some of them were negative to work in pairs.' 'Some dominate the pair.'
		Low achievers	'Some do not always give their full cooperation.' 'Some depend too much on their partner.'
		Collaboration	'Some learners want to choose their own partners.' 'Some conflict occurs.' 'Some talk too much and do not have enough time to complete assignments.'
	Assessment	Reliable	'Peer assessment do not work well.' 'Some unfair mark allocation occurs.' 'Some learners are negative about the assessment.'

who declared that they still prefer individual work on programming tasks after the 6-month intervention.

Interviews

Similar categories and themes to those mentioned in connection with the journals emerged. Analysis of the interviews sheds more light on why these experiences occurred and what teachers did to change some of the negative experiences.

The main positive experiences identified by teachers were the advantages for learners of their active involvement in the learning

experience, the advanced acquisition of programming skills, promotion of self-directed learning, improvement of learners' critical thinking, logical argumentation, problem-solving, communication and social skills. As the following quotations show, the respondents had become more aware than before of their learners' capability development:

'They achieve difficult outcomes much easier.'

'[I]mproved understanding of programming principles.'

'[L]ess syntax errors as the navigator double-checks the code.'

'[I]t fosters self-directed learning as learners are motivated to solve their programming problems.'

'[T]hey do not give up so quickly and learn to think for themselves.'

'[I]t improves their problem-solving skills.'

'[T]hey understand programming better.'

The pedagogic focus seems to have moved from the teacher to the learners, with a view to promoting active learning for all learners:

'All the learners are actively involved in the learning process.'

'There is no one learner who gets totally lost anymore.'

'[T]hey learn different ways to approach and solve a computer program.'

'[T]hey communicate at their own level ... they feel more confident to ask questions to peers.'

'[T]hey help, assist and teach each other, ... they are more creative and think on a higher cognitive level.'

'[T]he collaboration keeps them focused and motivated.'

'[T]hey depend less on my assistance when their programs do not run.'

Teachers mentioned that learners enjoyed pair programming and that as a result their self-confidence to program improved. Learners learned more when doing pair programming because strong learners shared their knowledge of new programming concepts:

'If one learner knows something or learns a new programming concept like how to use a dialog box, it quickly spreads through the whole class.'

‘It is quite common to hear the following words in my class: “Good morning sir, with whom am I working today? I’d like to start right away!”’.

The teachers viewed pair programming as a successful teaching-learning strategy for the acquisition of programming skills:

‘I am very positive that this strategy works very well.’

‘[G]ood for the acquisition of new knowledge.’

‘[M]ore challenging problems work extremely well with pair programming.’

‘I have a better view on the abilities and problems of all learners in my class; learners complete assignments faster ... it saves time.’

‘[R]educed workload on assessment.’

Concerning implementation, no teacher mentioned any problems with discipline; one of them said that it was because all the learners were actively working to complete assignments before the end of the contact session. Teachers also suggested that one of the members of the pair should present their work to the class, so as to keep both learners focused. They were all convinced that individual assessment after the completion of a pair-programming assignment played a major role in the success thereof:

‘Randomly choosing one of the members of the pair to demonstrate their program in front of the class is working quite well to keep both learners focused.’

‘[M]ark sheets work well and save time.’

‘[I]ndividual assessment of utmost importance.’

‘[T]he focus should not be on marks, but we should not do away with marks.’

Although the experiences of teachers were positive, negative aspects which could be dealt with in future implementations should also be mentioned. In some instances the assessment strategies did not work. Teachers reported that learners allocated unrealistically high marks for

themselves and their peers; high achievers complained that their pair marks were affected by low achievers who did not give their full cooperation. This problem was solved when teachers told learners that the peer and self-marks would be ignored if they did not correlate with the individual test of each learner after the completion of the pair-programming session. One teacher indicated that s(he) penalised learners when they did not give a realistic mark to themselves and their peers. That resulted in more reliable assessment by learners. Although problems existed with assessment, teachers reported that the assessment procedures forced all learners to be actively involved during the completion of programming assignments:

‘Self and peer assessment are not reliable.’

‘[A]ccurate marks for pair product done by the teacher not possible during class time.’

‘I adjust their marks if they do not correlate with the individual assessment; they were penalised for unreliable assessment.’

Another problem that some of the teachers mentioned was that textbooks were not written for pair programming and that not all assignments would be suitable for pair programming in the time available. The planning of pair programming could also be time-consuming because teachers needed to select suitable assignments. Furthermore, teachers indicated that they needed to select more than one programming assignment for pairs who completed the assignment quickly. On the other hand, when allowing learners to complete assignments in the next contact class, the absence of pair members as well as unreliability of the assessment of assignments done individually at home brought additional problems. Teachers therefore preferred to have assignments completed in one contact session:

‘Textbooks are not written for pair programming ... results in additional exercises which teachers need to develop.’

‘[T]hey have to complete an assignment in one contact session otherwise learner absence could be problematic.’

Regarding the downside of collaboration, teachers stated that some pairs were not compatible and did not work well together. In some instances this was because of culture or language differences, but in others it was a matter of ability level. Teachers reported that this was only a problem in the beginning and that learners soon realised that they were obliged to work together with everybody else in class. They subsequently gained confidence, got used to the situation and adapted. They understood that the teacher needed to allocate pairs and not the learners.

According to the teachers, the majority of learners worked well together. Some teachers mentioned that especially the strong learners preferred to work individually or wanted to choose their own partner. This was dealt with by assuring learners that they were going to get the opportunity to work with everybody else in the class and that they were all in need of better social skills. Teachers also experienced problems with stronger learners dominating the pair as well as weak learners who did not cooperate. This was dealt with by carefully monitoring the role of the navigator and driver and also by allocating a mark for their collaboration:

‘Two strong learners together tend to have more conflict to decide upon the best strategy.’

‘[S]ome still want to work alone.’

‘[S]trong learners became frustrated working with weak learners each time and need to be rotated regularly. You have to monitor the roles very carefully.’

Teachers’ suggestions on the implementation of pair programming can be divided into two categories: ideas on assessment and ideas on planning. These suggestions addressed some of the negative aspects of pair

programming as identified by the teachers. The fact that learners were penalised for unreliable peer and self-assessment and were asked to demonstrate their program in front of the class solved many of their problems with assessment:

‘[R]andomly chose one of the members of the pair to demonstrate their program in front of the class and penalised them if they are not able to explain the program, but give themselves a good mark in the self-evaluation.’

‘[C]lass presentations are working quite well to keep both learners focused because they do not know who is going to present the project.’

‘[A]djust their marks if they do not correlate with the individual assessment or penalise students for unreliable assessment.’

The second factor which some teachers felt strongly about was the quest for careful planning to ensure success for pair programming. Appropriate assignments had to be selected for the time available. The teachers suggested that learners with a strong ability in programming should at first be matched with learners with a weaker though not poor ability to program. If conflict occurred, the teacher needed to manage this without necessarily splitting them up. They had to learn to work with everyone in class:

‘We need at least 50 minutes per contact session to complete assignments; careful planning is necessary.’

‘[Y]ou have to explain the aims and objectives as well as the roles of the learners very carefully.’

‘[S]uccess of implementation lies in the correct management thereof.’

‘It is important to see to it that learners keep to the roles.’

‘[C]onclusion and reflection at the end of a pair programming session is of utmost importance in the learning process.’

‘Do not pair the strongest and weakest learner.’

‘[P]air the strongest with an average to strong learner and the weakest with an average to weak learner.’

‘[M]anage conflict but do not necessarily split up the pairs.’

The teachers expressed appreciation for the training session and suggested that all teachers should be trained before they implemented pair programming. They also mentioned that good training of learners was just as important as getting a commitment from learners for doing pair programming.

■ Discussion

Pair programming as an instrument to contribute to learners' capability development was unknown to the teachers participating in this research. Although all of them indicated that they only used individual programming in their classes before the intervention of this research, they were willing to implement pair programming after the training session. After the 6-month implementation of pair programming the participating teachers viewed it as an effective teaching-learning strategy that could develop a range of capabilities in their learners, especially when introducing a new or difficult programming concept. They pointed out that its success was due to the development of collaborative abilities where learners could speak to each other about their understanding of the problem, construct their own knowledge and help each other.

The class discussion after completion of a pair-programming assignment was more important to teachers than the direct teaching method on new programming principles. The motivation and enjoyment that accompanied this strategy resulted in the active involvement of all learners in the learning process. According to the teachers involved in this research, the learners learnt more and understood programming concepts better, and mastered the capability of becoming more self-directed. The overwhelmingly positive response from the participating teachers seems to suggest that they were going to continue using pair programming after

the completion of the six-month intervention. This indicates that they thought the strategy was a tool for developing their learners' capabilities. No teacher complained about discipline problems and time constraints, as learners worked faster on assignments when working together.

The main challenges which all teachers experienced concerned the self-assessment and peer assessment regarding the contribution of each member of the pair and the fostering of positive interdependence. Students tended to allocate marks which were too high and did not want to acknowledge their peer member's actual contribution and knowledge. This might have been because of peer pressure or because of the focus on assessment in the South African education system. In cases where teachers penalised learners when their individual assessments did not correspond with those of their peer or the self-assessment, learners mastered the capability of being more realistic with mark allocation. Some of the teachers even declared that self- and peer-assessment was no problem after additional measures had been put in place to ensure reliable assessment.

As far as implementation was concerned, one of the most important issues that teachers mentioned was the importance of training of teachers and learners not only for using pair programming successfully but also to view it with regard to the capability approach.

Despite certain challenging experiences, no participating teacher indicated that he or she still preferred learners only to program individually. This can be taken as proof that knowledge of the implementation of pair programming convinced teachers that it was advantageous for the mastering of programming skills, and hence the acquisition of several new capabilities. They acknowledged the fact that pair programming could be used as an effective pedagogical tool to help, guide and equip their learners

to become what they actually should be and be able to do what they are capable of doing. In capability approach parlance, this means that these teachers understood how to contribute to the general well-being of their learners, and thereby to the good life of the social groups they belong to.

■ Conclusion

Although the findings of this study may not be statistically generalised to the broader population, we contend that they can be substantively generalised from a naturalistic generalisation point of view (cf. Onwuegbuzie *et al.* 2009). This resonates with the view of Ekiz (2006) that if something happened in one place, there is a chance that it might also happen elsewhere. Although this research was done in only one province of SA, and although only a small number of respondents could be involved due to the scarcity of learners and teachers in this subject area, teachers' positive attitudes after the implementation of pair programming show that this strategy could be valuable with regard to capability development of learners at school level in SA as a whole.

The fact that these teachers said that they would keep on implementing pair programming is an indication of their trust in pair programming being of value to the learners for their personal and individual mastery of programming skills, and that they acknowledged, at least in principle, its value as a tool for developing learners' capabilities. The teachers were unanimous in their opinion that pair programming could improve programming skills and resulted in higher learner motivation, more enjoyment and an improved grasp of programming and problem-solving.

Although the evidence presented so far in this article seems to support our contention that pair programming could improve individual mastery of programming skills, there are some outstanding issues. Follow-up

research could, for instance, also include the other provinces of SA. This would introduce pair programming as a cooperative teaching-learning strategy to more IT teachers in SA. Working in pairs can also be extended to other subjects. In this way pair work could arguably contribute to meeting one of the critical outcomes of all school learning in SA, namely the ability to work effectively with other learners in groups or teams.

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■ Chapter 2: Summary

Based on Nussbaum and others' capability approach, it could be argued that education should be focused on development of the human capabilities of learners as central human functions; in other words, on what they are actually able to do and be. The same approach could be followed when teaching learners to master certain programming skills as part of their education. Traditionally, teachers prefer their learners to work individually when mastering programming skills. It is contended in this study, however, that pair programming, where learners work together on the same programming task, could more effectively improve a learner's mastery of programming skills because of the concomitant development

of the social interaction and collaboration capabilities required. Five Information Technology teachers, purposively selected with no previous experience of pair programming, took part in this study. After a pair-programming training session they were expected to implement pair programming in their classes for six months. Qualitative research was conducted to determine their perceptions and experiences of pair programming as a pedagogical tool for capability development in their learners. The results show that teachers indeed viewed pair programming as a teaching-learning skill that could contribute to greater capability development in their learners.

Navigating the terrain of academic writing in postgraduate research: The case of mature additional language students

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■ Introduction

Academic writing and research is a difficult terrain to navigate for the majority of students, particularly those who are mature students (those aged 23 years and above). It may be even more challenging for students

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who are not primary users of the English language. In this study we took ‘mature’ to refer to professionals over the age of 30 who are working adults (i.e. school teachers, Department of Education (DoE) officials, etc.), who have returned to higher education after some years in employment to further their studies. These educators would be family people with full-time work and home responsibilities. They would all be speakers of English as a second or third language, and henceforth additional language users as opposed to first-language speakers of or primary users of English.

This chapter reports on the academic writing and research challenges of a mature cohort of postgraduate students writing their research reports. Writing challenges are not only experienced by first-year university students ‘who enter higher education institutions with conversational fluency’ (Drennan 2015:131; Scholtz 2012:53; Shalem, Dison & Reed 2013:1077; Zulu 2014b:132) but by postgraduate students as well (Butler 2011:13; Claudius 2016:72; Du Plessis 2012:133; Imani & Habil 2012:460; Keong & Mussa 2015:27; Rambiritch 2015:33; Thesen 2013:109). Imani and Habil (2012:460) opine that non-native speakers find dissertation writing very difficult. Rugg and Petre (2004:129) explain how writing is ‘complex and demanding’ as ‘it involves many cognitive activities’. It is not surprising then that many students find writing challenging.

Claudius’ (2016) study of challenges of writing theses and dissertations amongst postgraduate students revealed that (lack of) academic writing skills was a key challenge evident in the documents he reviewed. In a survey to determine supervisor perceptions of postgraduate academic literacy as well as the academic writing requirements for postgraduate studies at one South African university, Butler (2011:80) found that the majority of additional language users’ writing ability was rated by their supervisors as ‘average’ to ‘poor’, yet ‘the successful completion of postgraduate studies depend[s] to a large extent on students’ writing

ability' (Butler 2011:17). In their study of NNS postgraduate students' academic writing, Imani and Habil (2012:462) found that these students had insufficient mastery of paraphrasing and summarising and tended to copy sentences. These authors also argue that academic texts should have 'structural variety' (p. 471) and 'grammatical accuracy' (p. 472).

Some of the issues tackled in Butler's (2011:12) and Du Plessis' (2012:124) studies regarding academic literacy levels of postgraduate students raise concerns about the effect of low literacy levels on students' time to completion, throughput, drop-out rates and increased effort and time spent by supervisors on students. These issues are indeed a matter of concern, not only regarding the toll it takes on both supervisor and student, but the overall slow increase in postgraduate student numbers and success rates for the university and the country as a whole. In such situations testing postgraduate students before admission to identify problem areas early might be a solution to throughput, drop-out and time to completion issues.

Academic literacy tests

The value of academic literacy tests for diagnosing literacy problems cannot be overemphasised. The National Benchmark Tests (NBTs), Test of Academic Literacy Levels and Test of academic literacy for postgraduate students (TALPS) are all useful predictors of academic performance. The TALPS in particular has been used at Pretoria University and the University of the Free State with insightful results. Butler (2009, 2011) and Du Plessis (2012) both acknowledge Albert Weideman for the development and introduction of TALPS, which has provided a solution for diagnosing postgraduate academic writing difficulties, particularly at universities where the majority of students come from what is commonly referred to as 'historically black' academic institutions.

It must be noted, however, that the results of the TALPS administered at the universities mentioned earlier point strongly to additional language users being the ones who ‘still struggle with academic writing’ (Butler 2009:291) or ‘are being admitted to postgraduate study with low academic literacy levels’ (Du Plessis 2012:134). This places the academic literacy plight of ‘additional language users’ in the spotlight. Highlighting this plight may raise awareness and honest reflection around the necessity of addressing this matter more seriously than has been the case at postgraduate level in all universities.

In his study, Butler (2009:291) found that a ‘specific group’ of postgraduate students at the University of Pretoria ‘still struggle with academic writing (and to a lesser extent, with reading academic texts in English)’. Similarly, in her assessment of the face validity of the TALPS amongst a cohort of postgraduate students at the University of the Free State, Du Plessis (2012:134) found that ‘many students have very little understanding of a theoretical articulation of academic literacy’. Hence, Kajee (2015:202) sees training in writing as ‘non-negotiable for student success’, as it ‘play[s] a gate-keeping function in higher education’ (Arbee & Samuel 2015:49).

■ Academic literacy training and writing centres

Zulu (2014a:222) argues that ‘research and academic writing and language skills ... are critical for success at postgraduate level’, and therefore, writing centres should play a more active role in offering training for postgraduate students. However, Arbee and Samuel (2015:66) raise an important point about the possibility that ‘there might be limited scope within writing centres which cannot traverse into discursive academic literacy at advanced levels’. This is not to say, however, that writing centres are not helpful,

but the point is that unlike undergraduate full-time students, postgraduate part-time students probably do not benefit as much from the services offered there as these are often available during weekdays when these students cannot access them. Part-time students attending only on weekends would benefit from writing centre services if time slots were also available over weekends (Zulu 2014a:222) as academic support and training in writing (and in other academic skills) is helpful in developing and enhancing students' academic discourse competence, not only during the early years of their academic career, but also throughout undergraduate and postgraduate study.

■ Academic discourse challenges

In his study entitled 'Using assessment strategically to gestate a student thesis' Grant (2013) noted that the majority of:

[E]ducation professionals enter the academy with 'everyday discourses' as well as 'professional discourses' [*which are not the type required for postgraduate study*], neither do they have the practical or procedural kinds of knowledge required for postgraduate study such as analysis, synthesis, creativity, critique, argument as well as citation and referencing [*which are essential elements of academic discourse*]. (p. 1253)

As a result of limited exposure to academic discourse, the main difficulty for professionals who are accustomed to 'everyday' discourses is the transition from one discourse to another, that is, from 'everyday' discourses including 'professional' discourses to academic discourse. In other words, when they enter the academic space they have to acquire and use a whole new set of specialised vocabulary and expression associated with academic writing and research. This transition can be challenging. It can lead to difficulties in the navigation of the terrain of academic discourse for all students for whom 'academia represents new cultural terrain' (Eybers 2015:82).

In South Africa (SA) and internationally, users of English as an additional or foreign language at undergraduate and postgraduate levels face similar problems as they grapple to function academically and linguistically in an unfamiliar language and discourse. Eybers (2015:82) makes a point about how being recognised as a member of a particular ‘social environment’ takes time. The same applies to becoming a member of the academic discourse community. According to Thesen (2013:108), ‘adult learners under apartheid were denied access to quality education, but experience the research process as a struggle amongst competing voices, many of which are silenced’. It is not surprising therefore that some of these adult (or mature learners as they are referred to in this study) find it difficult to think and write critically. Besides, explicit teaching of critical literacy was, and still is, not an integral part of the curriculum (or culture) of these mature learners. Nevertheless, it is assumed that at tertiary level, all students would already possess the necessary skills to meet the demands of academic study.

Keong and Mussa (2015:32) found that Iraqi postgraduate students studying in Malaysian universities faced many problems in academic writing, including vocabulary, grammar, weak paraphrasing, poor referencing skills and poor organisation and expression of ideas. They concluded that international postgraduates’ problems comprised ‘weak control in content and form, poor citation skills, limited reviewing ability, weak writer’s voice and rampant plagiarism’ (Keong & Mussa 2015:27).

Similarly, Claudius’ (2016) study on international student writing revealed that it is the writing phase of the research report that poses problems for many students in their dissertations and theses.

Other postgraduate writing difficulties noted in Butler (2011) include students’:

[I]nability to critically review, sift and query information gathered from the literature ... inability to write in an academic style, poor mastery of sentence and paragraph structure, poor ability in making use of connecting devices, lack of sufficient command of the language of learning to make functional and appropriate use of the language in writing. (p. 14–15)

Plagiarism is another major problem in postgraduate students' writing. Butler (2011:16) found that this practice is so common that 'even postgraduate students are often quite shocked to find out that they are not allowed to use someone else's exact words without quoting directly'.

Challenges with academic writing are prevalent at all levels. They occur at honours, master's and doctoral levels across different language groups and ability levels. Perhaps the difference amongst these levels and language groups may be in the type and gravity of challenges experienced. As Rambiritch (2015:39) states, 'the academic literacy levels of students depend on individual abilities in language, as well as their background, schooling, family life, race or region'. She (Rambiritch 2015) neatly summarises what good academic writing entails:

[W]riting, especially in the academic context ... cannot function in isolation and is dependent on other abilities the student should acquire. A student who is a poor reader ... cannot be a good writer. Good writing depends on a student's being able to read critically, to be able to summarise effectively what was read, and to use what was learned in the reading/research process to construct a logical, well-argued piece of academic writing. In addition, it is essential that students' writing be free of spelling and vocabulary/grammatical errors, that they know how to use a dictionary to avoid these very errors, that they are aware of the conventions of academic writing and that this be evident in their work. (p. 34)

For students to succeed, especially mature additional-language users, they need to be able to read and comprehend academic texts as well as complete writing tasks in a way that demonstrates mastery of academic writing conventions. This is in line with Weideman's (2003:xi) definition of

functional academic literacy (in Butler 2009:293). This definition explains what a student at tertiary level should be able to do, amongst which are: understanding a range of academic vocabulary in context; understanding relations between different parts of a text, via introductions to conclusions; interpret, use and produce information presented in graphic or visual format; know what counts as evidence for an argument; extrapolate from information by making inferences and apply the information or its implications to other cases than the one at hand; understand the communicative function of various ways of expression in academic language (such as defining, providing examples, arguing) and make meaning (e.g. of an academic text) beyond the level of the sentence (Weideman, cited by Butler 2009:293–294).

Not only are students at tertiary level expected to construct their arguments by ‘mak[ing] meaning beyond the level of the sentence’, they are also expected to engage with and transform information instead of merely reproducing it (Grabe & Kaplan, in Butler 2011:13). However, attempts to construct arguments in the manner expected at tertiary level are a big challenge for many additional-language users at honours and even master’s level. It often leads to misrepresentation of authors’ ideas or transformation of those ideas to such an extent that they are no longer recognisable. In other words, students’ attempts to paraphrase ideas result in what Paxton (2007:51) calls ‘circuitous writing’, or a rambling and confusing text.

Writing difficulty may be one of the factors responsible for some postgraduate students not completing their research projects timeously. Honours students generally complete their research methods module and other taught modules successfully within the first year of study, but tend to encounter difficulties when they embark upon the research project, resulting in prolonged time to completion. This phenomenon is common

amongst many postgraduate students, who usually complete their taught modules timeously but then take longer to complete their research project – a phenomenon Ahern and Manathunga (2004) refer to as ‘academic procrastination’.

Academic procrastination, according to Ahern and Manathunga (2004:243–252), may be explicable in terms of cognitive, affective and social domains, the details of which are beyond the scope of this study. For this study, the focus is on the cognitive domain as the successful completion of the research project essentially involves knowledge, understanding and reasoning combined with good academic literacy skills such as discourse competence or the ‘ability to produce unified written or spoken discourse that shows coherence and cohesion and which conforms to the norms of different genres (e.g. a business letter, a scientific essay [*a research report*] etc.)’ (Richards, Platt & Platt 1992:111).

Ahern and Manathunga (2004:244) categorise as ‘academic skills’ a combination of information technology, writing and library skills, all of which are essential for a student engaged in writing a scientific research report at tertiary level. Whether these skills can be acquired and mastered sufficiently by the majority of mature part-time professionals who have no prior exposure to them is cause for concern. A comment made in Butler (2011:13) is another area of concern in the BEd Honours programme, where the ‘Honours is lecture-based’; if students are not exposed to sufficient research and writing tasks they may indeed ‘start suffering when they reach master’s [*where*] they have to do extensive writing’.

■ Background and context

The context of this study is the academic discourse practices of the Bachelor of Education Honours 2013 cohort of students registered in the Education

Management, Law and Systems module in the School of Educational Leadership Development at the Mafikeng Campus of North-West University. The focus is on the research report of the Research Project (RSPR 671), which is a compulsory component of the BEd Hons programme, and as such successful completion of it is important not only for the award of the qualification to the student, but for postgraduate throughput at the university as well. The BEd Hons qualification provides access to further study and may be considered as an important leg of the ‘academic socialisation’ process of a student. Therefore it is critical for students to be equipped with the ‘necessary knowledge and skills’ to succeed.

However, from my teaching and supervision experience over the years, BEd Hons students do not come to the programme fully prepared for the process of advanced academic writing required in the preparation of a research report. For many years in the Faculty of Education and Training, the students in the BEd Hons programme comprised part-time education practitioners. The majority of them were secondary school teachers who had completed the Advanced Certificate in Education (ACE) or the National Professional Diploma in Education (NPDE). These teachers (for the most part) were mature students studying part-time over weekends and school holidays. Although the 2013 cohort was relatively younger in average age than the previous cohorts, there were still a few mature students who had registered earlier than 2013 and were still doing their project in that year.

Whilst I did not personally supervise the entire cohort, the few students whose projects I supervised afforded me further insight into the writing and research challenges of this cohort. Moreover, almost 50% of the 59 students registered for the RSPR 671 in 2013 were also registered for a module I taught, so I had a good insight into some of the students’ academic writing problems.

This motivated me to probe the issue further in order to gain a deeper understanding of the kinds of academic writing challenges evident in the writing of the research reports of the entire cohort.

Understanding students' writing and research challenges would facilitate the choice of an appropriate mediation strategy. Dixon, Reed and Reid (2013:1101) suggest that mediation may be necessary for 'cognitively under-prepared' students and that 'appropriately designed assessment tasks' should be used. They describe the development of an assessment tool designed to analyse assignment and examination tasks (Dixon *et al.* 2013:1101) which, they believe, can be useful for 'understanding the cognitive and academic literacy demands of subjects across a teacher education curriculum'. Rambiritch (2015:33) describes a postgraduate academic writing module developed by her institution to assist postgraduate students with their academic writing problems. A mediation strategy such as that described by Rambiritch may be helpful for other institutions to consider. Hence, understanding the nature of academic writing challenges of postgraduate students as they write their research reports would pave the way for the development of a mediation strategy to facilitate the transition of students from 'everyday' to 'academic discourses' (Dixon *et al.* 2013:1114).

■ Problem statement

Postgraduate students experience difficulties with academic writing, particularly in the context of the research project. Mature BEd Hons students do not seem fully prepared for the process of conducting research, in particular for the academic writing skills involved in the process. Academic literacy skills (reading and writing) as well as research skills are crucial for the academic socialisation of the student and successful

navigation of the postgraduate research terrain. In addition to identifying a research problem, students must prepare a proposal, conduct the proposed research, and write a scientific report on the project. To accomplish this, they need appropriate academic literacy and research skills, which the majority of students lack.

Consequently, the study sought to investigate the academic writing challenges displayed in the completed research projects of a cohort of part-time Education postgraduate students, and also to determine any challenges associated with the research process which the students might have encountered.

■ **Aims of the study and structure of this chapter**

There is little available information on the nature and extent of academic writing problems encountered by mature BEd Hons students in the writing of their projects. The aim of the study reported on in this chapter therefore was to identify the nature of academic writing problems experienced by students in the production of their research reports, as well as to determine challenges they encountered with the research process.

To reach its aims, the remainder of the chapter is structured as follows. Firstly, a conceptual-theoretical framework is outlined, and this is followed by an exposition of the research method that was applied. Then, the results are presented and discussed and recommendations are made.

■ **Conceptual-theoretical framework**

This study is broadly framed by the concept of ‘academic literacy’ with reference to (academic) written discourse rather than spoken discourse.

It also leans heavily on the notions of Gee's (2001, 2008, 2012) 'Discourses' and Swales' (1990) 'discourse community'.

■ Academic literacy

Academic literacy, in the view of Mgqwashu and Bengesai (2015:213–214), is a 'contested field, with different meanings for different people and inevitable tensions between those taking positions on or affected by its practical implications'. The two authors ask the question regarding what it means to be academically literate, and conclude that there is no straightforward definition of the concept, and that *academic literacy* is discursively constructed. Following is a discussion of Kern's model of academic literacy as presented in Scarcella (2003:10).

Kern proposes a model of academic literacy which has three different dimensions: linguistic, cognitive and socio-cultural/psychological (Scarcella 2003:10). The linguistic and cognitive dimensions of this model, specifically discourse competence (i.e. the ability to produce unified written or spoken discourse that shows coherence and cohesion and which conforms to the genre of a scientific or academic essay) take precedence in this study. To borrow from Butler (2011:12), academic literacy in this study also refers to a student's ability to 'integrate knowledge of language conventions in the production of their academic texts', in this case, the research report.

■ Discourse, discourses and discourse community

Whilst this study subscribes to Mgqwashu's and Bengesai's view of academic literacy as 'discursively constructed', it also has strong leanings on the notions of discourse/s as explicated by Richards, Platt and Platt (1992), Gee (2001, 2008, 2012) and Fairclough (1989).

‘Discourse’ is a ‘general term for examples of language ... larger units of language such as paragraphs, conversations and interviews’ (Richards, Platt & Platt 1992:111), and to Fairclough ‘discourse refers to the whole process of social interaction of which a text is just a part’. A text is viewed as a ‘product of the process of text production’ (Fairclough 1989:24). To Gee (2008:9, 2012:173) ‘literacy’ ‘is the mastery of or fluent control over a secondary Discourse ... [*and*] must be couched in terms of the notion of Discourse.’

Discourses and discourse

First a look at Gee’s notion of ‘Discourses, discourses, primary and secondary discourses’ in the context of this study. Gee (2008) explains the notion of Discourse with a capital ‘D’ and discourse with a little ‘d’ in the following manner:

‘Discourse’ is *saying-doing-being-valuing-believing* combinations, whereas ‘discourse’ means connected stretches of language that make sense. So ‘discourse’ is part of ‘Discourse’. Discourses are ways of being in the world; they are forms of life, which integrate words, acts, values, beliefs, attitudes, and social identities ... discourses are ways of ... reading and writing ... accepted as instantiations of particular identities (or ‘types of people’) by specific groups whether families of a certain sort, lawyers of a certain sort, bikers of a certain sort, business people of a certain sort ... they are socially situated identities ... They are thus, always and everywhere social and products of social histories. (p. 7)

As Discourses ‘always involve language’ (Gee 2001:719) and ‘language makes no sense outside of Discourses’ (Gee 2008:3), it follows naturally that language (social language) is an inextricable part of academic discourse. In the case of postgraduate research and academic writing, English is the language of instruction and communication generally used at academic institutions in SA. As such, proficiency in this language – but more

importantly in its academic use – is an advantage. It could be seen as the ‘gateway’ to academia. The BEd Hons research report is a product of the research process which at Honours level could be regarded as ‘primary’ initiation or socialisation into the discourse community of academia or the academic discourse community. *Primary* here is used in the sense of *initial* or *first* in a slightly different way than in Gee’s (2001, 2008, 2012) sense of ‘primary discourse’.

However, as Gee (2001:719) suggests, ‘social languages are acquired by socialization’. Gee maintains that when people learn new social languages and genres – at the level of being able to produce them and not just consume them – they are being socialised into what [he] calls ‘Discourse’ with a big ‘D’. So, ‘discourse’ with a little ‘d’ just ‘means language in use, or connected stretches of language that make sense’, whereas Discourses with a big ‘D’ means more than connected stretches of language: Discourses ‘are a way of being in the world ... they are forms of life which integrate words, acts, values, beliefs, attitudes and social identities’.

Discourse communities

People have more than one discourse. Consequently, they participate in various discourse communities. Swales (1990) characterises a discourse community as:

[H]aving a broadly agreed set of common public goals, mechanisms of intercommunication amongst its members, using its participatory mechanisms to provide information and feedback, utilizing and hence possessing one or more genres in the communicative furtherance of its aims, having acquired a specific lexis and having a threshold level of members with a suitable degree of relevant content and discursual expertise. (p. 25–27)

Academia is one example of a discourse community, membership of which is determined by specific ‘discursual expertise’, which many students in their first year [and postgraduate levels] find difficult to acquire.

The ‘complex discourses of academia’ are not always accessible to some students (Paxton 2007:9). This is particularly the case for students who, in Paxton’s (2007:47) view, ‘may not have been exposed to middle class literacy practices at home and at school’ and consequently find themselves in a state of ‘interim literacies’. Paxton coined this term in her study of first-year students to refer to the literacies between school and university, which she maintains ‘reflect a transition process from school and home to academic literacy’ (Paxton 2001:46).

This brings us to Gee’s notion of primary and secondary Discourses and how one’s primary Discourse affects one’s acquisition of a secondary discourse. Gee (2008:7, 2012:153) maintains that our primary Discourse is the one we acquire ‘early in life, in the home and peer group ... through our primary socialisation’. We do not acquire this Discourse through explicit instruction but by being a member of a ‘primary socializing group’ such as a family or clan. This primary Discourse then becomes the ‘foundation’ for other Discourses acquired later in life outside our home or community, in institutions such as the school, church, and universities.

Each of the Discourses acquired at the institutions has its own conventions that must be mastered to a level of fluency which allows access to the institutions (or membership of the discourse community). There may be ‘tension and conflict’ between the primary and secondary Discourses where aspects of one discourse are transferred to the other, according to Gee (2008:9). In the course of doing their research and writing their research reports, additional language users’ primary Discourses are more likely to be ‘dominant’, thereby causing tensions and conflict between the two Discourses. This is often the case when evidence of ‘everyday’ discourses is found in texts intended to be constructed in a secondary Discourse. Failure to function fully in the secondary Discourse

(academic discourse in this case) may result in students reverting to their primary Discourse to compensate for gaps in their written communicative ability.

In the context of this study then, to be academically literate might imply having ‘mastery of a secondary discourse’, i.e. that of academia. Having mastery of this secondary Discourse may facilitate access to ‘membership’ of the academic discourse community. In Rugg’s and Petre’s (2004:114) opinion, ‘general academic language signals membership of the general academic community’ and concomitantly of the academic discourse community.

The notions of Discourse, discourses and discourse community are pertinent in this study, in that generally BEd Hons additional-language users operate at the level of ‘discourses’ as defined in Gee (2008, 2012). Their primary Discourses more often than not conflict with their secondary Discourses and create tension between the two (or more) Discourses. This tension becomes evident in their construction of texts – particularly the scientific research report.

The research project for BEd Hons students is normally their first real immersion into the world of extensive reading, research and writing, coupled with ‘field’ experience. As mentioned earlier, students are expected to prepare a proposal, conduct research and write a scientific research report. For this they require more than just basic reading and writing competency or fluency in conversational English. Postgraduate study, unlike secondary school or undergraduate study, requires advanced academic literacy skills beyond the level of the sentence (Weideman in Butler 2009:294). Students need to operate at a more advanced level than what Gee terms ‘stretches of language that make sense’ (2008:7).

■ Empirical investigation

An exposition of the research method that was applied in the study follows in the next section.

■ Research approach

The case study approach was used in this study as the study's aim was to seek an in-depth understanding of the phenomenon of academic writing and research challenges of a specific group, not for generalisation but for the possibility of building theory about the nature of mature additional-language users' academic writing challenges.

■ Ethical considerations

The students' documents used for this research were obtained with permission from the examinations officer in charge of storing examined students' projects. They were retrieved prior to storing, and only the researcher had access to information in the documents, which were kept safely until the purpose for which they had been requested was achieved. All the documents were later returned to the examinations office for storage. No identifying information was used in the reporting of results.

■ Methods

The 2013 cohort of BEd Hons students was selected for study because it was one of the largest cohorts of students registered for the research project (RSPR 671) in the School of Educational Leadership Development that year since the introduction of the new research methods module – Foundations of Educational Research (FOER 611) in 2012. As a teacher in one of the modules in the programme, I had contact with more than half

of this cohort in my Education Management class, namely, Educational Management and Organisations (EMLO 611). I therefore had first-hand experience of their academic writing challenges in the EMLO 611 assignments.

I knew all the students by name and sight through the various contact sessions I had with them. Therefore, establishing their maturity and language status was not a problem, and neither was identifying the projects that belonged to them. In addition, the registration lists of the RSPR 671 and FOER 611 groups facilitated identification of relevant research reports and provided information on gender and marital status. The surnames of listed students gave an indication of their race. Projects of students from Botswana were not included, as these students did not fit the profile of additional-language users as it is understood in the South African context, nor were their projects based on research carried out in South African schools.

The research reports were obtained after permission had been granted by the examinations office of the university to retrieve the documents from a pile which had been stored temporarily in one office for later permanent storage. These documents were duplicates of the ones which had been sent out for examination. A total of 29 documents were retrieved.

The use of completed research reports rather than drafts of student reports would provide better insight into 'fossilised' academic writing problems of BEd Hons mature students. 'Fossilisation' in second language acquisition occurs when the learner stops learning and is 'trapped' permanently between the primary language and the target language – short of reaching target language competency. Richards, Platt and Platt (1992:145) define fossilisation (in second or foreign language learning) as 'a process which sometimes occurs in which incorrect linguistic features

become a permanent part of the way a person speaks or writes a language'. Similarly, fossilisation may occur in the acquisition of academic discourse. Using completed research reports would also indicate that whatever problems are identified would have 'survived' the entire supervision process as well as editing assistance, if that was used. Students are notorious for ignoring mistakes even after repeated calls to attend to them. That is why mistakes in documents tend to persist until they are submitted for examination.

Data collection

Document analysis was used for collection of written data based on unpublished projects of BEd Hons students. These were selected because they were deemed suitable sources to shed light on the phenomenon of academic writing challenges in the written research reports of mature additional-language users of English. Textual data were collected from research reports of the 2013 cohort of BEd Hons students. Yin (2009:101–102) details six sources of evidence in case study research, amongst which is documentation. This method has its strengths and weaknesses, and one of the strengths is that documents are stable and can be reviewed repeatedly, and one weakness is that it may be difficult to retrieve them (Yin 2009:102). However, in this case it was easy to retrieve the research reports as only the 2013 reports of the entire university campus were in temporary storage, thus it took only a few hours to locate the ones which were required for the study.

Merriam (2009:151) advises that documents should be checked for authenticity and that the value of a data source should be judged according to whether it 'contains information or insights relevant to the research question' (Merriam 2009:153). In this case the authenticity of the research

reports was checked against the list of 2013 registered students and against the information provided on the cover page of each document, which had the name of the student, the programme, the year and the supervisor's name. All the students and supervisors were known to the researcher and that facilitated retrieval of the relevant documents from the piles in temporary storage. The research projects which were the data sources for the study were judged to be relevant sources for information and insights into academic writing challenges of BEd Hons students.

Data analysis

Textual analysis of written data in the students' research reports was done in line with the qualitative interpretivist tradition, where emphasis was on interpreting the meaning of the documents (Strydom & Delport 2011:381). The unit of analysis was academic writing challenges as displayed in the writing of the research reports. The Autumn and Spring 2014 graduation reports were used to verify whether the students had graduated.

The procedure for data analysis followed a system of first scanning each document to see if all the stages in the research process had been addressed. Studies which had problems related to the research process were not included in the analysis of the academic writing stage. Those were studies which lacked coherence between problem, objectives and method of investigation, had evidence of plagiarism, presented findings on only one of the research questions posed, had no data but had findings and recommendations, had no alignment between topic and actual study, no data on any questions posed, but data on a different topic instead. In the end, 15 out of 29 documents were useable, as these were equivalent with regard to coverage of all the steps in the research process.

The 15 usable documents were then carefully analysed for any instance of academic writing difficulty. Skimming and scanning were used to check each chapter of the document for obvious mistakes. Then a close reading was done of the literature review chapter, which often contains the richest data on various aspects of academic writing. Each identified instantiation was recorded by hand in a separate notebook and initially coded according to type, such as: grammar, citation, referencing, coherence, sentence and paragraph structure, argumentation, plagiarism, inconsistency, vocabulary, et cetera.

After all the documents had been analysed, several pages of instantiations of various academic writing difficulties were generated and further coding was done to refine the initial codes and describe them in more detail. If a segment of text was initially coded grammar, for instance, a more accurate code was later assigned to describe the precise type of grammatical point. Following this, similar codes were clustered together with typical examples of each. This generated a pattern of common academic writing challenges occurring in the writing of the research reports, with the literature review chapters providing rich data.

■ Findings and discussion

The findings in this study seem to point to a pervasive academic literacy problem, which is experienced by some students throughout their academic career. It is not only first-year students but also postgraduate students who experience difficulties with different aspects and levels of academic literacy. As pointed out by Scholtz (2012):

[T]he challenge for many students is not only about acquiring and developing the academic discourse of the discipline, but having to engage and be proficient in an additional language to their first language . . . (p. 47)

Several academic writing challenges were evident in the research reports of the completed BEd Hons research projects. The most prevalent of the challenges in ‘communicating the substance of the research’ (Kruger & Bevan-Dye, in Zulu 2014a:216) related to the writing of the research reports and the process of conducting research.

■ Challenges related to the writing of the research reports

First a summary of the challenges related to writing the research report is given, followed by relevant examples to illustrate typical cases. Then challenges related to the research process and typical examples are given.

The findings revealed many of the academic writing challenges already mentioned by researchers such as Claudius (2016:72), Keong and Mussa (2015:27), Rambiritch (2015:33), Thesen (2013:109), Du Plessis (2012:133), Imani and Habil (2012:460) and Butler (2011:13). The main ones are outlined in Table 6.

TABLE 6: Examples of grammatical inaccuracy.

Challenges related to writing	Examples
No subject-verb agreement	What meaning do educators attaches to the word discipline? Responding to this view one of the participant stated ... It is the researcher’s responsibility to inform and ensure that the identity of all involved individuals remain confidential.
Wrong tense	There is no well define method of managing learner discipline. The school will be use as case study ...
Misrepresenting author’s words	Heystek et al. [2008] indicated that people do not feel in control of their environments because the locust of control is external [<i>extract from a student’s writing</i>]
Misuse of the apostrophe	Learner’s behaviour has caused a lot of misery amongst teachers [<i>intended word is learners, so the apostrophe should be after ‘s</i>]
Inaccurate vocabulary	Learner indiscipline has been sighted as a major contributor to increased stress levels of teachers.

There were also various citation and referencing challenges, chief of which was inability to cite secondary sources appropriately. A common problem amongst students at BEd Hons level is copying sentences as they are in the source text together with the secondary source, instead of indicating that X (in Y year Z:00) argues that ... et cetera.

The difficulty then arises when the student is asked to produce evidence of having read source X. That usually does not happen, because source X which was quoted by author Y was never in the student's possession to begin with. Many students express surprise when it is pointed out to them that it is the source they actually read that should be acknowledged. In addition, students' writing was characterised by weakness in the use of discourse connectors or 'devices that connect sentences together to make a whole integrated text' (Gee 2001:719). Coupled with that was a notable lack of good use of discourse markers or 'linguistic features that characterize larger stretches of text and give them unity and coherence' (Gee 2001:718).

Challenges related to the research process

Title incompatible with actual study

One of the main writing challenges in relation to the research process was the occurrence of study titles which were incompatible either with the actual study, or with parts of the study such as the stated questions (Box 1).

Problems related to understanding methodology

The following excerpts exemplify misunderstanding of sampling methods associated with qualitative and quantitative approaches, which indicates weak control of research methods:

[A] strictly qualitative method of data collection and analysis was applied in which participants were randomly selected based on availability. For the purpose of this

BOX 1: The examples (stated questions) are taken verbatim from the documents.

Example 1:

What are the roles of SGB in maintaining school discipline?

Sub-questions: What are the kinds of learner misconduct problems of ...?

What are the causes of learner indiscipline?

What factors impede the implementation of disciplinary measures?

None of the questions posed was related to the SGB at all.

Example 2:

Topic: *The relationship between discipline and learner performance*

However, the actual study focused on *causes, forms and strategies of learner discipline*.

Example 3:

Topic: *The degree of ill-discipline in Grade 10 learners*

The actual study dealt with *causes, forms and strategies of learner discipline*.

study a simple random sampling was used to select members of the SGB. These participants were purposefully selected because of some defining characteristics that make them holders of the required ... (n.p.)

In the methods section a *structured interview* is stated as the data collection method, but the actual instrument used is an *open-ended set of questions*.

Some students experience problems with grasping the research jargon and applying it appropriately, perhaps because of the limited time that is given to the research methods module (one semester), and the enormous amount of information students have to grasp in this short time and apply in the execution of the research project. Moreover, it is common practice for mature students to take a break between taught modules and the project, with many postponing it until they have forgotten what they had learnt in the research methods module.

□ Gaps in data presentation

In some instances omissions occurred where empirical data were only gathered to answer one of a number of questions. In some cases there was no engagement with data – they were presented and not discussed or interpreted, but recommendations were made nonetheless.

In one particular instance there was no discussion of data collection instruments and data collection, but findings and recommendations were presented. This was a clear example of a study which had no empirical part, either because the student lacked the skills to conduct empirical research or something major happened for the student to omit such an important part of the study.

Perhaps it would be unfair at the BEd Hons level to expect mature students who have been out of touch with academia for a while to be easily re-aculturated without prior or ongoing assistance. It would also be unrealistic to expect these adults who study part-time, and may have completed their research methods modules/courses several years previously, to fully understand the research process and associated academic discourse within one year.

A number of studies had a mismatch between the title and the actual study. As mentioned earlier, these documents were not used for analysis of academic writing problems, but for information on students' problems with the research process. Their inclusion in the findings is deemed relevant as they provide insight into the seriousness of some students' level of understanding of research, and concomitantly the level and nature of academic discourse training required to enhance students' research and writing skills.

■ Recommendations

In view of the findings of this study, the following recommendations are made:

- Discipline-specific support and training in collaboration with writing specialists should be considered. Discipline experts require the assistance of (academic) writing specialists to be able to correctly identify students' academic writing difficulties.
- A postgraduate academic writing module should be developed to assist postgraduate students with their academic writing problems and, as far as possible, students should be encouraged to form 'writing communities' or have what is commonly referred to as 'writing buddies'.
- Academic writing workshops which focus on specific areas of difficulty, such as citation and referencing skills, should be conducted at least twice a year. Discipline lecturers should attend these workshops in order to reinforce what is learned there in their teaching and assessment of student writing.

Students should be encouraged to attend workshops and seminars on research skills organised by the university and the faculty.

■ Conclusion

This chapter has reported on the academic writing and research challenges of a mature cohort of postgraduate students writing their research reports in a BEd Hons programme. Academic discourse is difficult for students whose mother tongue is not English, especially those who have been out of academia for a number of years. As revealed by this study, their writing and research displayed several challenges, which could be a consequence of weak control over academic writing and research skills. The main academic

writing challenges identified included citation and referencing, coherence and cohesion, grammar and vocabulary. Challenges in research skills included defining the problem and writing problem questions, understanding research methods and interpreting findings.

Mature postgraduate students should have regular exposure to academic writing and research skills workshops in order to close the knowledge gap and to appropriately introduce them to the academic discourse community.

■ Chapter 3: Summary

Academic writing in postgraduate study is a difficult terrain to navigate for the majority of students, particularly for additional language users who are mature students. This study reports on the research and writing challenges encountered by a cohort of Bachelor of Education Honours students in writing their research reports. A case study approach was adopted utilising textual analysis of the 2013 completed research reports. The results show that students encounter a variety of difficulties related not only to the process of conducting research, but also to using appropriate academic discourse in writing the research report. The main academic writing challenges include citation and referencing, coherence and cohesion, grammar and vocabulary. Research skills challenges include defining the problem and writing problem questions, understanding research methods, and interpreting findings.

It is recommended that mature postgraduate students be given appropriate discipline-specific training and guidance in academic discourse, research skills and critical engagement with texts.

Evaluation of professional development of a student peer tutor programme: Lessons learnt

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■ Introduction

Large and growing numbers of students, reduced resources, open access and the admission of students who are underprepared are some of the challenges that institutions of higher learning globally and in South Africa face (Harding, Engelbrecht & Verwey 2011). Supplemental instruction (SI) is an academic support programme that may be a solution to some of these problems (Alpay *et al.* 2009; Xu *et al.* 2001).

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The Mafikeng Campus of North-West University implemented SI as tutor programme in 2007. The programme grew and currently has more than 200 SI facilitators running sessions in five faculties. Initial training and ongoing professional development sessions were conducted for the SI facilitators, who completed a feedback form at the end of each session, rating their experience of the training. However, no comprehensive evaluation of the professional development initiatives has been conducted since the introduction of the programme (Cronje, Materechera & Mokoena 2014).

Successful peer tutor programmes such as SI are dependent on extensive training and professional development of the facilitators (De Smet *et al.* 2010; Hurley, Jacobs & Gilberts 2006). A common reason for failure of SI programmes is the lack of proper training, supervision and professional development of the facilitators (Lipskey 2006). Evaluation of professional development programmes (PDPs) is crucial in order to determine their effectiveness. Ways to evaluate PDPs are limited to programmes offered to teachers or trainers. The researchers are unaware of any evaluation models for professional development strategies for the SI programme or peer tutors. Guskey's model of evaluating professional development seemed to be suitable for the purpose. This study reports on how Guskey's model was applied to determine the effectiveness of professional development initiatives for SI facilitators on the Mafikeng Campus. Findings indicate that Guskey's model can be successfully applied to determine the benefits of training activities of SI facilitators and can be broadly applied for other peer tutor programmes.

■ Theoretical framework

The two theoretical frameworks that guided this study were the principles that underlie the SI programme and Guskey's model to evaluate professional development.

■ The SI programme

Historically peer tutoring dates back to the ancient Greeks, and it has evolved over time. Although changes affect the definition, the concept of learning and imparting knowledge still stands. Thus the changes have not affected the principles of the initial intentions of the programme; it still carries the concept of transmitting knowledge from one person to another (Topping 1996). Peer tutoring has developed through the ages, and a more applicable definition for our age is: ‘people from similar social groupings who are not professional teachers helping each other to learn and learning themselves by teaching’ (Topping 1996:2). This definition shifts the focus from the mere transfer of knowledge to the collaborative nature of peer tutoring and is therefore better understood through social constructivism. SI is the ‘brand name’ for a collaborative peer tutor programme that was developed in 1973 at the University of Missouri-Kansas City (Drake & Foresman 2012). SI has spread globally and is now used at more than 1500 higher education institutions in 29 countries (Martin 2008; Power 2010).

The SI programme is used as an academic support programme that offers regular scheduled, out-of-class sessions to students in a specific module. The sessions are facilitated by a senior student (the SI facilitators) and attendance of the sessions is voluntary. The SI facilitators not only review the content material with the students using collaborative learning strategies, but also guide students in applying appropriate study strategies (Hurley *et al.* 2006). As such, these SI facilitators (tutors) acquire skills they otherwise would have not gained.

Whilst the main goals of the SI programme are to improve student learning, lower attrition rates of difficult or ‘high-risk’ courses, improve student grades and increase graduation rates (Hurley *et al.* 2006; Jacobs, Hurley & Unite 2008), SI also yields other benefits to both the SI facilitators

and the students attending the SI sessions. One of the main benefits is that of professional development of the SI facilitators. Other benefits include the provision of collaborative experiences that enhance students' openness to diversity, which is believed to play a role in students' achievements. The learner-centredness, it is suggested, not only emphasises content knowledge but also teaches students to take responsibility for their own learning.

Through interactions during SI sessions, the following are some of the achievements attained (Longfellow *et al.* 2008; Ning & Dowing 2010):

- Acquiring coping skills.
- Sense of ownership over the learning process.
- Positive effect on learning competence and academic performance.
- Reduced feeling of intimidation in acquisition of study skills.
- Collaborative learning practices.
- Acquisition of time management.
- Acquisition of exam preparation.
- Leadership, facilitation, communication and organisation skills.

Drawing from the benefits gained, the SI programme contributes to the agreement made by university communities on attributes which their students should develop before they graduate. These attributes include, amongst others, disciplinary expertise or technical knowledge that prepares students as agents of social change in an unknown future. Thus, the knowledge, skills and abilities acquired beyond discipline content knowledge are applicable in a range of contexts. These should be acquired as a result of completing any undergraduate degree (Barrie 2006).

The SI facilitators play a vital role, then, in the programme and have to assume responsibility for planning the sessions, collaborating with the module lecturer, and marketing and running the SI sessions. Such partnership

with the module lecturers and sessions where student-to-student teaching and learning occurs provides a learning atmosphere free of intimidation.

Whilst SI plays such a vital role, it is crucial to guard against any failures. In order to alleviate some of the failures of the SI programme, if any, and for SI facilitators to be effective, comprehensive training and ongoing professional development need to be in place (Lipskey 2006).

PDP for SI facilitators

Training and supervision of the SI facilitators is coordinated by the SI coordinator. The PDP consists of an initial 2-day training, followed by additional 2- or 3-hour workshops during the semester. The initial training is offered in a student-centred manner and includes collaborative learning strategies and role-play. The initial training focuses on the following:

- An overview of the SI programme.
- SI guidelines and basic principles.
- Relationships between the SI facilitator, the student and the lecturer.
- Planning for SI sessions.
- SI session strategies that include, (1) questioning techniques, (2) visual techniques, (3) collaborative practices, (4) engagement techniques, (5) problem-solving, (6) learning strategies and (7) optimising self-efficacy beliefs.
- Information on how to execute administrative roles in the SI programme.

The additional workshops are conducted to enhance the SI facilitators' competencies, are offered every two weeks and include topics such as:

- time management
- study skills

- exam writing strategies
- activities to use in SI sessions
- educational games.

The assumption is that attending the training equips SI facilitators with the preparedness and confidence to run effective SI sessions (Lipskey 2006). The question that arises is are they effectively equipped after training? Although literature accepts the need for proper professional development of SI facilitators, the evaluation of the PDPs for the SI facilitators is not addressed. When evaluating the success of the SI programme, mention is made of the benefits of the programme, the increase in student marks and pass or throughput rates (Harding *et al.* 2011; Malm, Bryngfors & Mörner 2011). However, no mention is made of a model or system to evaluate the PDP or a conceptual framework to guide such an evaluation.

Evaluating professional development

Over the years the evaluation of professional development went through many challenges. Owing to several intervening variables it was pointed out that it was impossible to link professional development with student achievement because of the weaknesses in evaluation initiatives (Killion 2002). It also emerged in some studies that in order to evaluate the impact of professional development on student learning, it is important to use a strong professional design approach that can continuously promote deep changes.

Quality professional development is a key component in improving education. Hence, PDPs are regarded as ‘systematic efforts to bring about change in classroom practices of teachers, in their attitudes and beliefs and in the learning outcomes of students’ (Guskey 2002a:381). Although many PDPs differ a great deal in ‘content and format’, they aim at ‘changing the professional practices, beliefs and understanding of student learning’

(Guskey 2002a). Thus, professional development should not be viewed in isolation but as nested within a larger system. This also supports the notion that professional development is more effective when approached not in isolation but as a coherent part of a reform effort in an organisation.

Furthermore, it was argued that professional development theories need to include both cognitive and social aspects of learning (Borko 2004). Cognitive perspectives have centred on notions of changes in teachers' beliefs or knowledge. On the other hand, social perspectives have considered professional learning through participation (Lave & Wenger 1991). Social learning theory (SLT) (Bandura 1977) provides a theoretical approach that integrates cognitive aspects and social effects in learning. The use of SLT can be explored by interpreting the effects of a PDP that was designed to support teachers in using student-centred problem-solving (SCPS) approaches in their teaching. Thus, student collaboration and discussion characterise the SCPS approach to teaching and are used in the process of solving open-ended tasks and activities (Watson 2013).

In the past not much attention was paid to the evaluation of professional development of peer tutors, but it became necessary to address this gap looking at return on investment. In addition, technological changes and the shift towards promotion of students' critical thinking and problem-solving necessitated changes in professional development that facilitates students' learning (Fullan 2003). Although there was recognition of the importance of evaluating professional development, a systematic approach was not used in evaluating many PDPs (Soebari & Aldridge 2015).

This study used Guskey's five-level model for evaluating professional development in an attempt to assess the effectiveness of a student peer tutor programme in improving student performance. The assumption is that the same principles that are followed in the professional development

of teachers are applicable in the professional development of student peer tutors. Guskey's model was adapted and adjusted from a model developed by Kirkpatrick in 1959 and addresses both what is happening and why it is happening (Guskey 2000). Although Guskey's model was developed for teachers, it is comprehensive and can easily be adapted to evaluate the PDP in a peer tutor programme such as the SI programme.

Three main types of evaluation were identified in the model, namely: planning evaluation, formative evaluation and summative evaluation (Guskey 2000, 2002b). These also involve data collection and analysis. Planning evaluation is done before a PDP starts and includes the aims to be met, procedures to be followed and how success will be determined. Planning evaluation forms the basis for the other two types of evaluation. Formative evaluation occurs during the actual running of the PDP or activity and provides ongoing information on progress and problems that may occur. Information gathered during formative evaluation is used as early warning signals to make the necessary adjustments. Summative evaluation is conducted once the PDP or part of it is completed. The aim of summative evaluation is to decide on the overall effectiveness or worth of the programme. Many PDP evaluation models focus on this last type of evaluation only (Guskey 2002b).

Guskey incorporated the three types of evaluation into five critical steps, or levels, at which the data need to be collected. Each level builds on the previous levels and good results on one level are a prerequisite for success at the higher levels. The higher the level, the more complicated the data collection (Guskey 2002b). Each level of data collection is characterised by a question to be addressed and suggests data collection instruments for that level, what is evaluated and how the data collected can be used. The different levels presented in Table 7 and discussed below are in accordance with Guskey's (2000, 2002b) evaluation model.

TABLE 7: Guskey's five levels of professional development evaluation.

No. Evaluation level	Typical questions addressed	Information-gathering methods	What is measured or assessed?	How will Information be used?
1	Participants' reactions - Did they like it? - Was time well spent? - Did the material make sense? - Will it be useful? - Was the presenter knowledgeable? - Did physical conditions support learning?	- Questionnaires administered at end of session - Focus group interviews	Initial satisfaction with the experience	- To improve programme design
2	Participants' learning - Did the participants acquire the intended knowledge and skills?	- Paper and pencil tests - Simulations & demonstrations - Participant reflections - Portfolios	New knowledge & skills of participants	- To improve programme content, format & organisation
3	Organisation support and change - What was the impact on the organisation? - Did it affect the organisation's climate or procedures? - Was implementation advocated, facilitated & supported?	- Records - Minutes from meetings - Questionnaires	Organisation's advocacy, support, accommodation, facilitation & recognition Degree & quality of implementation	- To document & improve organisational support - To inform future change efforts - To document & improve implementation of programme content
4	Participants' use of new knowledge or skills - Did participants effectively apply the new knowledge & skills?	- Questionnaires - Structured interviews with participants & their supervisors - Participant reflections & portfolios - Direct observations		

Table 7 continues on the next page →

TABLE 7 (Continues...): Guskey's five levels of professional development evaluation.

No. Evaluation level	Typical questions addressed	Information-gathering methods	What is measured or assessed?	How will Information be used?
5	<ul style="list-style-type: none"> - What was the impact on students? - Did it affect student performance or achievement? - Did it influence students' physical/emotional well-being? - Are students more confident as learners? - Is attendance improving? - Are dropouts decreasing? 	<ul style="list-style-type: none"> - Records - Questionnaires - Structured interviews with students, parents, teachers & administrators - Participant portfolios 	<ul style="list-style-type: none"> - Student learning outcomes 	<ul style="list-style-type: none"> - To focus & improve all aspects of programme design, implementation & follow-up - To demonstrate the overall impact of professional development

Source: Guskey (2002b:46)

Level 1: What was the participants' reaction to the experience?

The first level of data collection is addressed directly after a professional development intervention, for example a workshop or training session. The focus is on whether or not the participants liked it and found it useful. This information can assist in improving future design and delivery of the programme. Favourable reactions to this experience are a prerequisite for the higher levels.

Level 2: Did the participants learn something?

Data collection on Level 2 is done to determine if participants had learned something and should measure the knowledge, skills and attitudes they acquired. It is important to take the learning goals or outcomes of the specific programme into consideration in this evaluation. The assessment and analysis of the data gathered on this level can be used to improve the content, format and organisation of the programme.

Level 3: Does the organisation support the programme and did the PDP bring about change in the organisation?

Even if the evaluations on Levels 1 and 2 deliver encouraging results, all knowledge and skills learnt can be in vain if there is a lack of organisational support and change. Data collection efforts at Level 3 focus on institutional support, attributes necessary for success and available resources. The results of evaluation at this level can be used to improve organisational support but also to inform future change initiatives.

Level 4: Can participants use and apply the new knowledge and skills?

Evaluation on this level seeks to determine if the new knowledge and skills that participants learned are applied in practice. Data collection in this respect cannot follow immediately after the professional development

activities, and time must pass before application of knowledge and skills are evaluated as implementation takes time. Different types of evaluation measures need to be conducted after different time intervals. The information collected can be used to restructure future programmes and activities for better implementation.

Level 5: Did the participants benefit?

Level five is where the final outcomes are evaluated. When evaluating if participants benefitted, cognitive and affective indicators as well as skills and behaviours need to be taken into account.

It is important to look for evidence and not proof when applying Guskey's model to evaluate a PDP. It is possible to collect good evidence, but it can be difficult to obtain proof as human behaviour is difficult to quantify (Guskey 2002b). When applying Guskey's model for evaluating professional development there are three important issues to consider:

- Each of the five levels is important. No level can be omitted as each one provides important data to improve the quality of a PDP.
- Experiencing success on one level does not mean that the others will be equally successful.
- Reversing the order of the levels can be used to plan your PDP. This application of the model is the most important (Guskey 2002b).

■ Research method

The study was guided by the following main research question: How effective is the professional development of the SI peer tutor programme offered at Mafikeng Campus?

The objectives were derived from the research question and informed by Guskey's model. The objectives to achieve the aim of this study specifically referred to each level of Guskey's model, and are as follows:

- To determine the initial satisfaction rate of the participants.
- To determine if the participants learnt something.
- To determine the organisational support and change as a result of the professional development.
- To determine if participants use and apply the new knowledge and skills.
- To determine if the participants and students benefitted.

A case study design was chosen as the strategy of inquiry to evaluate the effectiveness of the professional development process of the peer tutors. In order to conduct a comprehensive evaluation of the PDP we used a mixed-methods research design, applying both qualitative and quantitative data collection methods (Creswell 2009). Data were collected using a variety of instruments over a period for one semester. The participants in the study were purposefully selected and included students attending SI sessions at the Mafikeng Campus of North-West University, SI facilitators running the SI sessions and lecturers participating in the SI programme.

In order to address ethical issues, permission was obtained from the participants to share the collected data and was given on a voluntary basis. The participants were reminded that the information obtained during the study would be treated confidentially and that they would stay anonymous. As part of a study the Higher Degrees Committee in the Faculty of Education approved the collection of data from students and staff members.

The sample included 234 SI facilitators, 14 lecturers and 456 students involved in the SI programme at the Mafikeng Campus. The 456 students that

participated represent 10% of the total number of students that attended SI sessions. The student records used in the study were those of the total number of students that attended SI sessions. The sample of SI facilitators selected for evaluation of application of the skills and knowledge shared (Guskey Level 4) comprised a smaller sample of 37 SI leaders who were randomly selected, more or less 10% of the larger sample of 234 SI leaders.

A variety of data collection instruments, such as closed- and open-ended questionnaires, observations, document and student data analysis, were chosen to best answer the research questions posed at each level of Guskey's evaluation model. Data were collected from three groups of participants: the SI leaders, the students and the lecturers.

Data collection for Level 1 of Guskey (to determine initial satisfaction rate)

A questionnaire consisting of seven closed-ended questions with a yes or no answer was used to determine the initial satisfaction rate with the workshops offered to the SI facilitators. A pre-existing questionnaire used for all workshops offered at the Academic Development Centre (ADC) was used and included questions on achievement of the outcomes of the workshop, relevance of the content shared during the workshop, quality of the facilitation and the possibility to apply the knowledge gained. To ensure richer data and for triangulation purposes an open-ended question was asked on the general experience of the workshops.

Data collection for Level 2 of Guskey (to determine if the participants learnt something)

SI facilitators were expected to simulate the running of an SI session during the training. They were divided into groups, and each facilitator

was offered the opportunity to facilitate a 10-minute SI session with the group members. Observations of the simulations were documented. The second type of data collected for Level 2 were obtained from SI facilitators running sessions. The facilitators were expected to submit weekly planning forms for their sessions as well as monthly feedback reports. The planning forms indicated the content covered as well as the facilitation strategies used. The monthly reports covered narrative feedback on topics such as student attendance and attitude, collaboration with the lecturer, student experience, self-evaluation and challenges experienced. The data collected from the simulation observations as well as the planning forms and monthly reports were coded and funnelled into emerging themes.

Data collection for Level 3 of Guskey (to determine organisational support and change as a result of the professional development)

To determine if the type and quality of institutional support offered to the SI facilitators was sufficient to ensure effective implementation of the knowledge and skills learnt by the SI facilitators, both quantitative and qualitative data collection instruments were used. Quantitative data were collected by distributing a 5-point Likert scale consisting of 7 questions. The questions related to support offered by the ADC advisors, the lecturer, faculty and availability of venues. Qualitative data were collected by analysing minutes of meetings held with the SI facilitators as well as from the narrative monthly reports they submitted. The qualitative data were also used to determine if the professional development brought about change in the organisation.

Data collection for Level 4 of Guskey (to determine if participants use and apply the new knowledge and skills)

Quantitative data collection was conducted by distributing a 5-point Likert scale questionnaire to 37 of the SI facilitators. The questionnaire consisted of 6 items relating to teaching strategies used, hand-outs offered to students and use of the learning management system. Qualitative evidence of the application of skills was obtained by ADC advisors observing SI sessions of these SI facilitators and completing a structured observation form for each observation. The narrative information on the observation forms were coded into emerging themes.

Data collection for Level 5 of Guskey (to determine if the participants benefitted)

Level 5 is where the final outcomes are evaluated, and it is important to look for evidence rather than proof of benefits. When determining if the professional development did make a difference three important participants play a role and benefit from the outcomes of the PDP: the lecturer who offers the module, the SI facilitator running the sessions and the students attending the SI sessions. Data were collected from students who attended SI sessions to determine whether the outcomes of the SI programme were met. Was there improvement in their marks, did the throughput rate increase and did their study skills improve? We also wanted to determine if the students gained other skills or attitudes whilst attending the SI sessions.

Quantitative data were collected by analysing student records and attendance registers from all students who attended SI sessions. A Likert type of questionnaire with a 3-point scale ranging from disagree to agree and consisting of 10 items was distributed to 457 students. The questions focused

on skills that the students acquired. To determine the benefits to the organisation a similar questionnaire was distributed to lecturers. Only 14 of the 80 lecturers responded. The questionnaire consisted of five items including questions on the benefits for students attending SI sessions, the competence of the SI facilitators and if they would make use of the SI programme in future. Qualitative data on the benefits for SI facilitators were obtained through analysis of the monthly reports they had to submit. Two open-ended questions were posed where they had to reflect on their own experience and do self-evaluation. The answers to these two questions were coded into themes.

■ Results

The results are presented to correspond with Guskey's evaluation levels.

■ Level 1: Initial reaction of the SI facilitators after the professional development workshops

The results of the questionnaires distributed to the SI leaders at the end of the initial training and ongoing workshops are represented in Figure 1. The majority of the 227 SI leaders found the knowledge and skills taught useful: 99% indicated that the outcomes of the workshops were clearly outlined at the beginning of each session; 99.6% of the facilitators agreed that the facilitation was of a good standard; 99% indicated that they had the opportunity to actively participate during the workshops; 99% were confident that they would be able to apply the new knowledge and skills gained; 99% indicated that the time allocated to the workshop was sufficient; and 99% felt that their expectations were met. The qualitative feedback received on the workshops acquired from the open-ended questions revealed the major themes outlined below.

Application of knowledge and skills learnt

The SI facilitators indicated that they gained new knowledge and skills that they would be able to apply in their SI sessions: ‘I use the knowledge from these workshops and students enjoy them a lot’, ‘I will apply these strategies’ and ‘[t]he training made us feel ready for the sessions’.

Learnt innovative ideas to apply in the SI sessions

The workshops opened the eyes of the SI facilitators to new ideas that they could use in their SI sessions: ‘I learnt new ways of making SI sessions more interactive and interesting’ and ‘I enjoyed the games a lot and will try them with my participants’.

Challenged them to think creatively

The workshops also challenged the SI facilitators to think more creatively: ‘She gave me new ideas to think about’ and ‘[i]t inspires met to have more interesting SI sessions’.

Request for more workshops

There were requests from SI facilitators for more workshops: ‘Can we have more of these workshops?’ and ‘[t]he workshops really works, can we have more?’.

■ Level 2: Could the facilitators describe and/or act on what they have learned?

The simulation SI sessions held during the training indicated that most SI leaders could apply the facilitation strategies, collaborative activities and questioning techniques that they were taught. Some still resorted to

‘chalk and talk’ strategies, but after reflection sessions realised this and explained how they would improve on it. The planning forms completed by the SI facilitators before conducting the sessions indicated the outcomes to be obtained and the content covered, but not all facilitators indicated specific strategies and activities to be used. It was difficult to make any deductions about what they learnt from them. The main themes that emerged from the analysis of the facilitator reports are outlined below.

The confidence of the SI facilitators increased due to the training

The SI facilitators reported a growth in their confidence when conducting sessions, ‘I have learnt to become very bold and to speak in public’.

Discussion sessions and collaborative learning was taking place

Feedback is positively marked by students’ advance preparation and their partaking in the discussions.

Students enjoyed the activities and received positive feedback from them

In their reports the SI facilitators indicated that the students enjoyed the sessions and rated them favourably in the evaluation instruments: ‘They enjoy my sessions’ and ‘[f]eedback from the students is positively marked and most importantly they have an increased pass rate’.

SI facilitators were able to handle a diverse student group

This campus caters for a diverse student group with regard to background, culture and learning styles. The SI facilitators explained that the training

did prepare them for coping with diversity: ‘I have worked with different types of people so I can survive in the work field’.

Student attendance was not always as high as required

Attendance of SI sessions is voluntary and therefore attendance is not always as high as expected. Some students did not attend owing to a heavy workload. However, they requested the facilitators to continue with the sessions as they would attend them when they could. The training included time-management skills and the SI facilitators did apply this in balancing their own studies and their facilitation role.

The facilitation strategies they were trained in were used

The facilitators reported that they did apply some of the facilitation strategies they were exposed to during the training workshops: ‘Each and every day is a learning path and I improve with the facilitation skills we learnt’.

SI facilitators and students learnt about time management

‘This has taught me how to manage my time well in order to accommodate students and my workload’.

Level 3: Institutional support offered and change

Analysis of the minutes of meetings held with SI leaders indicated the two main problems regarding institutional support were lack of sufficient venues to run SI sessions. Also, some lecturers did not support the SI leaders with textbooks, marketing SI sessions in classes or guidance on what content to cover and how to go about it. Analysis of the SI facilitator reports, however, indicated that the support received by the lecturers was good.

Most lecturers held regular meetings with the leaders, discussed the content with them, motivated them and marketed the SI sessions in class:

‘Lecturers are positive about SI’s and they also encourage students to attend; they are also available for module discussion and for clarity on complex topics.’

‘We usually meet with the lecturer once every week in preparation for the next topic, but you could meet with the lecturer at any time for clarity.’

A few of the reports did mention a few lecturers not supporting the facilitators or not meeting with them regularly: ‘We do not meet regularly, but I can go to the lecturer if I experience problems’.

Figure 1 explains the results of the questionnaires administered to the selected SI leaders on support received. The main issues seem to be a lack of venues to run SI sessions in, getting printing done and availability of academic material such as textbooks. Administrative support by the ADC as well as support by lecturers is rated sufficient by the majority of the SI leaders, but does need attention.

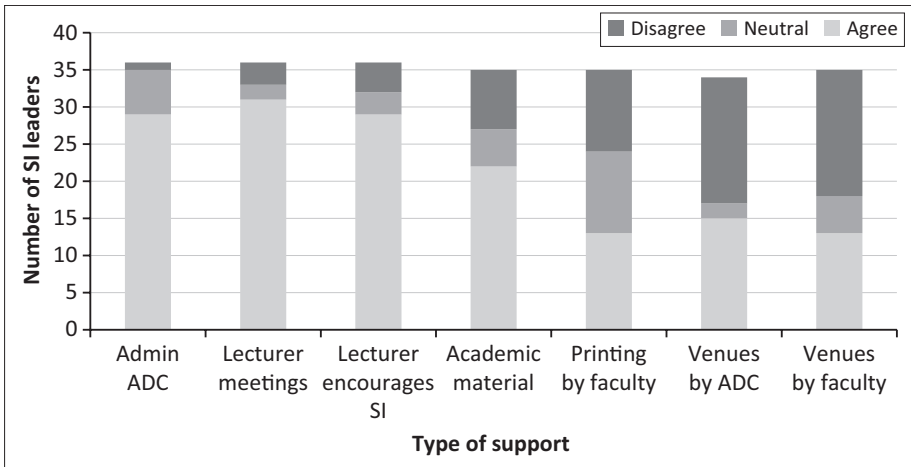


FIGURE 1: Results of questionnaires on institutional support.

■ Level 4: Were the SI facilitators applying the skills and knowledge?

Analysis of qualitative data (observations executed by mentors and SI coordinators) revealed evidence of certain skills and knowledge being applied, but not all of the aspects covered in the training sessions were used in the SI sessions observed.

The skills and knowledge that emerged as themes that were applied in the SI sessions were as follows:

- Good classroom management.
- Prior planning is evident in most sessions.
- SI leaders are confident and enthusiastic.
- SI facilitators were knowledgeable regarding the content.
- Good interaction between SI leader and students.
- Group discussions did take place in one large group.
- The majority of the SI leaders did apply redirecting of questions.

Issues that emerged as themes during observation of the SI sessions:

- Low level of interaction between students.
- Group strategies were rarely applied.
- SI leader dominates session in many sessions.
- Visual strategies, games and hand-outs were rarely used.
- The majority of the facilitator leaders did not incorporate study methods in their sessions.

The results for the questionnaires distributed to the 37 selected SI facilitators indicate that some of the facilitation strategies shared in the workshops are used. The percentages of the facilitators using the various strategies are depicted in Figure 2. The majority of the SI

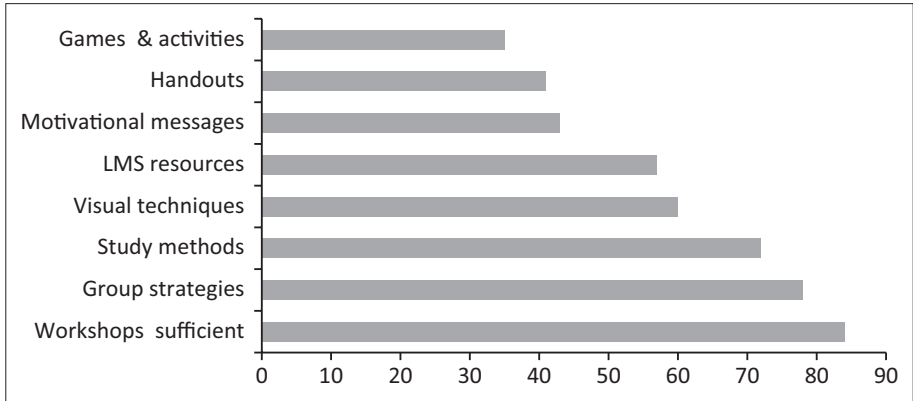


FIGURE 2: SI facilitators' responses on application of skills learnt in workshops.

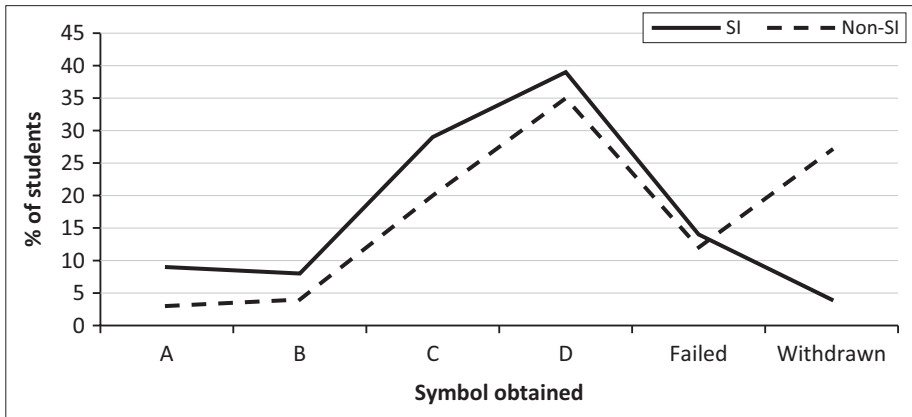
leaders indicated that they applied group strategies (such as think-pair-share, jigsaw, De Bono) and incorporated study methods in their SI sessions. They also felt that the workshops offered were sufficient to equip them for their job as SI leaders. Less than half of the SI leaders used educational games and other activities or prepared hand-outs for the students attending the sessions. The additional resources posted for the facilitators on the learning management system were used by more than half of the facilitators and the motivational messages by less than half.

■ **Level 5: Did the participants benefit?**

Two groups of participants could benefit from the professional development initiatives: the students attending the SI sessions and also the SI facilitators running the sessions.

Benefits for students attending the SI sessions

Guskey (2002b) explains that not only cognitive evidence should be evaluated, but also other indicators such as skills, behaviours and attitudes.



Source: North-West University institutional office.

FIGURE 3: Comparison of SI and non-SI participants' final results for 2011.

□ Student results

Analysis of student records for 2011 indicated that students attending SI sessions scored higher marks throughout. The results are demonstrated in Figure 3. The number of SI students that dropped out was much less for those who did not attend SI sessions, compared to those that did attend. The percentage of students obtaining symbols ranging from A to D was higher for those attending SI sessions compared to those who did not attend. The number of students who failed was higher for SI than non-SI students, but the difference is marginal.

Figure 4 presents the difference in six module averages between students who attended the SI sessions and those who did not attend. The average marks obtained by students attending SI sessions were all reasonably higher than those who did not attend, and ranged from 15% to 24% higher.

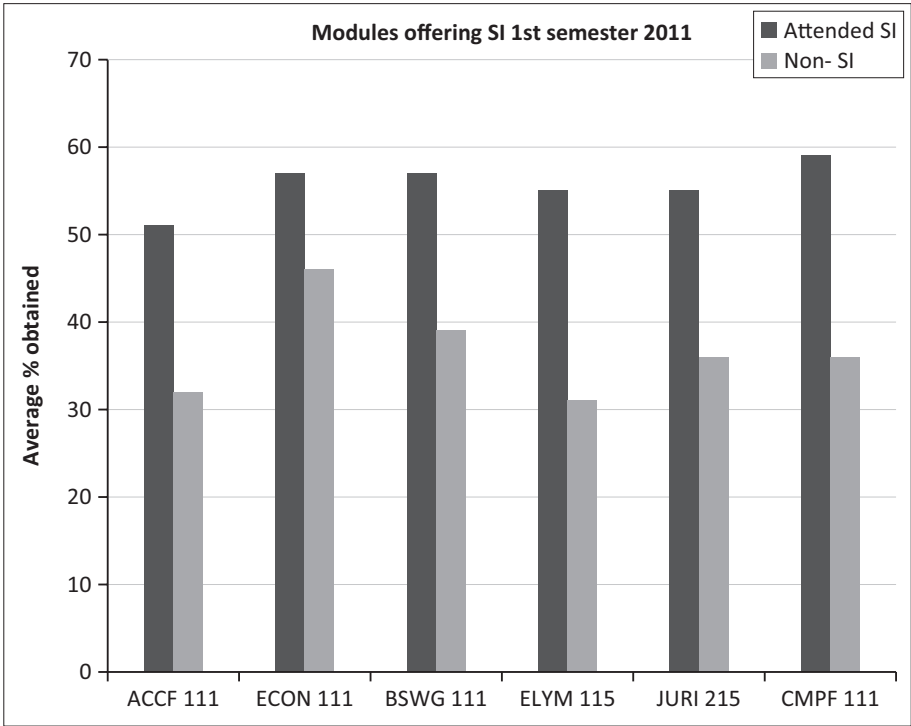


FIGURE 4: Difference in average of attending and non-attending students.

Other skills gained by students

A questionnaire was distributed to 84 lecturers using SI sessions to determine their view on the benefits of SI sessions for students. Only 14 of the 84 lecturers responded, and the following results were revealed: The majority of the lecturers (92%) indicated that the students attending SI sessions benefit academically, and 86% indicated that the pass rate of their students improved and that they would use the SI programme for their students again. Of the lecturers that responded 64% were of the opinion that the SI facilitators were competent in running the SI sessions, and 57% thought that the learning strategies used by the SI facilitators

were sufficient. The sample of lecturers that did respond was very small and this may have an influence on the results.

Questionnaires distributed to students to determine which skills they gained from the SI sessions delivered the results shown in Figure 5. The most important skills acquired by the students and indicated by a score higher than 90% were academic, exam writing, communication and critical thinking skills. The students also indicated that the SI sessions helped them to adjust to campus life. Other skills that were also rated highly (80%) were self-reflection, study and social skills. Students also indicated that their self-esteem improved.

■ Benefits for SI facilitators

Although the main purpose of the SI programme is to improve the throughput rates of students, the SI facilitators themselves also gained

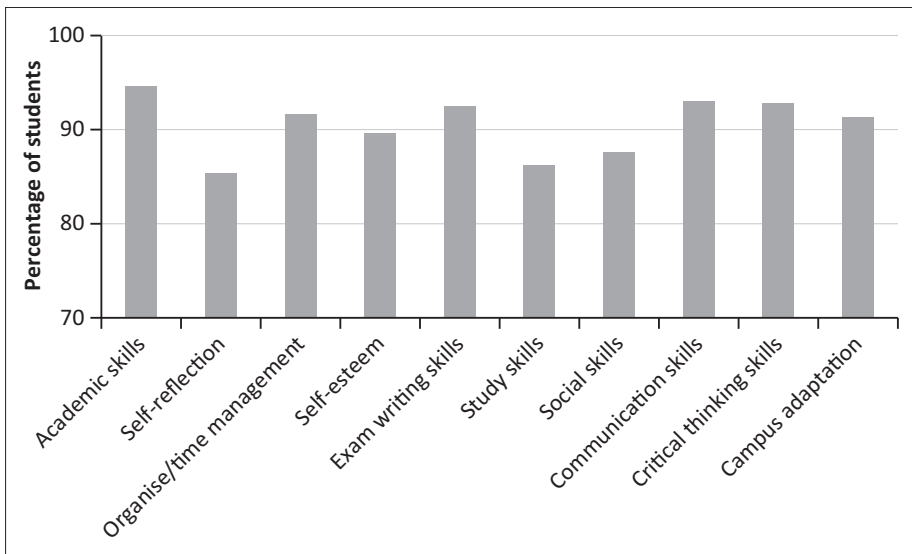


FIGURE 5: Skills gained by students attending SI sessions.

from the programme. Themes that emerged from their monthly reports where they had to reflect on their own experience were:

- Improved presentations skills: 'I have learnt to become very bold and speak in public. I could not explain to others before, but I can do it now'.
- Improved confidence: 'It improved my confidence to talk in front of a group of people'.
- Improved communication and interpersonal skills: 'As SI facilitator it is an exposure for me. Like interacting with different types of students and the problems encountered by the students'.
- Gained a better understanding of the course materials: 'I have also learnt so much. It has broadened my knowledge about the discipline in so many domains'.
- Improved leadership skills: 'This experience has been beneficial in that it equipped me with the vital skills of success such as leadership and presentation'.
- Learnt how to plan and apply time management skills: 'This has taught me how to manage my time well in order to accommodate students and my workload'.
- Improved their study skills: 'It improved my own study skills. I learnt new methods of memory and diagrams'.
- Improved English: 'It helped me to articulate better in English'.

Quantitative data were also collected from 37 SI facilitators using closed-ended questionnaires on what they gained from the SI sessions. The results are depicted in Figure 6 and indicate that more than 90% of the SI facilitators gained many academic skills and other soft skills.

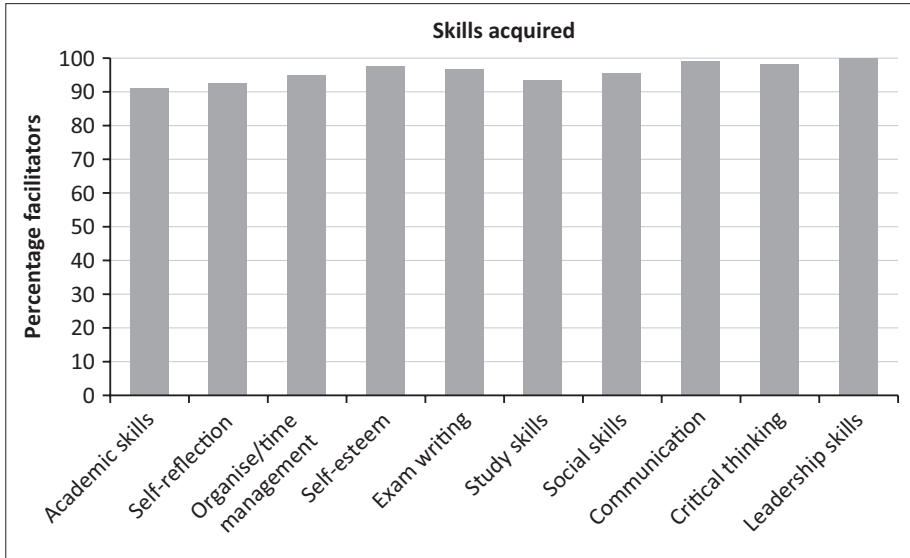


FIGURE 6: Skills gained by SI facilitators.

Discussion

The initial feedback of SI facilitators after attending the professional development workshops was very positive. The majority of the facilitators indicated that they were excited to apply the new knowledge and skills learnt. It was concluded that future workshops can be planned and executed in the same manner. The SI facilitators requested more workshops, and it was decided to offer additional workshops on cooperative learning and engaging activities, as this was a gap identified during the SI session observations. The satisfaction expressed by the participants ensures a foundation for possible success in the higher Guskey levels.

Guskey's Level 2 indicates the importance of determining if learning has taken place during the initial workshops. In order to assess if learning took place, the SI facilitators were required to present simulations of SI sessions. The results of the simulations were very promising, and the SI facilitators used collaborative strategies, activities and questioning techniques that they were exposed to during the simulation sessions. Engaging and cooperative learning strategies are an integral part of the success of the SI programme, and it is important that the SI facilitators master these and apply them in their SI sessions.

SI session planning forms indicated the outcomes to be achieved and the content covered, but did not provide specific space for teaching strategies – and unfortunately the SI facilitators did not indicate the strategies used. In future the format of the planning forms will be adjusted to provide space for such activities. Analysis of the reports submitted at the end of the semester, however, confirmed that some of the facilitators did apply collaborative and engaging activities that were addressed during training. This indicated that some learning did take place. An important finding was that the majority of the facilitators explained how their confidence increased due to the knowledge and skills they were exposed to in the workshops.

The poor student attendance at some of the SI sessions might be an indication that more attention should be given to marketing of the SI programme during training.

Sufficient support is crucial for the success of the SI programme. It is problematic if the training programmes are effective and the SI facilitators have gained the necessary skills and knowledge, but do not have the resources and support to apply the knowledge and skills. The most important issue regarding institutional support that emerged from the findings is the lack of venues where the SI facilitators can conduct SI

sessions. This was reported to university management, but will not be addressed immediately. The facilitators also indicated challenges with printing and access to study material. The lack of sufficient administrative support to SI facilitators was addressed by opening an office at the ADC to assist facilitators with administrative and printing tasks.

Guskey's Level 4 requires the evaluation of application of knowledge and skills learnt. The outcomes should indicate both the degree and level to which the skills and knowledge are applied. Analysis of the data collected from questionnaires and session observations indicates that some of the new knowledge acquired was applied in the SI sessions. The skills which were well applied included good classroom management, prior planning of sessions, the confidence of the SI facilitators, group discussions taking place and good rapport and interaction between the facilitator and the students. A shortcoming was the degree and quality of the implementation.

Group discussions held were mainly in one big group, and a variety of collaborative strategies such as think-pair-share and the jigsaw were not used in the sessions. Discussion sessions between facilitators and the students did occur, but little interaction between the students themselves took place. The SI facilitators dominated the sessions and little evidence could be found of games, visual strategies and hand-outs. Our impression is that the SI facilitators applied the strategies superficially and selectively.

The final stage of evaluation, according to Guskey, is to determine the benefits for the participants and whether the outcomes identified by the SI programme were met. These outcomes are to improve student learning, lower attrition rates, raise student grades and increase graduation rates. The final results indicate that the grades of the students attending SI were higher than those not attending SI sessions. The fact that the number of students who withdrew was much lower for SI attendees than non-SI

attendees is evidence that the SI programme does lower attrition rates and could increase graduation rates. Evidence of improved student learning can be seen in the higher grades of SI attendees, but also in the feedback on the questionnaires completed by the students. Figure 5 indicates that students gained different graduate attributes or soft skills such as communication skills, critical thinking and time management. The higher marks indicate cognitive improvement, whilst the higher self-esteem and self-reflection gained indicate improvement in the affective domain.

The SI facilitators also benefitted from professional development and the running of the SI sessions, as indicated in Figure 6. The themes that emerged from the SI facilitator reports include leadership skills, working with diverse people, time management, communication and interpersonal skills.

The evaluation levels indicate that the PDP of the SI programme on the Mafikeng Campus has an impact on how the SI sessions are conducted, and students and SI facilitators derive benefits from them. Applying Guskey's evaluation model to the professional development process helped in identifying gaps in programme design, content and implementation. It also highlighted shortcomings in the institutional support of the programme and benefits gained by both students and SI facilitators.

■ Conclusion and recommendations

This study contributes to revealing the importance that PDPs play in the overall success of peer tutor programmes and, more specifically, the SI programme. The issue of the quality and outcomes achieved by PDP programmes was addressed by applying Guskey's evaluation model to the PDP of SI on the Mafikeng Campus. Although the overall findings indicate that the outcomes defined by the SI programme were achieved by the PDP administered, several gaps were identified that needed urgent attention.

Shortcomings identified had an influence on the quality and degree of success of the SI programme on campus. Although the majority of lecturers support the SI facilitators sufficiently, attention needs to be given to lecturers not offering the necessary support and not marketing the SI sessions regularly. Training sessions for lecturers may be a solution. SI mentors were appointed to mentor small groups of SI facilitators to address these shortcomings. By applying Guskey's model in reverse mode, subsequent PDPs could be planned more effectively. Specific attention needs to be given to the quality of implementation. This aspect has to be emphasised during the initial training and more activities must be built into the training programme to master these aspects.

The planning forms were adjusted to include tick lists where SI facilitators indicated which activities and strategies they used to act as a reminder for future implementation. The issues identified can be utilised for future planning of the professional development activities of the SI facilitators. This will necessitate the reversal of Guskey's levels: starting with the outcomes to be achieved, and then deciding which instructional practices and procedures are needed in order to achieve the required outcomes. These instructional practices will determine the institutional support required for the practices to be implemented. The teaching methods will prescribe what knowledge and skills the SI facilitators acquire. Lastly, it can be decided which workshops are crucial to create the necessary experiences to acquire the skills and knowledge required.

The findings in this research were applicable to a single case study at one university and customised for the SI programme; whilst they cannot be generalised, they will be useful for application to any tutor programme at any tertiary institution. Another limitation might be the sample size of the lecturers involved, but as lecturers do not play a significant role in the

PDPs this should not have a major influence on the results. Findings also suggest that the general principles can be applied to any tutor programme administering professional development.

The contribution that this study makes is to highlight the importance of evaluating the PDPs used in peer tutor or SI programmes. The assumption cannot be made that because SI facilitators are trained extensively the outcomes will be achieved. This study confirms the value of using an evaluation programme for quality assurance purposes. The evaluation of PDPs also highlights other benefits that tutor programmes may have.

However important quality might be, the most significant use of Guskey's evaluation model is its utilisation in the planning and identification of content and activities for training of SI facilitators. This study indicates both the need for evaluation of PDPs for SI facilitators, but also the rich treasure of useful information embedded in Guskey's evaluation model that can be used when planning professional development for peer tutors.

Recommendations for further research are for a study of why the number of students who failed was higher for SI attendees than for non-SI attendees, as well as a follow-up study which involves more lecturers.

■ Chapter 4: Summary

University students are faced with many learning challenges that can make or break them, especially in the first year of study. Challenges include amongst others large classes, more access to higher education, admission of underprepared students and limited resources. The benefits of supplemental instruction (SI) as a peer tutor programme to address these challenges in higher education institutions have been widely recognised.

Professional development of peer tutors plays an important role in the success of these programmes, yet little attention has been given to its evaluation, nor to evaluation of the professional development of SI facilitators. The application of Guskey's model for the professional development of peer tutors in the SI programme on the Mafikeng Campus of North-West University was investigated. The model was adapted to comply with SI principles and procedures. Findings show that both students attending SI sessions and SI facilitators benefitted from the professional development initiatives.

Promoting conceptual change in Physical Sciences teachers: Impact of a professional development intervention

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■ Introduction

After years of poor performances in education rankings, South Africa (SA) finally achieved its lowest ranking in an international measure of the quality of Mathematics and Science education (Gernetzky 2012). The achievement of a sustained, general and significant improvement in Mathematics, Science and Technology (MST) teaching and learning throughout the public school

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system in SA continues to be an elusive goal (Gauteng Department of Education 2010). The Mathematics and Science results of 2009–2012 Grade 12 final examinations are further evidence of this.

For example, Mabe (2013) lamented that for the North-West province, 35.99% of the matriculants passed Physical Science at 40% and 58.55% passed at the 30% level in 2011. She went on to say that in 2012, still in Physical Sciences, 38.99% of the matriculants passed at 40% and 62.54% passed at 30%. A significant amount of funding, effort and time had been applied to raise the quality and results of MST education over the past 16 years, yet the problem has been largely resistant to change (Gauteng Department of Education [DoE] 2010).

The impediments to success and reasons for the poor pace of progress are complex and only vaguely understood. These include poverty, lack of resources, entrenched learning cultures, poor infrastructure of schools and low teacher qualifications as well as inappropriate regional distribution of Mathematics and Science teachers (Kriek & Grayson 2009). To overcome impediments such as lack of resources, entrenched learning cultures and low teacher qualifications, the *Integrated Strategic Planning Framework for Teacher Education and Development in South Africa (2011–2025) Technical Report* (Departments of Basic Education and Higher Education and Training 2011) stated that teacher development support structures and functions need to be improved and better coordinated amongst the national, provincial, district and school levels, and also need to involve higher education institutions. The same report further stated that existing funding mechanisms for teacher education and development need to be improved. Currently funding mechanisms are cumbersome, insufficiently coordinated, ineffectively utilised and poorly monitored (Departments of Basic Education and Higher Education and Training 2011). The crisis in

MST education cannot be emphasised enough. Thus all existing budgetary resources for teacher education and development need to be optimally and manifestly exploited.

Many groups and organisations, from non-governmental organisations to businesses, provincial education officials and student volunteers, have tried to improve the state of school Mathematics and Science through a variety of interventions. In an attempt to address some of the impediments related to pedagogical factors, the DoE's Mathematics, Science and Technology Services (MSTS) North West province, which is part of the General and Further Education Training Services, held a professional development intervention programme in February 2013. Professional development involved teacher training and learning. From a situative perspective, teacher learning 'is usefully understood as a process of increasing participation in the practice of teaching, and through this participation, a process of becoming knowledgeable in and about teaching' (Adler & Reed 2002:37). The purpose of the intervention was threefold, namely:

1. To train Science teachers on the use of Science equipment so that they can conduct practical work with learners inside the classroom.
2. To ensure that educators are knowledgeable and skilled regarding the proper use and handling of laboratory Science equipment.
3. To ensure that educators are knowledgeable and skilled regarding performing or conducting of the actual experiments for Grade Levels 8–12.

In so doing the DoE officials expected that this would eventually improve the pass rate in Science subjects. A closer look at the intervention indicates that the purpose is closely aligned to the National Strategy for Mathematics, Science and Technology Education in General and

Further Education and Training, adopted by the State in 2001 (Gauteng Department of Education 2010). The strategy laid out three main thrusts. These were:

1. To raise participation and performance by historically disadvantaged learners in Senior Certificate Mathematics and Physical Science.
2. To provide high-quality MST education for all learners taking the first General Education and Training (GET) certificate and Further Education and Training (FET) certificate.
3. To increase and enhance the human resource capacity to efficiently deliver quality MST education.

However, the intervention described in this chapter is only for Physical Science teachers and is specifically related to Chemistry practical work.

The professional development intervention programme in context

The National Curriculum Statement (NCS), introduced together with the outcomes-based education philosophy in 2005, have recently been revisited with a view to simplifying the original documents and subsequent supporting documents (Subject and Learning Area Statements, Learning Programme Guidelines and Subject Assessment Guidelines) for all subjects. The aim was to produce national Curriculum and Assessment Policy Statements (CAPS) as a 'refined and repackaged' version of the original documents, and not to create new curricula.

The refining and repackaging of both the GET and FET college Science documents was completed, and CAPS was launched at FET colleges, starting at the Grade 10 level in 2012. As part of the refinement, Prescribed Practical Activities and Recommended Practical Activities were introduced.

The learning outcomes in the NCS were replaced by content standards in the CAPS curriculum. However, the changes in classroom practices demanded by such reform visions ultimately rely on teachers (Fullan & Miles 1992; Spillane 1999). Changes of this magnitude require a great deal of learning on the part of teachers and are difficult to make without support and guidance (Ball & Cohen 1999; Borko & Putnam 1996).

To support and guide the teachers, the DoE's MSTs, North West province, decided to collaborate with a large research university in the province, Somerset Educational (Pvt) Limited and the schools. The university provided quality professional development such as providing the expertise needed by teachers regarding content, process, strategies and structures and contexts. Somerset Educational (Pvt) Limited, which supplies chemicals to 85 countries in the world including SA, provided the chemicals to be used during training and was contracted to eventually supply the chemicals to all participating schools within 2 weeks after the training intervention.

The schools fall under the DoE, and each participating school was compelled to release one Physical Science and one Natural Science teacher for the workshops. Teacher learning would entail knowledge; skills and beliefs; content; pedagogy; leadership skills; and improved teacher practices. The workshops were run along seven principles for effective professional development identified by the Professional Development Project of the National Institute for Science Education in the USA (Loucks-Horsley & Stiles 2001). These principles are: having a clear image of effective classroom learning and teaching; developing teachers' knowledge and skills to broaden teaching approaches; using instructional methods that mirror the methods to be used with learners; building or strengthening the learning community of Science teachers; preparing and supporting

teachers to serve in leadership roles; providing links with other parts of the educational system; and helping teachers frame appropriate continuous assessment tasks.

Teachers attended five consecutive full-day workshops on regular school days in February 2013. The first 3-day workshops were held for Grade 10–12 Physical Science teachers, and the last 2-day workshops were held separately for Grade 8 and 9 Natural Science teachers to address specific issues pertaining to the instructional units for each band.

■ Research questions

The purpose of the study was to ascertain the impact of a professional development intervention on Physical Science teachers' conceptual change. The focus of the professional development intervention was to assist teachers with regard to content, process, strategies and structures and contexts. It was hoped that by the end of the intervention teacher learning would entail improved knowledge, skills and beliefs, content, pedagogy, leadership skills and enhanced teacher practices. The impact of these process skills was therefore investigated in relation to conceptual change. To achieve this purpose, three questions provided a focus for this study. These are:

1. Which common alternative frameworks about electrochemical cells, reaction rates and acid-base titrations, reported by Garnett and Treagust (1992), Sanger and Greenbowe (2000) and Çalık, Kolomuç and Karagölge (2010), are held by our practising teachers?
2. To what extent did the professional development intervention address the identified alternative frameworks harboured by teachers?
3. What are the implications of this research for classroom practice and Science curriculum development?

■ Theoretical framework

The *conceptual change* theoretical framework guiding this study focuses on knowledge acquisition in specific domains and describes learning as a process that requires the significant reorganisation of existing knowledge structures and not just their enrichment (Vosniadou & Brewer 1987). According to Vosniadou, Ioannides, Dimitrakopoulou and Papademetriou (2001), this learning of Science differs in important ways from the usual empiricist approach, which says Science learning is mostly a matter of enrichment and improving existing conceptual structures. These structures are built on the basis of experiences that are initially concrete and limited.

The conceptual change approach has its own critics. According to Vosniadou *et al.* (2001) some researchers criticised the conceptual change approach on the grounds that earlier beliefs do not disappear when the currently accepted scientific explanations are understood. This disappearance of earlier representations is not, however, a necessary requirement of the conceptual change approach. The conceptual change approach forces the creation of new, qualitatively different representations. The old representations may continue to exist or may disappear. This condition should be studied by empirical research and is beyond the scope of this study.

The conceptual framework related to this theory and also guiding this study is based on literature on the operationalisation of the phrase *alternative frameworks* (Hamza & Wickman 2008; Novak 2002; Özmen 2008). Over the past few decades considerable research has been conducted on student conceptions and alternative conceptions for a variety of aspects of Chemistry (Özmen 2008). Students' self-constructed conceptions have been referred to in the literature as alternative

conceptions, misconceptions, preconceptions, naive conceptions, children's Science, intuitive beliefs, *alternative frameworks*, students' errors, etc. (Clough & Driver 1985), limited or inappropriate propositional hierarchies (Novak 2002), and non-scientific ideas (Hamza & Wickman 2008). These mental representations of concepts – which are at variance with currently held scientific theory – are distinguished into two kinds (Nakiboglu 2003):

1. Alternative or experiential or intuitive or native conceptions.
2. Instructional misconceptions.

In this chapter the author uses the term 'alternative frameworks' without discriminating between alternative and instructional misconceptions, and the term 'students' is replaced by *teachers*. Throughout this article the phrase 'alternative framework' has been used to refer to these ideas that are not in agreement with accepted scientific ideas. According to De Jong, Acampo and Verdonk (1995), students at all levels, and even Science teachers, hold alternative frameworks: conceptual and propositional knowledge that is inconsistent with or different from the scientific consensus and is unable to adequately explain observable scientific phenomena.

Some alternative frameworks that are capable of adequately explaining an individual's experiences and observations appear to be quite logical to the individual and are consistent with his or her understanding of the world. In these instances, alternative frameworks are very resistant to change, persistent, and difficult to extinguish even with instruction designed to address them (Novak 1988). Although there have been many reports on conceptions of students at different levels and prospective and/or preservice teachers about various Chemistry topics, studies of practising

teachers are scarce (Haidar 1997). As a result, the study was designed to identify previously reported and new alternative frameworks of practising teachers using both prescribed and recommended practical activities in the recently introduced CAPS curriculum, taking into account the uninvestigated concepts.

Two other terms which need operationalisation are 'practical work' (Millar 2004; Moore 2006; Wellington 1998) and 'professional development' (Bell & Gilbert 1996; Loucks-Horsley, Stiles & Hewson 1996). Practical work is the second phrase which needs operationalisation. The terms practical work, laboratory work (lab work), experiments, 'hands-on' activities and practical activities have been used by Science educators interchangeably. That these terms have been used synonymously is acknowledged by some renowned scholars (Nott & Wellington 1996; Woolnough 1991) on the subject of school Science laboratory work. Loosely, the terms have been used to refer to the teaching and learning of Science inside or outside a laboratory, during which experiments or practical exercises with Science apparatus are done (Woolnough 1991). Millar, Le Marechal and Buty (1998) recognise the problem of separating laboratory work from the other teaching and learning activities associated with Science instruction. According to Millar *et al.* (1998) demarcation of laboratory work from other Science teaching and learning activities is problematic because almost all Science teaching/learning activities can be viewed as either preparation for practical work or a reflection on some practical activity. They describe laboratory work as encompassing those teaching and learning activities which involve students in doing or watching someone doing a practical task, or designed to prepare students for some specific aspect(s) of such a task inside or outside a laboratory. By their own admission, this is clearly a very loose definition.

None of the surveyed literature has made an effort to give precise and exact definitions of the terms in usage, although literature on laboratory or practical work in school Science is both extensive and intensive. Such a precise definition of terms is not about satisfaction of an appetite for semantics but a discursive necessity. Perhaps there has been too much of an a priori assumption that everyone will understand the other, irrespective of whatever term is chosen.

The truth of the question is, do these terms mean the same? Is practical work the same thing as laboratory work and experimental work? Are Science practical activities the same thing as laboratory work or experimental work? As a way of answering some of these questions there is need to define laboratory work. A definition of laboratory work is given elsewhere (Vhurumuku 2001). That definition is extended and articulated as follows: laboratory work or lab work is about all those instructional activities done by the teacher, the teacher together with the students or by the students on their own (individually or in groups) in order to accomplish experiments or demonstrate or illustrate scientific phenomena. The activities can be done inside or outside the classroom or laboratory. Laboratory work activities are those during which there is physical manipulation of apparatus, chemicals, living organisms, objects and materials in general. As a result of the manipulation, the apparatus, chemicals, organisms, objects or material must exhibit some observable phenomenon. The observer must be able to qualitatively or quantitatively record his or her observations. Essentially, observation and manipulation form the core of school Science laboratory work. Gabel (2000) recognises the centrality of observation and manipulation in laboratory work, and asserts that laboratory teaching assumes first-hand experience in

observation and manipulation of the materials of Science and is superior to other methods of developing understanding and appreciation.

To this end, Wellington (1998:12) noted that there are ‘at least six types of activity’ that take place in school Science ‘that we would probably all classify as practical work’:

- Teacher demonstrations.
- Class practicals, with all learners on similar tasks.
- Working in small groups.
- A circus of ‘experiments’ with small groups engaged in different activities, rotating in a carousel.
- Investigations, organised in one of the above two ways.
- Problem-solving activities.

These activities are the same as those being advocated by the CAPS document for Physical Sciences. The DoE (2011) states that:

Practical activities, as used in this document, will refer to practical demonstrations, experiments or projects used to strengthen the concepts being taught.

Experiment will refer to a set of outlined instructions for learners to follow in order to obtain results to verify established theory.

Practical investigations will require learners to go through the scientific process.
(p. 11)

This study adopted Millar’s (2004:2) definition of practical work as ‘any teaching and learning activity which at some point involves the students in observing or manipulating the objects and materials they are studying’. The term ‘practical work’ is used in preference to ‘laboratory work’ in this chapter, because location is not a salient feature in characterising this kind of activity. The observation or manipulation of objects could take place in a school laboratory, or in

an out of school setting such as the learner's home or in the field (e.g. when conducting a project).

There is a growing body of research that shows the effectiveness of 'hands-on' and 'brains-on' activities in school Science taking place inside and outside the laboratory (Dillion 2008). This body of research argues that practical work is central to teaching and learning in Science and that good-quality practical work helps develop learners' understanding of scientific processes and concepts.

There are many espoused purposes for doing practical work in school Science. Some of the most frequently stated purposes by teachers are to: encourage accurate observation and description; make phenomena more real; arouse and maintain interest; promote a logical and reasoning method of thought (Moore 2006); practice seeing problems and seeking ways to solve them; develop a critical attitude; develop an ability to cooperate; and find facts and arrive at new principles (Millar 2004). The espoused purposes point to the fact that good practical work activities provide a learning environment where learners can forge links between theoretical concepts and experimental observations (Dillion 2008). Moreover, learning goals that can be achieved through practical work experiences include: subject-matter mastery; improved scientific reasoning; an appreciation that experimental work is complex and can be ambiguous; and an enhanced understanding of how Science works (Moore 2006). Skills that can be developed through high-quality practical work include manipulation of equipment; experiment design; observation and interpretation; problem-solving and critical thinking; communication and presentation; data collection, processing and analysis; laboratory 'know-how', including developing safe working practices and risk assessment skills; time management; ethical and professional behaviour; application

of new technologies; and teamwork (Bennett & O'Neale 1998). However, Millar (2009) lamented:

As practised in many schools, it [practical work] is ill-conceived, confused and unproductive. For many children, what goes on in the laboratory contributes little to their learning of Science or to their learning about Science and its methods. Nor does it engage them in doing Science in any meaningful sense. At the root of the problem is the unthinking use of laboratory work. (p. 176)

Practical work is, nonetheless, necessary for developing learners' understanding of scientific concepts and explanations.

Professional development is the third term which needs operationalisation. According to Loucks-Horsley and Stiles (2001), designers of professional development can be guided by the extensive body of research on how effective change occurs in educational settings. Professional development of teachers is not new, but in recent years it has been realised that the way in which it is structured and delivered needs to be reconceptualised. Dass (1999:2) reported that traditional 'one-shot' approaches to professional development had been inadequate and inappropriate in the context of current educational reform efforts. Ball and Cohen (1999:5) indicated that professional development of teachers is 'intellectually superficial, disconnected from deep issues of curriculum and learning, fragmented and non-cumulative'.

Prior studies have established the importance of teachers engaging in long-term, discipline-specific professional learning experiences to support enduring changes in their classroom practices (Whitcomb 2013). Professional development that is of longer duration and timespan is more likely to contain the kinds of learning opportunities necessary for teachers to integrate new knowledge into practice (Brown 2004). Recent findings

suggest that multiple studies are necessary to determine what works in professional development, a view consistent with recent panels on scientifically based research in education (Cummings & Worley 2014). Penuel *et al.* (2007) findings were consistent with the view that studies of different curricula are likely to yield overlapping but distinct findings about what makes professional development effective. In reviewing particular studies and synthesising findings across studies, the particular curricular and school contexts need to be taken carefully into account, as do the limits of generalisability of research findings. For example, Bell and Gilbert's (1996) Science teacher development model emphasised three components:

Personal development in which the teacher must be aware that there is a need for professional development and acknowledges the desire to acquire new ideas or strategies.

Social development in which the teachers have opportunities to discuss ideas with other teachers, and to collectively renegotiate what it means to teach Science and be a teacher of Science.

Professional development in which the teachers are supported in implementing the new ideas and strategies in their classroom practice, drawing on the changes they make personally and socially. (n.p.)

These three components are viewed as essential to building on teachers' commitment to enact change within their own classrooms and professional communities. Identifying teachers committed to personal development can be useful in selecting participants, whilst social development and professional development aspects of the model can be used in designing teacher development programmes. The three components emphasised by Bell and Gilbert's (1996) Science teacher development model became the backbone and guiding principle of exploring the idea of teachers as

learners by synthesising a range of accounts of teacher learning in the professional development intervention programme described in this chapter.

Another view is that of Hottecke and Henke (2015), who describes professional development as a key aspect that underpins knowledge to be shared amongst teachers which brings understanding of why ongoing training is an integral part of a professional culture and how it can be fostered in schools. Thus, sustained professional development workshops in Science instruction are vital for the development of understanding of Science concepts for teachers and students. The critical feature is to engage in practice that is sustained and aims at continuous progress toward a performance goal over time. According to Battista and Foster (1999). Science workshops are designed to help teachers learn Science concepts at the same time as they are refining their inquiry abilities. Each workshop consists of three phases:

1. An introductory phase, where the workshop facilitator explains the concept and the task.
2. An activity phase consisting of engaging in hands-on activity and sharing with their group about their experience with the activity.
3. A period for reflection and discussion, where the facilitator sums up the lesson.

The introductory phase is a time for the facilitator to spur interest and prior knowledge on the workshop topic, to explain the activity, and to go over safety issues so that the activity period goes smoothly. This is also the time for clarifications and ensuring the activity specifications and procedures have been understood by the participants. The phase helps to learn about participants' interest and to determine their content knowledge

before beginning the activity. In the activity phase participants form groups and engage in the activity, taking notes, dialoguing, and engaging in the hands-on activity. This is the time for negotiation amongst group members, resolving problems, proposing solutions and staying on task. Participants' first hands-on experiences are accompanied by discussion and writing that help process their thoughts on the investigation. The facilitator's role during the activity period includes questioning, observing and assessing participants as well as monitoring the activity. Aspects of Battista and Foster's (1999) work also became guiding principles in the professional development intervention programme described in this chapter.

■ Methodology

A case study research method was used in the study since it is particularly appropriate for in-depth research. It is also effective in attaining a desired goal in a short time (Çepni 2003).

■ Sample

□ Participants

The sample consisted of 123 Physical Science teachers (80 males and 43 females) and 7 Physical Science subject advisers (3 males and 4 females) who teach in the FET band, that is, Grades 10–12. The sample was randomly stratified from the North-West province of SA. The teachers came from 123 schools; each school seconded one teacher for the workshops. North-West province has about 300 high schools. The DoE of North West province did the selection. The criterion for selection was based on the performance of learners (pass rate) in the

Physical Science Matric examination for 2012, and the participating teachers were selected from underperforming and Dinaledi schools. Of the 123 teachers, 81 were from underperforming schools and 42 were from Dinaledi schools. Underperforming schools are those that achieve an average pass rate of less than 50% in the National Senior Certificate, specifically in this case in Physical Sciences (Gauteng DoE 2010). The Dinaledi schools fall under the Dinaledi programme which supports selected schools with a view to significantly increasing the participation and performance of learners, especially African and girl learners, in Mathematics and Science subjects (Departments of Basic Education and Higher Education and Training 2011). Since its inception in 2002, the Dinaledi programme has expanded from 102 to 500 schools across all nine provinces (Gauteng DoE 2010). Dinaledi schools receive additional learning resources and teachers who are equipped with appropriate pedagogical and content skills, and languages of instruction. For inclusion in the Dinaledi programme, secondary schools were selected on the basis of having achieved at least 35% Senior Certificate Mathematics passes by black learners. Some former Model C schools that met these criteria were also included in the Dinaledi project (Gauteng DoE 2010). Former Model C schools are schools which used to have the best resources and teachers, and some of these schools currently still enjoy these privileges.

The North West DoE, as well as the subject advisors and participating teachers of the 123 schools, gave consent for conducting the study. The research design was also approved by the ethics committee of the North West DoE, which funded this project. All 130 participants were informed that their participation would be voluntary and that they

could withdraw from the study at any time. However, no participants withdrew.

Researchers

The professional development providers included four Science educators specialising in Chemistry, Biology and Physics. Of the four, one specialised in Chemistry (male), two in Physics (one male and one female) and one in Biology (female) from a large research university. The Science educator specialising in Chemistry had a PhD in Chemistry Education and had taught Organic, Physical, Inorganic and Analytical Chemistry for 15 years at both high school and tertiary level. The Science educator specialising in Biology also had a PhD in Biology Education and had taught Genetics, Cell Biology and Introductory Laboratory courses for 19 years at both high school and tertiary level. She was working at one of the three campuses of the participating university. The two Science educators in Physics had a Master of Science (MSc) degree with the education component and were both working towards their PhD. They both had 22 years of experience teaching at high school and university level.

Research methods

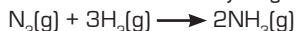
The participants were first given a concept pretest, which consisted of a taxonomy of misconceptions in electrochemical cells, reaction rates and acid-base titration. Twelve concepts (four from each section) were adapted and fashioned by the researcher in the light of related literature (Çalık *et al.* 2010; Garnett & Treagust 1992). The taxonomy of misconceptions measured is listed in Table 8. Suggestions by four experts in Chemistry education were taken into consideration whilst adapting the questions (Box 2).

TABLE 8: Taxonomy of misconceptions in galvanic cells, rate of a chemical reaction, acids and bases concept test.

No.	Taxonomy of misconceptions
1	Electrons enter the solution from the cathode, travel through the solutions and the salt bridge, and emerge at the anode to complete the circuit.
2	Anions in the salt bridge and the electrolyte transfer electrons from the cathode to the anode.
3	Cations in the salt bridge and the electrolyte accept electrons and transfer them from the cathode to the anode.
4	The anode is positively charged because it has lost electrons; the cathode is negatively charged because it has gained electrons.
5	Strength (of acid) and concentration mean the same thing; confusion between concentration and moles.
6	The forward reaction reaches completion before the reverse reaction begins.
7	At equilibrium, the concentration of reactants is equal to the concentration of products.
8	The rate of reaction is not affected by the concentration of reactant that takes part in the reaction.
9	Acids and bases show opposite properties of each other.
10	Reactions of acids and bases always result in a neutral solution.
11	Indicators are used to provide the neutralisation in acid-base reactions.
12	At pH=0 substances are neither an acid nor a base.

BOX 2: An example of the structure of the questions.

Item 24: Ammonia gas forms from the reaction of hydrogen gas and nitrogen gas:



Before equilibrium:

- The rate of ammonia formation is greater than the rate of hydrogen formation.
- The rate of hydrogen formation is greater than the rate of ammonia formation.
- The rate of ammonia formation equals the rate of hydrogen formation.

Reason/justification: Before equilibrium:

- The rate of the reverse reaction is greater than the rate of the front reaction.
- The rate of the front reaction is greater than the rate of the reverse reaction.
- The rate of the reverse reaction equals the rate of the front reaction.

The pretest had 25 items, each with two tiers:

1. A content question with two to four choices.
2. Four to five possible justifications for all potentially possible answers in the first tier which reflect the participants' common misconceptions in galvanic cells, rate of a chemical reaction, acids and bases concepts.

Content validity of the instrument was determined by considering the experts' ideas in the Educational Faculty of North-West University and the Chemistry Department of the same university. The reliability of the test was determined as 0.81. Qualitative content analysis (Creswell 2009) was used to analyse the data. Firstly, two researchers independently analysed written responses of in-service Science teachers, then they came together and discussed the answers to reach consensus. The same test was given as the post-test after the intervention to check for conceptual change. The post-test was administered after a week.

The participants were then divided into four groups of about 32 participants each. This was done by the DoE officials. The stratified random sampling technique (Gall, Borg & Gall 2007) was used. The officials wanted to ensure that the groups were representative of Dinaledi and poorly performing schools. The groups were labelled A, B, C and D. Each facilitator (professional development provider) was assigned a venue labelled 1, 2, 3 or 4. A timetable was drawn up, ensuring that participants had equal time with each of the facilitators.

Sessions commenced at 8 o'clock in the morning and ended at 5 o'clock in the afternoon. Effectively sessions ran for 7 hours, excluding lunch and tea breaks. The data were collected through performing the actual prescribed and recommended practical activities which teachers should perform with their learners in the classroom according to the recent CAPS document. This chapter focuses only on the Chemistry

aspects and from now onwards the discussion pertains to what transpired in the Chemistry sessions of the professional development intervention programme.

Practical tasks were prepared for six sets of apparatus. Each group had an average of five participants. Each time a new group was attending, the researcher (who was the Chemistry facilitator) made use of different group formation methods/tools, for example matching card method, picture cards, drawing a token from a bag, line up according to birth date, height or gender. All these methods were briefly discussed so that the participants could use these methods with their learners in schools during practical work or forming group work when teaching various Science concepts. Once the groups were established, participants were instructed by the facilitator to assign themselves different roles and activities in a group, for example, timekeeper, resource manager, secretary (scribe), motivator (lab assistant), checker or summariser. Participants in each group would exchange roles when doing a different experiment.

The experiments covered in the intervention included:

1. Investigating
 - The temperature of water over a period of time.
 - The shape of a heating/cooling curve.
 - More about heat transfer during changes of state.
2. Investigating rates of reaction
 - The concentration effect on the rate of a chemical reaction.
 - The temperature effect on the rate of reaction.
 - The effect of a catalyst on the rate of a chemical reaction.
3. Determining the measurement of the potential difference of a Cu-Zn electrochemical cell.
4. Preparation of a standard solution of sodium carbonate.

5. Standardisation of a hydrochloric acid solution using a standard solution of sodium carbonate.
6. Determination of acetic acid content of vinegar.
7. Preparation of ester.

These experiments are inclusive of the prescribed and recommended practical activities outlined in the CAPS document. Discussion was held along the lines of how some of the experiments could be converted into demonstrations, investigations or project topics, so that teachers would teach Chemistry-related aspects using various activities as stipulated in the curriculum documents.

■ Data analysis

In their respective groups, the participants were expected to answer questions related to each experiment after performing it. The questions were different from the pretest and post-test questions, but related since they were soliciting understanding on the same concepts. The questions contained the concept under study in order to activate preconceptions of teachers and cause dissatisfaction with their current conceptions. The teachers were expected to respond to the question and explain their answer individually first, before discussing with their colleagues in groups.

Teachers' alternative conceptions were directly stated as each member of the group shared their answers to come up with one agreed group answer for each single question. In this way the teachers were expected to be dissatisfied with their existing ideas. During class discussion which ensued after group discussions, scientifically acceptable explanations related to concepts were given. These explanations were supported by concrete examples and figures to help teachers' understanding of the concept. Finally, as part of the group discussions the teachers were provided with different

statements related to the concept in order to prove that the new concept is more fruitful than their preconceptions. In this way, efforts were made to change teachers' alternative conceptions into scientific ones.

The discussion of the questions aimed to remedy alternative conceptions determined by the literature and the concept test. Group members would discuss and agree on an answer to each and every question, after which the scribe would write down the answer for discussion and eventual submission purposes. A class discussion ensued after groups had completed performing and discussing each experiment. The role of the class discussion was for the participants to see where they had gone wrong and to check their answers which they had agreed upon in their respective groups. The groups' responses were marked against a memorandum (ideas that are in agreement with accepted scientific ideas), and it is from each group's responses that alternative frameworks were identified for various Chemistry topics and aspects. This approach is different from the one employed by Demđrcđođlu (2009), who used conceptual change texts to see if they were effective before or after the instruction on Grade 10 students' conceptual understanding and alternative conceptions about acids and bases. Grouping of participants' responses was conducted by analysing the quality of the responses and categorising them following criteria used by Muchtar (2012). A colleague (a Science educator at the same university) also independently analysed and categorised the quality of the participants' responses for two aspects, namely the shape of a heating/cooling curve and determining the measurement of the potential difference of a Cu-Zn electrochemical cell. There was agreement in the analysis and categorisation, which signified reliability.

In this chapter, there are four diagnosed categories of alternative conceptions, which were all presupposed categories. Following interreliability

checks, participants' responses were then classified into four categories based on the following criteria by Muchtar (2012):

1. Scientifically correct (SC): This group consists of scientifically complete responses and correct explanations.
2. Partially correct (PC): Any scientifically correct responses but incomplete explanations fit into this category.
3. Specific alternative frameworks (SAFs): Any completely scientifically unacceptable responses or explanations are included in this category-naive Chemistry (naïve is a predetermined philosophical position indicating that respondent's views are not in agreement with scientifically accepted positions).
4. No understanding (NU): Groups who do not give any response, give irrelevant or unclear explanations, just rewrote the question or gave no explanations are put into this category.

As mentioned earlier, the terms 'alternative frameworks' and 'misconceptions' have the same meaning and can be used to refer to participants' conceptions that are different from scientifically accepted ones (Taber & Tan 2011). The alternative frameworks were then compared with those in literature (Garnett & Treagust 1992; Ogude & Bradley 1994; Sanger & Greenbowe 2000). The process would also lend itself to identifying new alternative frameworks harboured by the participants for these topics. A Wilcoxon signed rank test was conducted to determine if there was a change in the scores on the concept test from the pretest to post-test.

■ Results

Grouping of participants' responses (based on their understanding) was conducted by dividing the responses into four different groups: SC, PC,

SAF and NU. Based on the data analysed from participants' responses to all questions on various experiments, most of the responses fitted into the SC category. The participants harboured conceptual and propositional knowledge that is consistent with or not different from the scientific consensus, and they are able to adequately explain observable scientific phenomena in most Chemistry aspects dealt with during the workshops. No responses from the participants fitted into the NU category. Participants' responses in three Chemistry aspects fitted into the SAF and PC categories:

1. Determining the measurement of the potential difference of a Cu-Zn electrochemical cell.
2. The concentration effect on the rate of a chemical reaction.
3. Standardisation of a hydrochloric acid solution using a standard solution of sodium carbonate.

The specific alternative frameworks which the participants elicited in each of these Chemistry aspects are described as a summary of responses given for each aspect.

Determining the measurement of the potential difference of a Cu-Zn electrochemical cell

In their respective groups the participants designed a galvanic cell using provided apparatus and chemicals. After set-up the participants – still in their respective groups – went on to measure the voltage of the galvanic cell. The follow-up questions to the activity were:

- What is the reading on the voltmeter before connecting the salt bridge and after connecting the salt bridge with the switch closed?
- Which electrode is the negative electrode? Which electrode is the positive electrode?

- Which electrode is the anode? Which electrode is the cathode?
- Write down the two half reactions. Write down the complete reaction.
- Write down the cell notation.
- Explain the direction of current/indirect transfer of electrons.
- What is the function of the salt bridge?
- Calculate the electromotive force (*e.m.f*) of the cell.

Responses to these questions enabled the researcher to identify at least five SAFs related to this topic:

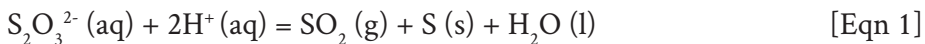
1. The anode is positively charged because it has lost electrons; the cathode is negatively charged because it has gained electrons.
2. Cations in the salt bridge and the electrolyte accept electrons and transfer them from the cathode to the anode.
3. Anions in the salt bridge and the electrolyte transfer electrons from the cathode to the anode.
4. Electrons enter the solution from the cathode, travel through the solution and the salt bridge, and emerge at the anode to complete the circuit.
5. Cations and anions move until their concentrations are uniform.

These same SAFs were found in teachers' responses to the pretest. Responses which fitted into the PC category were those that were related to the function of the salt bridge. Participants in their respective groups wrote the correct answers, for example to complete the circuit and to maintain electrical neutrality. When asked to explain or elaborate these responses during class discussion, SAFs response 2 and 3 then surfaced.

The concentration effect on the rate of a chemical reaction

A chemical reaction that exhibits some easily observable physical changes was chosen so that the progress of the reaction could be conveniently

monitored. Many experiments can be performed to illustrate this. However, in this workshop the reaction between sodium thiosulphate and diluted sulphuric acid was chosen:



Again in their respective groups, the participants performed the experiment and had to answer follow-up questions to the activity. Some of the questions which the participants had to answer in this section were:

- Plot the time required for the disappearance of the cross against the initial concentration of sodium thiosulphate on a graph paper. Label your graph properly.
- How is the rate of reaction affected by the concentration of the reactant? Define: (a) concentration and (b) reaction rate.
- Describe your observations of what happens in flask A.
- What does the formation of the yellow precipitate indicate during the experiment? (Do NOT state that sulphur has been formed.)
- From your graph, what is the relationship between concentration and reaction rate?

Responses to all questions enabled the researcher to determine participants' alternative frameworks about the reaction rate concept, and find out more about their command of the concepts in the unit. From these questions, six SAFs related to this topic were identified:

- Decrease in concentration of one of the reactants increases the concentration of the other reactant; thus, reaction rate is constant.
- Whilst a reaction occurs, concentration of products increases in time; thus, reaction rate increases.
- Reaction rate is independent of reactants' concentration.

- When concentration increases, surface area increases; thus, reaction rate increases.
- The rate of reaction is not affected by the concentration of reactant that takes part in the reaction.
- Strength (of acid) and concentration mean the same thing; confusion between concentration and moles.

As with the previous concept, the teachers confirmed the alternative frameworks they had shown in the pre-test. Some of the explanations made by the participants which indicated these alternative frameworks are, for example: 'The rate of reaction did not remain stable because there were no substances affecting the reaction', and 'The reaction is realised and the rate of reaction gets faster and faster'.

Standardisation of a hydrochloric acid solution using a standard solution of sodium carbonate

After preparing a standard solution of sodium carbonate, the participants in their groups went on to standardise hydrochloric acid solution using the standard solution of sodium carbonate they had prepared. After performing the titration, the participants in their respective groups had to answer 10 questions, and some of them were:

- Why is a conical flask rather than a beaker used in the experiment?
- Why is the funnel removed from the burette after adding the acid solution?
- Why is more than one accurate titration carried out?
- Explain why hydrochloric acid is not used as a primary standard.
- If you used only 10 cm^3 of sodium carbonate solution in the conical flask, calculate how much acid would be required to neutralise it.

Responses to these questions showed that the participants did not harbour alternative frameworks, but most of the responses fitted into the PC category. Most of the participants' responses in this unit were scientifically correct responses but had incomplete explanations. For example, in calculations most participants did not take into account that 1 mole of Na_2CO_3 reacted with 2 moles of HCl. In response to the question 'Why is a conical flask rather than a beaker used in the experiment?', some participants wrote 'to avoid spilling' instead of 'to allow for easy mixing of the contents'. Again, these were similar to the PC responses picked from the pretest.

Pre- and post-test results were found as follows: A paired-samples *t*-test was conducted to evaluate the impact of the intervention on participants' scores on the taxonomy of misconceptions in galvanic cells; rate of a chemical reaction; and acids and bases concept test. There was a statistically significant increase in concept test scores from the pretest ($M = 36.56$, $SD = 10.24$) to the post-test ($M = 75.57$, $SD = 12.01$, $t [129] = 15.39$, $p < 0.0005$). The eta-squared statistic (0.50) indicated a large effect size. *Eta-squared* measures the proportion of the total variance in a dependent variable that is associated with the membership of different groups defined by an independent variable. We can conclude that there was a large effect, with a substantial difference in the concept test scores obtained before and after the intervention.

A Wilcoxon signed rank test was conducted to determine if there was a change in the scores on the concept test from the pretest to post-test. Teachers' two sets of scores (pretest and post-test) were found to be significantly different, as determined by the Wilcoxon signed rank test ($Z = -8.23$, $p = 0.00$).

■ Discussion

The results showed that participants have some misconceptions in various aspects of Chemistry. The results also clearly indicated that the basic concepts about electrochemical cells, reaction rates and acid-base titrations are hardly understood by some participants in this study, although all have taught Chemistry as a component of Physical Science in their classes for years.

The teachers who harboured alternative frameworks on the copper-zinc electrochemical cell, in general could not provide any correct reasons for what they stated they know. Alternative frameworks concerning electrochemical cells detected in this study were consistent with students' alternative frameworks presented in previous studies in the literature (Garnett & Treagust 1992; Sanger & Greenbowe 2000). Most of the participants who harboured the alternative frameworks could not distinguish electrolytic cells from galvanic cells. For example, they wrote 'the anode is positively charged because it has lost electrons and the cathode is negatively charged because it has gained electrons'. Furthermore, due to them incorrectly identifying the charge of the electrodes as anode (positive) and cathode (negative), they could not correctly predict the flow of electrons. Surprisingly, some of the participants said electrons enter the solution from the cathode, travel through the solution and the salt bridge, and emerge at the anode to complete the circuit. Some participants had difficulty in explaining the polarity of the electrodes as well as electron and ion movement in electrochemical cells.

Similarly, these alternative frameworks were observed in the studies carried out by Ozkaya (2002) and Çalık *et al.* (2010). The remaining participants identified alternative frameworks emanating from the function of the salt bridge. When the participants were asked to make a

reading before connecting the salt bridge, all groups managed to state that the reading was 0V. However, after connecting a salt bridge, all groups obtained a reading. The rationale given by the participants when responding to questions that followed the activity revealed alternative frameworks such as: cations in the salt bridge and the electrolyte accept electrons and transfer them from the cathode to the anode; anions in the salt bridge and the electrolyte transfer electrons from the cathode to the anode; and cations and anions move until their concentrations are uniform. However, findings such as those shown in the current study do not support previous research findings. Analyses of such results show several difficulties in learning electrochemical cells. In the light of the findings, this study has some far-reaching implications.

When it came to the concentration effect on the rate of a chemical reaction, the results of this study showed that participants have alternative frameworks about reaction rate. The participants elicited some alternative frameworks such as ‘while a reaction occurs, concentration of products increases in time; thus, reaction rate increases’ and ‘reaction rate is independent of reactants’ concentration’. When the participants were asked to calculate the initial concentration of the sodium thiosulphate in the mixture so that they could draw a graph of reaction rate versus time and inverse of time, it was found that participants were confused regarding concentration and moles as well as strength (of acid) and concentration, because to them it meant the same thing. A possible explanation for this might be the abstract nature of the topic. Rate of reaction is a highly structured topic which is a central part of the Chemistry curriculum (Cachapuz & Maskill 1987).

However, irrespective of the topic being abstract, it is rather surprising to find such confusion, since we would expect that teachers’ understanding

of the topic would be better than that of learners so that they would be able to teach these concepts effectively. One reason for this confusion may be that teachers constructed this topic inadequately or superficially in their mind. Therefore, teachers may have developed a very basic understanding of the meaning of reaction rate, which they went on and used in everyday teaching practices.

For standardisation of a hydrochloric acid solution using a standard solution of sodium carbonate, the participants showed difficulty with calculations. Results from this study showed that the participants might not have fully understood the acid-base Chemistry concepts during their years of in-service or pre-service training. Participants seemed focused on memorising the formulas and theories given during their own learning process without comprehending them. The participants had difficulties in working from first principles and preferred algorithms. These problems might have been strengthened by low mathematical skills of participants that increased the degree of difficulties in learning acid-base Chemistry. Participants could be heard lambasting their mathematical skills during group discussions.

Research has shown that alternative frameworks amongst learners and teachers are resistant to change, and persist even with formal instruction change (Novak 1988). Some sources of these alternative frameworks include the way teachers were taught; textbooks; intuitive/direct observations of events from daily life; use of terms/words/metaphors in everyday language; lack of contextual hands-on and minds-on 'doing Science' experiences to link with abstractions to construct schemas; and superficial as opposed to in-depth and breadth of subject matter knowledge (Thompson & Logue 2006). These alternative frameworks need to be remedied if meaningful learning and teaching is to take place in schools.

A paired-samples *t*-test was conducted to evaluate the impact of the intervention on participants' scores on the taxonomy of misconceptions in galvanic cells, rate of a chemical reaction, and acids and bases concept test. The average percentage of correct responses in the pretest was 33.04% and that of the post-test 65.31%. The results of the analysis indicated that there was a significant difference between the performance of the participants in the pretest and post-test. The non-parametric Wilcoxon signed rank test showed that there was also a significant difference in teachers' scores obtained in the pretest and the post-test. This shows that the performance improved after the intervention.

The professional development intervention had an impact on the teachers and their performance improved after the intervention. As mentioned before, the same test was rendered to the teachers before and after the intervention. However, of importance is the quality of responses given by the teachers after the intervention. A limitation of this study is that there might have been a contamination effect between pretest, group assignment and post-test that contributes to the Wilcoxon scores, signifying a difference in performance. The alternative frameworks and partially correct responses – which initially were observed in the pretest and group responses to practical activity questions – were absent in the post-test responses. This might indicate that the intervention positively changed teachers' alternative frameworks to desirable conceptions.

These results provide serious alerts on the teaching of Physical Science at the secondary education level in SA. DoE officials need to pay more attention to teachers' misconceptions. An effort needs to be made to diagnose and treat teachers' misconceptions on a frequent basis. The current study contributes to this effort.

However, a systematic and continuous diagnosis of teachers' misconceptions needs to be put in place. As seen from the results of this study, and similar findings of other studies, the guiding principles that explain the effectiveness of the intervention in this chapter are that a teacher has to identify students' alternative conceptions before the instruction can more easily help students to gain scientifically acceptable conceptions by using alternative teaching strategies. The identification can be achieved by teachers assessing students' prior knowledge and learning needs before the instruction, since alternative teaching strategies emphasise the importance of learners' preconceptions. This entails that practising Science teachers might first have to understand the importance of prior knowledge in learning.

Jonassen and Grabowski (1993) define prior knowledge as the knowledge, skills or ability that a student brings to the learning environment, because they are strong predictors of student achievement. After identification of prior knowledge, teachers might have to be informed about the usage of strategies of conceptual change that explicitly deal with students' prior knowledge and alternative conceptions, due to the fact that much research indicates that there is a strong relationship between prior knowledge and performance of students.

Teaching strategies taking students' alternative conceptions into consideration might have to be used, which may be useful for enhancing meaningful learning. Amongst these teaching strategies are classroom discussions, which would have to be employed to give students opportunities to focus on the interpretation of phenomena and help them build up new concepts. A combination of conceptual change and traditional approach teaching strategies might have to be used, which might result in significantly better acquisition of the scientific conceptions and the elimination of alternative conceptions.

■ Conclusion and recommendations

In light of these results it is essential that teachers must be supported with and through ongoing professional development. The study helped participants realise what they already knew about and of the various Chemistry concepts that were dealt with during the workshops. However, in-service education activities should be designed so that these identified alternative frameworks can be eradicated.

In this respect, teachers can be informed of the alternative frameworks they harbour and be encouraged to revise what they know. Taking a leaf from Dass' (1999) suggestion, professional development needs to be restructured and reconceptualised, as traditional 'one-shot' approaches to professional development appear to be inadequate and inappropriate in the context of current educational reform efforts.

Professional development of teachers should be significant and connected to deep issues of curriculum and learning, continuous and cumulative. This might be true for the professional development intervention programme described in this chapter. Although appropriate, the approach seems inadequate if identified alternative frameworks are to be eradicated. After attending professional development programmes such as the one described in this chapter, teachers should be assisted in schools during the actual teaching and learning process to ensure maximum support is rendered. Teacher trainers should also regularly provide instruction, either at university or to groups of teachers in schools, in practical workshop skills that will enable teachers to make use of simple equipment to enrich Chemistry lessons. Those delivering these sessions will need to allow time on site for a lot of rehearsal. Teachers who receive such instruction should be encouraged to train other teachers in their immediate area, perhaps by establishing

local self-help groups. These would complement existing or future government schemes.

Wherever possible, local education departments should cover travel expenses for teachers to get together and share their practice. This will strengthen Science teachers' content knowledge, which should be an essential component of any professional development programme. Considering the importance of collecting the data on teachers' alternative frameworks, this study recommends that other researchers investigate teachers' alternative frameworks for other topics in Chemistry and suggests ways of eradicating them for effective teaching and understanding of concepts by learners.

From existing literature it is clear that once-off professional development is not the answer to teachers' needs, regardless of some improvement depicted in the results of this study. The study recommends a deviation from the norm and suggests approaches to professional development that are adequate and appropriate in the context of current educational reform efforts.

■ Chapter 5: Summary

Changes in classroom practices demanded by reform visions, such as the shift from the National Curriculum Statement to the Curriculum and Assessment Policy Statements (CAPS), ultimately rely on teachers. A great deal of learning on the part of teachers is required if changes of this magnitude are to be a success. Teachers, just like their learners, also harbour alternative frameworks in Chemistry concepts. Studies show that teachers reflect these alternative frameworks in Chemistry classes, especially when abstract concepts are being taught. The purpose of this

study is to examine the impact of a support and guidance professional development intervention programme in practical work on Physical Science teachers concerning various Chemistry aspects. The study is guided by the conceptual change theoretical framework. A case study research method was used in a survey, and the sample consisted of 123 Physical Science teachers and 7 Physical Science subject advisers drawn from the North-West province of South Africa. The data were collected whilst teachers performed the actual prescribed and recommended Chemistry practical activities suggested by the CAPS document. Data were analysed using criteria adopted from Muchtar (2012). The results indicated that teachers harbour alternative frameworks in various Chemistry concepts. Findings showed that basic concepts about electrochemical cells, reaction rates and acid-base titrations were hardly understood by some of the teachers who participated in this study, although all have taught Chemistry as a component of Physical Science in their classes for years. The professional development intervention had an impact on the teachers, and their performance improved after the intervention. The significance of this study rests in recommending more such interventions throughout the year, to enable teachers to improve in their content knowledge and Science pedagogy, as evidenced by analysis of their summative evaluation of the intervention. Recommendations and areas for further study are suggested.

Evaluating an environmental learning programme in developing understanding of environmental education concepts amongst selected in-service primary school teachers in South Africa

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■ Introduction and background

Developing understanding of environmental education and environmental concepts amongst in-service teachers is part of an international process that started in 1972 and culminated in the Earth Summit's (1992) Agenda 21 and the United Nations' Decade of Education for Sustainable Development (DESD) (Holdsworth *et al.* 2008; Marong 2003; Tilbury 2010). Chapter 36 of the Earth Summit's Agenda 21 is titled 'Promoting training' and states that:

[C]ountries should strengthen or establish practical training for graduates from vocational schools, high schools and universities, in all countries, to enable them to meet labour market requirements to achieve sustainable livelihoods. (n.p.)

It further encourages countries to consult with people in isolated situations, whether geographically, culturally or socially, to ascertain their needs for training to enable them to contribute fully to developing sustainable work practices and lifestyles [United Nations (UN) 1992:225]. In January 2005 the UN General Assembly launched the DESD (Haigh 2006). The UN Educational, Scientific and Cultural Organization (UNESCO) was tasked to lead the DESD and draft the international implementation scheme (Tilbury 2009; UNESCO 2005). However, the UN DESD also identified the need to reorientate teacher education towards sustainability: 'education systems will need reshaping. Teacher education system should prepare teachers for active/interactive learning processes, rather than a one-way transfer of knowledge' (UNESCO 2005:22).

UNESCO also prepared guidelines and recommendations for reorientating teacher education to address sustainability. The document outlined four thrusts for change in teacher education towards sustainability (UNESCO 2005):

- Change across institutions of higher education.
- Change within faculties of education.
- Change related to engaging pre-service and in-service teacher education.
- Change at the individual faculty member level.

To build on achievements and create new momentum after closure of the UN DESD in 2014, UNESCO, as the lead agency, developed a Global Action Programme (GAP) on Education for Sustainable Development (ESD) (UNESCO 2014) based on broad consultations and input from a wide range of stakeholders. The GAP on ESD launched in Nagoya, Japan, seeks to generate and scale-up action in all levels and areas of education and learning of the DESD to accelerate progress towards sustainable development.

The GAP focuses on five priority action areas:

- Advancing policy.
- Integrating sustainability practices into education and training environments (whole-institution approaches).
- Increasing the capacity of educators and trainers.
- Empowering and mobilising youth.
- Encouraging local communities and municipal authorities to develop community-based ESD programmes.

The GAP aims to implement a twofold approach to multiply and scale-up ESD action by, (1) integrating sustainable development into education and (2) integrating education into sustainable development. Corresponding to this overall approach, the programme has two objectives. The first is 'to reorient education and learning so that everyone has the opportunity to acquire the knowledge, skills, values and attitudes that empower them

to contribute to sustainable development', and the second is 'to strengthen education and learning in all agendas, programmes and activities that promote sustainable development' (UNESCO 2014:14).

Change that relates to engaging in-service teacher education is important, because it brings on board those practising teachers who are geographically and socially isolated from the benefits of higher educational provision that would enable them to develop sustainable work practices in primary schools. Objective 2 of the GAP to reorientate teacher education towards sustainability is therefore addressed by this research.

In the literature, reasons have been cited for lack of progress in engaging in-service teachers towards sustainability. Ferreira, Ryan and Tilbury (2007) as well as Firth and Winter (2007) argue that such efforts have tended to engage mainly teachers who are already interested in or committed to environmental education. It is further argued that a critical obstacle to developing environmental education in schools has been the lack of in-depth training that reflects the spirit of the Tbilisi goals (Knapp 2000). The professional development of all teachers in environmental education is important because it will profoundly shorten the response time for achieving sustainability in schools (Hopkins & McKeown 2002).

The National Department of Environmental Affairs (DEA) of South Africa (SA) engaged the university to which one of the authors is attached to respond to the goal of developing environmental education expertise amongst in-service teachers in SA. Four short elementary programmes on environmental education were presented in four provinces of SA, namely Limpopo, Free State, Mpumalanga and Northern Cape. These programmes engaged in-service teachers with environmental education

expertise, officers with environmental science expertise, as well as teachers without the expertise of environmental education, following the Tbilisi principles of environmental education (Breiting 2009; Charoensilpa *et al.* 2010). In general, the Tbilisi principles propound that environmental education must be offered to all age groups and that all the subjects of the school curriculum must be used to address environmental issues (Wright 2002).

The aim of this chapter is to report on to what extent the short environmental learning programme developed understanding of environmental education concepts amongst select in-service primary school teachers in the four above-mentioned provinces. It first presents the statement of the problem, followed by the conceptual-theoretical framework upon which the investigation was based. The next section explicates the research design and methods. The results of paired *t*-tests are then presented to show change (or not) in the understanding of environmental education concepts before and after the short environmental learning programme. A discussion in view of the conceptual and theoretical framework follows. Finally, some recommendations are made regarding improvement of praxis and policy implications for environmental education in SA.

■ Problem statement

The South African Curriculum Assessment Policy Statement (CAPS) as part of the National Curriculum Statement (NCS) pronounced the inclusion of environmental concepts in all subjects of the school curriculum (CAPS, South Africa. Department of Basic Education 2009). A need exists for the professional development of teachers in environmental education because it provides them with the expertise to include environmental

issues in school subjects (Chepesiuk 2007; Loubser, Swanepoel & Chacko 2001). The DEA sponsored the Geography and Environment Education subject group at the university, to which the authors are attached, to develop and present an elementary short environmental learning programme aimed at developing understanding of environmental education concepts and principles amongst select in-service primary school teachers in the above-mentioned provinces. The programme was built on the Tbilisi principles and was presented with the goal of empowering these teachers with practical hands-on knowledge and skills to be able to include environmental concepts in all subjects of the school curriculum in line with the NCS.

The Tbilisi principles constitute the framework, principles, and guidelines for environmental education at all levels. The principles were adopted at the world's first intergovernmental conference on environmental education organised by UNESCO in cooperation with the UN Environment Programme (UNEP), convened in Tbilisi, Georgia (USSR) in October 1977. These principles played a crucial role in providing the fundamental principles for ESD and were reaffirmed at the RIO +20 conference by the General Assembly of the UN on 27 July 2012 (UN 2012).

To improve praxis, these short environmental learning programmes were researched with the following research questions as guidelines:

- What is the in-service primary school teachers' understanding of selected environmental concepts?
- What is the in-service primary school teachers' understanding of selected environmental education principles?
- What change occurred in the in-service teachers' understanding of environmental education concepts and principles?

■ Conceptual-theoretical framework

‘Environmental education’ and ‘environmental concepts’ are relevant for the empirical part of this research. The manner in which these concepts were integrated with the social cognitive theory (Louw, Louw & Van Ede 1998), which informs this report, is also explained.

The role, status and scope of environmental education are contained in the White Paper on Education and Training, the National Environmental Management Act and other South African national curriculum documents (Maila 2003). For the purpose of this research, environmental education is defined as the intellectual tasks of critical appraisal of environmental situations, and the formulation of a moral code concerning such environmental issues (Stevenson 2007). The ultimate goal is to promote environmental learning for in-service teachers in a school context.

The term ‘environmental concept’ is important because it is believed that it will strengthen the environmental education process (Jain & Raghunathan 2001). In this research ‘environmental concepts’ include but are not limited to biodiversity, conservation, water and waste management and energy and sustainable development. Understanding of these concepts could strengthen the environmental education discourse if they are linked to the social, economic and environmental diversity of the school subjects taught in South African primary schools (Breiting 2009; Lubchenco 1998; Rickinson 2001; Werther & Chandler 2010). This implies that environmental education must be implemented in Life Sciences, Geography, Life Orientation, Business Studies, Economics, Agricultural Science, Natural Sciences, Social Sciences, Economic and Management Sciences, Technology and Mathematics, as reflected in CAPS. This can be

possible only when the teachers have an understanding and praxis of environmental issues based on the Tbilisi principles.

Development of the in-service primary school teachers' environmental education understanding was pursued following Bandura's social cognitive theory, because it aims to integrate the cognitive and behavioural aspects required to teach environment issues (Louw, Louw & Van Ede 1998). The strength of the social cognitive theory is that it synthesises cognition and behaviour, and in this way can help to bridge the rigid divisions that may exist between understanding and practical action (De Wit 2009; Slavin 2006). It asserts that teachers alter their personal cognition and behaviours through imitation, modelling and observation of behaviour (Louw *et al.* 1998). For this study 'cognition' refers to in-service teachers' knowledge of environmental education concepts. The word 'behaviour' is used here to refer to the process for teaching environmental concepts, designing lesson plans, and teaching and assessing environmental education concepts through the in-service teachers' subject areas.

The following four major propositions of social cognitive theory, which are essential to develop understanding of environmental education concepts amongst the in-service teachers, were borrowed from Gibson (2004:197):

1. *Observational learning's four elements*: Attention, which maintains that people must attend to the important components of behaviour being modelled; retention asserts that people must be able to remember the modelled behaviour; behaviour production is the process of translating the observational learning into performance by rehearsing, in which participants gradually adjust their behaviour based on self-observation.

2. *Reciprocal determinism*: Behaviour, cognition, other personal factors and environmental factors all operate interactively as determinants of one another.
3. *Self-regulation behaviour*: People learn the standard of behaviour, which then becomes the basis of self-evaluation.
4. *Self-efficacy*: One's ability to organise and execute given types of performances. Positive self-efficacy is built upon a strong base of knowledge and skills (Burney 2008). Bandura (1997) described self-efficacy as a future-oriented belief about the level of competence a person expects that he or she will display in a given situation. On the whole, self-efficacy relates to perseverance, which means the stronger the self-efficacy the greater the perseverance and the greater the perseverance the greater the chances that teachers' behaviour will further improve. A person's behaviour is partially shaped and controlled by the influences of social networks, such as social systems, and the person's cognition, such as expectations and beliefs (Chiu, Hsu & Wang 2006).

The social cognitive theory was relevant for this study because the researchers used its propositions to assess the development of understanding of environmental education concepts amongst in-service teachers who attended the short environmental learning programme. The propositions adopted from social cognitive theory were operationalised in this study in the following manner:

- Observational learning was used in the process of influencing the self-efficacy and outcomes expectation of the in-service teachers, so that they developed new knowledge and the behaviour required to teach environmental concepts. In this process the facilitators used the experiences of the in-service teachers to demonstrate how to plan, teach and assess the environmental concepts in the various subjects.

- Behaviour production is the process by which the in-service teachers practised the planning, teaching and assessment of environmental concepts at the short learning programme, using the perspectives of their subjects. Behaviour production comes after various ways of connecting environmental concepts to the subjects of the in-service teachers have been explored and discussed with them. The strategies used are engagement, facilitation and demonstration (Rickinson, Lundholm & Hopwood 2009).

Observational learning and behaviours production mentioned above are thought to build an attitude of self-efficacy amongst in-service teachers, which engenders their motivation and ability to teach environmental concepts in their own setting with self-regulation, thereby ensuring that they apply standards of behaviour for the teaching of environmental concepts in their school settings.

The purpose of developing these propositions of social cognitive theory amongst in-service primary school teachers is not an end: the propositions are required because these should be transferred in their respective schools and subjects. Through developed knowledge and behaviour, teachers can therefore plan, teach and assess environmental issues to integrate them into their respective schools and subjects. The development of environmental education concepts is not a one-way transfer of information but a two-way exchange of environmental education concepts that can lead to transformative learning. The in-service teachers, therefore, requested that assumptions and expectations be modified by designing the short learning programme to be more inclusive and reflective (Mezirow 2003).

Mezirow (1997) described transformative learning as a route to the development of critical thinking. Mezirow's transformative learning

theory provided the theoretical foundation for this process to transform to more sustainable living. The theory offers an explanation of the learning process underlying this journey. Transformative learning theory describes how individuals encountering situations, knowledge or attitudes which conflict with their understanding of the world may engage in a process of critical reflection and discourse in which they question and analyse their foundational beliefs, attitudes and perspectives. Such reflection may lead to a shift in their attitudes, values and behaviours or, potentially, result in a transformation of their world view.

Social cognitive theory adopts an agentic perspective to change (Bandura 2002, 2003). An agentic perspective is the ability to shape the experience and environmental events (Bandura 2002). There are various forms of agency. Personal agency is exercised individually and is related to the process in which the teachers bring their influence to bear on their own functioning and environmental events. Proxy agency is exercised socially and relates to the process by which the teachers use the influence of those with resources to determine their functioning and control of environmental events. The notion of collective agencies entails that teachers do not live in autonomy but seek to achieve things by working together through interdependent efforts (Bandura 2000, 2002, 2004, 2006).

An aspect of contentious dualism normally manifests itself amongst personal agency and social structure, self-centred agency and communality as well as individualism versus collectivism (Bandura 2000). The contested dualism holds that forms of agency operate separately and without interaction and interchange (Internet Encyclopedia of Philosophy n.d.). However, developing sustainable work practices in primary schools does not require operations that are isolated from the broader environment.

For this study these forms of agency are important because they promote the teaching of environmental education based on the Tbilisi principles. It is therefore maintained that the planning, teaching and assessment of environmental education concepts require individual teachers' knowledge and behaviour that are socially constituted and implemented in their respective schools through their interdependent efforts.

Based on the above conceptual-theoretical framework, an empirical study was undertaken aimed at developing the understanding of environmental education concepts amongst a sample of in-service primary school teachers in four provinces of SA.

■ Research design and methods

The empirical investigation was embedded in a quantitative research design because it presents statistical data relating to teachers' elementary understanding of environmental education concepts in selected South African primary schools (Creswell 2009).

The knowledge, beliefs and consciousness of the in-service teachers were developed by presenting various areas of environmental education at the workshops. These included: introduction to environmental issues, principles of environmental education, teaching strategies in environmental education and the assessment of environmental education. The environmental education concepts and principles were then selected from these units and used to evaluate the teachers' understanding thereof.

■ The survey

The following research questions were posed: (1) What are the in-service primary schools teachers' understanding of selected environmental

concepts?, and (2) What are the in-service primary school teachers' understanding of environmental education principles? To answer these research questions a survey was initiated to collect data from the selected in-service teachers at short learning programmes presented in the four mentioned provinces of SA. This was done using a structured questionnaire which consisted of closed-ended questions with a list of selected environmental education concepts and principles covered during the learning programme. The following scale was used to evaluate and determine the selected environmental education concepts and principles: 1 = Strongly agree, 2 = Do not agree, 3 = Partly agree, 4 = Agree.

Population and sampling

The population for this study consisted of primary school teachers from the four mentioned provinces ($n = 155$). The schools were selected by the DEA. A stratified random sampling technique (McMillam & Schumacher 2010) was used because in-service school teachers were drawn from subsets of rural, urban and township schools.

Data collection process, ethical considerations and analysis

The collection of data from teachers in the four provinces proceeded over a period of one year in the following sequence: Limpopo on 05 and 07 July 2012, Free State on 09 and 11 July 2012, Mpumalanga on 27 and 28 June 2013 and Northern Cape on 25 and 27 September 2013. It was important to use the same questionnaire for the in-service teachers in all four provinces because the course material was similar and taught at primary school level. The in-service teachers in the different provinces did not have contact with one another.

Two surveys were conducted in each province. Survey A provided the baseline data and examined the in-service teachers' pre-existing understanding of environmental education concepts and principles before they were introduced to the material of the environmental education short learning programme. Thereafter, course materials were presented during a 3-day workshop to introduce the in-service teachers to some environmental education concepts and principles. A follow-up survey (Survey B) was administered on the last day of the workshop. Data from Survey A and Survey B document the change that occurred in the in-service teachers' understanding of environmental education concepts and principles.

As part of the process of informed consent and voluntary participation, all the teachers who attended the workshop were informed of the objective of the study. It was explained to them that non-participation would cause them no harm and that their privacy and anonymity would be strictly protected.

The collected data were captured and analysed by the university's Statistical Consultation Services using the Statistical Package for Social Sciences (SPSS) (Connolly 2012). SPSS was also used to calculate the means and standard deviations and the paired *t*-test and *p*-values (Hoy 2010; Mertler & Charles 2008). The difference between the means of the different surveys was used to calculate the Cohen's effect sizes *d* (Cohen 1988). Significant differences were identified as occurring between Surveys A and B. The Cohen's effect sizes show the extent to which the environmental education concepts amongst in-service teachers were developed after the short learning programme. The following criteria were applied to evaluate the Cohen's effect sizes (Cohen 1988) *d*-values: 0.20 = small effect size, 0.50 = medium effect size, 0.8 = large effect size and practically significant effect.

■ Results

The empirical data show the teachers' understanding of environmental concepts and of environmental education after administration of Surveys A and B.

■ In-service teachers' understanding of selected environmental concepts

To assess change relating to the in-service teachers' understanding of selected environmental concepts, a paired *t*-test was used to compare group means for Survey A (onset) and Survey B (after the workshop). The results are shown in Table 9.

Table 9 shows no effect between means for concepts 1, 2, 3, 4 and 5, and because the *d*-values are below 0.20 ($p > 0.05$). This suggests that the teachers had pre-existing knowledge about these concepts as perspectives pertaining to these concepts did not change after the short learning programme at the workshop. Table 9 also shows small effect size (0.20, $p > 0.05$) for concept 7, 8, 9, 10 and 15. It also shows a medium effect size (0.50, $p > 0.05$) for concepts 10, 13, 16 and 21 and a large effect size for concept 11 (0.50, $p > 0.05$). These small, medium and large effect sizes seem to suggest that in-service teachers acquired new knowledge about the role of human beings in the environment, waste management and sustainable development.

■ In-service teachers' understanding of environmental education principles

To assess change in the teachers' understanding of environmental education, a paired *t*-test was used to compare group means for environment

TABLE 9: In-service primary school teachers' understanding of environmental concepts after administration of Survey A and Survey B.

Selected environmental concepts	Survey A		Survey B		Paired-sample t-test		
	Mean	SD	Mean	SD	t	p	d
1. Indigenous plants agree with the local environment	3.80	632	3.85	558	115	0.91	0.01
2. Indigenous plants are part of our heritage	3.86	550	3.76	741	122	0.90	0.01
3. Alien plants overcrowd our own indigenous plants	3.23	1.003	3.53	706	551	0.95	0.01
4. Indigenous plants use less water	3.49	1095	3.53	1.080	1.573	0.77	0.03
5. Fresh-water resources of the Earth are only important for human use	2.37	1.262	2.15	1.258	2.32	0.08	0.14
6. Conservation of biodiversity is a waste of money	1.80	1.132	1.64	962	902	0.37	0.09
7. Littering removal campaigns must be organised by schools on a regular basis	3.49	658	3.32	1.007	2.819	0.05	0.27
8. Energy-saving globes are negative for the environment when thrown away	2.89	1.207	3.24	1.091	2.721	0.0.3	0.25
9. Plastic shopping bags should be provided free of charge	2.44	1.374	1.81	1.037	2.456	0.02	0.36
10. Polystyrene is the best packaging material for take-away foods	2.86	1.167	2.32	1.296	1.609	0.01	0.45
11. Humans were created to reign over nature, plants and animals	3.04	1.220	2.30	1.305	3.551	0.00	0.71
12. Development of urban areas must not be restricted	2.60	1.241	2.41	1.184	863	0.45	0.03
13. Sustainable development is a concept to ensure the growth of the economy	3.63	598	3.41	1.076	1.186	0.01	0.39
14. Infrastructure in remote towns should be developed by the government to curb urbanisation	3.33	890	3.38	779	1.244	0.749	0.04
15. Job creation in SA must get preference over nature conservation	3.83	1.339	2.41	1.328	141	0.01	0.28

Table 9 continues on the next page →

TABLE 9 (Continues...): In-service primary school teachers' understanding of environmental concepts after administration of Survey A and Survey B.

Selected environmental concepts	Survey A		Survey B		Paired-sample t-test		
	Mean	SD	Mean	SD	t	p	d
16. Man is the most important organism in creation	3.38	1.101	2.64	1.411	1.601	0.02	0.50
17. Non-renewable resources like coal and iron-ore must be fully used whilst still available	2.47	1.237	2.21	1.318	2.611	1.00	0.10
18. Nature and wildlife areas should be extended to ensure economic growth	2.47	1.237	2.21	1.318	2.611	0.010	0.32
21. Residents must collectively take responsibility to keep parks neat and clean	3.33	0.736	3.92	0.277	2.084	0.05	0.49
22. Neatness of parks is the exclusive responsibility of municipalities	2.44	1.374	1.81	1.037	2.456	0.02	0.36

Significance of the $p > 0.05$. Significance of the $d > 0.20$.

education and related concepts between Survey A (onset) and Survey B (after the workshop). The results are shown in Table 10.

Table 10 shows no effect between means for principles 23 and 24 because the *d*-values are below 0.20 ($p > 0.05$). This suggests that the teachers had pre-existing knowledge about these principles as perspectives pertaining to these concepts did not change after the short learning programme at the

TABLE 10: In-service primary school teachers' understanding of environmental education principles after administration of Survey A and Survey B.

Selected environmental education principles	Survey A		Survey B		Paired-Sample t-test		
	Mean	SD	Mean	SD	<i>t</i>	<i>p</i>	<i>d</i>
23. How to utilise diverse learning environments and a broad array of educational approaches to teaching, learning about and from the environment with due stress on practical activities and first-hand experience	3.68	589	4.00	0.00	2.694	0.41	0.07
24. How to enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences	2.80	1.307	2.66	1.353	766	0.39	0.11
25. How to be interdisciplinary in approach: drawing on the specific content of each discipline in making a holistic and balanced perspective possible	3.88	327	3.00	1.136	1.432	0.00	0.40
26. How to relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in the early years	2.91	1.050	3.39	1.046	3.302	0.00	0.48

Source of environmental education principles: UNESCO/UNEP (1977). Significance of the $p > 0.05$. Significance of the $d > 0.20$.

workshop. Table 10 also shows a medium effect size (0.50, $p > 0.05$) for principles 25 and 26. This result suggests that in-service teachers acquired new practical knowledge regarding the interdisciplinary application of environmental education and relating environmental sensitivity, knowledge, problem-solving skills and values clarification to every age.

■ Discussion

The schools that participated in the workshops were nominated and fully sponsored by the National DEA. In general, the short environmental learning programmes during workshops were well attended because they took place during the school holidays. This suggests that in-service school teachers seemed to derive encouragement from embracing environmental education concepts. The Tbilisi principles selected for the study are those that link the various phases of the South African school curriculum: early childhood phase, intermediate phase, senior phase and further education and training phase; those that touch every learning area as well as those that focus on problem-solving using the learner experiences and a diversity of teaching methods (South Africa Department of Basic Education 2009; UNESCO/UNEP 1977).

■ In-service teachers' understanding of selected environmental concepts

Moseley, Reinke and Bookout (2002) argue that one way to evaluate teacher effectiveness is through self-efficacy. Bandura (1997) defined self-efficacy as 'a belief or judgment of his or her capabilities to bring about desired outcomes of learners engagement and learning' (Tschannen-Moran & Woolfolk Hoy 2001:743).

In addition, Schmidt (1996) states that teachers should be knowledgeable about the environment to effectively instruct in environmental education. Based on observation of the baseline data and post-baseline data (Tables 9 and 10), it can be concluded that the in-service teachers could be effective in teaching some environmental concepts because they had some pre-existing knowledge and understanding of some environmental education concepts. These concepts relate to the conservation of biodiversity. Much of the knowledge and understanding which in-service teachers had before the short learning programme apparently stemmed from their cultural interaction with environmental issues. This can be said because teachers seemed to have a good grasp of concepts such as the role of indigenous plants and their effect on water resources, the impact of alien plants on the environment and the importance of fresh-water resources.

Although the in-service teachers had pre-existing environmental knowledge, which could determine their teaching effectiveness, Table 9 shows that they developed understanding of new environmental concepts during the workshops, as a small effect size, medium effect size and large effect size were obtained for these concepts. The new concepts that in-service teachers seem to have acquired relate to the following:

- Littering and removal campaigns must be organised by schools on an ongoing basis.
- Energy-saving globes must be used widely to save the environment.
- The need for and reason why plastic shopping bags should not be provided free of charge.
- The need to use paper bags instead of polystyrene in the packaging of take-away foods.
- The need for residents to take collective responsibility to keep parks neat and clean.

- The need to work closely with municipalities to ensure the neatness of parks.
- Job creation in SA must not be given preference over conservation.
- What sustainable development is about in the context of economic growth.
- Human beings were not created to reign over nature irresponsibly.
- The role and importance of other species or components of biodiversity.

These new concepts seem to relate to knowledge skills and values required for collective responsibility and commitment for waste management. In the draft White Paper on integrated pollution and waste management for South Africa, the Department of Environmental Affairs and Tourism (1998) asserts:

[T]he government will promote pollution and waste management by increasing the awareness of and concern for pollution and waste and assisting in the developing of knowledge skills values and commitment for successful integrated management. (n.p.)

However, the results suggest that the goals of the White Paper are yet to be attained, especially amongst the schools participating in this case study. Therefore, it can be concluded that there is a need for further education and training regarding waste management in primary schools. This integration of waste management concepts in schools needs to be linked to the paradigm of sustainable development.

■ In-service teachers' understanding of environmental education principles at selected South African primary schools

In-service teachers displayed pre-existing understanding of environmental education principles that could be helpful in designing effective strategies.

Firstly, they understood how to utilise diverse learning environments and a broad array of educational approaches to teaching, learning about and from the environment, with due stress on practical activities and first-hand experience. Secondly, they understood how to enable learners to participate in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences. These pre-existing ideas could be helpful in designing more effective teaching strategies for environmental education in primary schools (Rickinson 2001).

The in-service teachers developed new understanding of environmental education principles at the workshops relating to the following:

- How to create an interdisciplinary approach, drawing on the specific content of each discipline in making a holistic and balanced perspective possible.
- How to relate environmental sensitivity, knowledge, problem-solving skills, and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years.

The above principles emphasise the need to strengthen the in-service support regarding how teachers could restructure their lesson plans to integrate environmental issues. The other aspect emanating from these results relates to how to use the Tbilisi principles in environmental education teaching

■ Recommendations and policy implications

In-service teachers should be assisted in a very practical way to transfer their understanding of environmental education concepts and principles

to their subjects at their respective schools. The social cognitive theory promotes cognition and behaviour that could assist with the promotion of practical skills for the interdisciplinary planning, teaching and assessment of these concepts. One way of assisting them to reach this goal after a workshop is to give post-training which promotes cognition and behaviour inherent in the social cognitive theory (Schroeder, Wingard & Packard 2002). Post-training is a process of giving additional support to in-service teachers once they have completed a short learning programme on environmental education. To initiate this post-training, the common obstacles that in-service teachers may encounter with regard to transferring knowledge and skills to their respective schools must be identified.

The following could be viewed as some potential obstacles (Johnson 2006; Niemi 2006; Urdan & Schoenfeld 2006):

- School management may not offer enough support for environmental education.
- Lack of material for delivering environmental education concepts.
- Teachers may lack enough motivation and incentive for environmental education.
- Teachers may not have enough time to practise new environmental education skills.
- Co-teachers may apply peer pressure against changing methods.

The researchers are of the opinion that the above and other obstacles could be addressed by establishing support groups at schools as part of the post-training strategy (Orpinas & Horne 2004). The support groups should work with the school management teams (SMTs) and convince them of the importance of interdisciplinary teaching of environmental education concepts. The support groups should be encouraged to share the video material from the short learning programme with SMTs so that they also

develop understanding of environmental education concepts and principles, and meet regularly to discuss problems, amongst others obstacles encountered and problems applying the new skills and practice. The work of small groups at school should embrace the propositions of social cognitive theory.

There is also a need to develop understanding of the draft White Paper on integrated pollution and waste management for SA at school and management level. This is important because the results of the study show that most of the concepts that relate to waste management were new to the in-service teachers. SMTs should be encouraged to use the draft White Paper as a management tool. Teachers must also be encouraged to select topics from the draft waste management policy and teach and assess them through the eyes of their learners and beyond their subjects.

This is important because they guarantee the need for schools to practise what they teach and also assist schools to become agents for implementation of the White Paper. The researchers are of the opinion that this attitude would further enhance the development of environmental education understanding and practices related to waste management.

There is a need to continue engaging with the teachers in schools that have participated in the environmental learning programme, because this would enable teachers to keep in contact to encourage retention of the material and put the developed knowledge and skills into action. The most obvious way to facilitate this activity is to provide an online facility (Ho *et al.* 2008; Hung 2006) that enables teachers to keep in email contact with one another. Ho *et al.* (2008) argue that online facilities are becoming more embedded in many higher education institutions around the world because they are flexible, provide a variety of assessment tools and enable communication between the different users.

Finally, there is a need to continue with the post-training observations for an accurate assessment as to whether teachers have made permanent performance improvements based on social cognitive theory. It is also important to conduct continuous evaluation studies to determine the impact over a longer period. Evaluation of key outcomes should concentrate on asking whether practising teachers have been able to meet outcomes for the interdisciplinary analysis of environmental education concepts.

■ Conclusion

This chapter reports on efforts to develop understanding of environmental education concepts amongst selected in-service primary teachers in the provinces of Limpopo, Free State, Mpumalanga and Northern Cape in SA. The environmental learning programme that came out of this educational initiative was structured to promote skills for the practical application of interdisciplinary teaching of environmental issues in the various phases of the South African school curriculum. It offered an opportunity for in-service teachers to develop understanding about how to help learners to bond with nature and provide ecological solutions needed in environmental protection geared for sustainability.

These opportunities were deemed important for teachers, who are able to put learners on the path to sustainable development and able to teach transformational practices (Mezirow 1997). The development of environmental education understanding consistent with this exercise should not be a one-time event. It is important to continue supporting teachers along the lines of social cognitive theory because this bridges the gap between cognition and behavioural skills. This attitude would help school teachers to stay competitive and provide environmental learning best suited to changing realities and school conditions.

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■ Chapter 6: Summary

Past efforts to reorientate education towards sustainability have tended to engage with officials of the National Department of Education and teachers already interested in environmental education. The aim of this article is to report on research into the influence of a 3-day short environmental learning programme on developing understanding of environmental education concepts amongst in-service primary school teachers ($n = 155$) in four provinces of the Republic of South Africa. The research data were collected by means of a structured questionnaire survey comprising a baseline survey (Survey A) and a survey after the short environmental learning programme intervention (Survey B). Data collected were analysed using Cohen's effect size, which indicated that the programme provided in-service primary school teachers with new knowledge about environmental concepts and practical application of environmental education principles. This research can be used to improve the praxis of short environmental learning programmes in environmental education for sustainable development. Post-training support and continuous evaluation are recommended.

Meeting the challenges of teacher quality demands – A model for WIL

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No matter how much formal education and training people receive, they will not really be equipped for a position of responsibility unless they have the ability to learn from their experience.

- Boud & Walker 1991:9

■ Introduction

The critical role which quality early childhood education (ECE) plays in addressing the poor educational standards in schools is widely accepted.

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Duncan *et al.* (2007) report on an investigation involving close to 36 000 preschoolers, confirming that children's early academic and attention skills are the best predictors of later school success. Similar studies showed concurring results (Barnett 1998; Bouguen *et al.* 2013; Burchinal *et al.* 2009; Fantuzzo *et al.* 2005; Marcon 2002; Taguma, Litjens & Makowiecki 2012).

Whilst the importance of quality ECE is indisputable, reference is also made to studies indicating that inappropriate early childhood programmes may do more harm than good (Anderson *et al.* 2003; Burchinal *et al.* 2009; Marcon 2002). Findings by The Schuyler Center for Analyses and Advocacy (2012) show that young children who spend excessive hours in poor-quality childcare characterised by low staff qualifications are more likely to have higher levels of the stress hormone cortisol and to develop social, emotional and behavioural problems.

In developing countries such as South Africa, unqualified persons often have the responsibility to prepare children for formal schooling in an informal and unstructured preschool system. The South African Government came to realise the critical role of quality early childhood programmes in later academic success of learners, and a comprehensive ECE initiative has been launched. This initiative includes access to a quality reception year (Grade R) for all 5 to 6-year-old children by 2019 (South African Department of Basic Education (DBE) 2013:5).

Although access to early childhood care has increased, the quality of learning- readiness programmes offered, especially in schools serving low socio-economic status communities, often do not meet the required standard (Van den Berg 2012; Welsh *et al.* 2010). Whilst factors such as

a lack of resources and poor teacher remuneration contribute to the poor quality, the biggest concern is insufficient qualified Grade R teachers to provide quality Grade R education to all 5 or 6-year-olds in their mother tongue (Excell & Linington 2011:9; Welsh *et al.* 2010). The DBE advises under- or unqualified practising Grade R teachers to attain an accredited qualification (South African DBE 2011:82). Whereas distance learning (DL) is often the only way in which under- and unqualified practising teachers can attain a qualification, higher education institutions (HEIs) are offering qualifications via DL to supply the dire need for qualified Grade R teachers. However, the practice-based disposition of Grade R education poses various challenges to DL programme design and delivery.

■ Problem statement

Concern regarding HEIs offering substandard teacher education is shared by many in the field (Centre for Development and Enterprise 2015; Taylor 2015; Welch 2008:329). This concern is not limited to the South African context, as is evident from the following admonition by Darling-Hammond (2010):

Programmes that do not prepare all of the teachers they train extremely well and cannot transform themselves to do so need to get out of the business of teacher education – and they need to do so quickly. (p. 39)

Related literature specifically expresses concern about the capacity of DL programmes to develop professional competencies of teachers through applied practice (Binns & Wrightson 2006:8; Creed 2001:18; Paige, Chartres & Kenyon 2008; Upko 2006:260). This concern is understandable, where Frawley (2013:22) upholds that all teacher

education programmes should support the development of a deep understanding of teaching which comes from ‘doing – interpreting, manipulating, analyzing, reflecting – not in isolation, but in contact with others’. In light of this criterion it is evident that the practice-based disposition of Grade R education poses even more challenges to the design and delivery of DL programmes aimed to ensure a deep understanding of teaching and consequent applied competence as programme outcome. Designers of the Diploma in Grade R Teaching delivered via DL by a South African HEI were thus confronted with the following problem: How can the applied competence of Grade R teachers be ensured in a DL programme?

A thorough literature investigation was conducted in search for answers to the problem and as grounding for the work-integrated learning (WIL) component of the DL programme.

■ Research orientation

The literature investigation followed a constructivist paradigm (Guba & Lincoln 1994:109–111). According to this orientation the theoretical view is based on a concurrence in related research findings reported in the literature. The way the literature agrees regarding various aspects contributing to applied competences of teachers was thus interpreted and used to construct a model for effective DL programme design for Grade R teachers. Guba and Lincoln (1994:113) highlight that ‘constructions are subject to continuous revision, with changes most likely to occur when relatively different constructions are brought into juxtaposition in a dialectical context’. It is thus imperative that new literature and research findings, grounded in future programme evaluations, should serve to inform and refine this model.

■ Conceptual and theoretical framework

The literature confirms that the success and expected outcomes of the Grade R initiative will be determined by the quality and standard of teacher qualifications. Pasensie (2014:3-4) remarks that ‘quality education can only be delivered to five year olds if there is an investment in producing suitably qualified teachers, supported by appropriate in-service training programmes’. This pivotal role of teacher competence in quality Grade R education is confirmed by Excell and Linington (2011:4).

The DBE admits that mere enrolment in a Grade R class does not guarantee improved learning readiness and that special emphasis needs to be placed on ensuring that Grade R is of an acceptable quality (South African Department of Basic Education, 2011:29). A report on the impact of the Grade R initiative on later learning outcomes (Van den Berg 2012:3), pronounces that, notwithstanding a massive expansion in provision of Grade R in recent years, the effect of this initiative on later academic success remains poor. Insufficient teacher training resulting in a lack of deep understanding of how young children learn is blamed as one of the key causes for this poor impact. Related literature was scrutinised for concurrence regarding foundational principles of quality teacher education programmes to be supported by the DL programme for Grade R teachers.

■ Findings from the literature on foundational principals of applied competence as outcome of teacher education programmes

Whilst research confirms the value of quality early learning programmes, not only for learners but for the advancement of a country as a whole (South African Institute for Distance Education 2010), the critical role of the teacher in achieving the goals of the ECE initiative cannot be ignored.

Teacher expertise has more powerful effects on learner achievement than socio-economic status (Darling-Hammond, 2010:36). The ECE initiative will therefore not deliver the anticipated output if Grade R teachers are not competent and well prepared for their role as agents of change. Koster and Dengerink (2008) define a competent teacher as follows:

[S]omeone who is able to act appropriately (effectively) and professionally in a certain context. Somebody who is competent uses knowledge, skills, attitudes, personal characteristics and values with alertness to the specific situation and in an integrated way. (p. 139)

This definition implies that a quality teacher education programme supports the development of knowledgeable and competent Grade R teachers who can apply their knowledge in the most relevant way in practice.

The literature further concurs regarding critical foundational principles as keystones of effective teacher education programmes ensuring applied competence as programme outcome. Although numerous factors play a role in teacher education outcomes, four aspects came to the fore as predominant determinants of a programme that will effectively equip teachers for practice.

Pedagogical content knowledge

The first foundational principle stands central to all components of a teacher education programme, namely relevant pedagogical content knowledge (PCK). Attaining knowledge of learning content and the most developmentally appropriate way to present this content to learners should be guaranteed as an outcome of an effective teacher education programme (Darling-Hammond 2010:35; South African Departments of Basic

Education and Higher Education and Training 2011:4; Van Driel & Berry 2012:27). Shulman (1987) defines PCK as:

[T]he blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. (p. 8)

To enable student teachers to blend content and practice requires that the programme guides them to continuously reflect on the interrelationship between content and practice. Teacher education programmes should therefore focus student teachers' attention on the implications of content *for* practice but also the implications of contextual factors such as learner background and the specific context of the school. Contextual factors will also have specific implications for the teaching strategies employed. Whilst student teachers should be equipped to adapt content and teaching strategies to meet the specific learning needs of their learners and to accommodate socio-economic and cultural diversity, they should nevertheless adhere to curriculum requirements.

Applying PCK in practice

The second foundational principle of applied competence requires that student teachers have the opportunity to apply PCK in practice. Sheridan *et al.* (2009:396) stress that 'training alone is insufficient and ongoing support efforts are necessary to transfer knowledge to practice'. This is especially true regarding the training of teachers who will be required to lay a solid foundation for all learners in Grade R. Darling-Hammond (2010:36) further found that teacher education programmes that connect coursework directly to practice in much more extensive practicum settings contribute to improved programme outcomes, and that graduates of these kinds of programmes feel better prepared, are rated as more effective and contribute to effective learning in schools.

Learning in practice, however, requires guidance by a more knowledgeable person or mentor, especially in cases where the student teacher has little or no prior knowledge or experience of Grade R teaching. The following definition of mentoring by Shea (1992, in Fischer & Van Andel 2002) endorses the role of guided application of knowledge in practice:

([M]entoring entails) a developmental, caring, sharing, and helping relationship where one person invests time, know-how, and effort in enhancing another person's growth, knowledge, and skills, and responds to critical needs in the life of that person in ways that prepare the individual for greater productivity or achievement in the future. (p. 3)

A report on research evidencing that current Grade R programmes do not have a significant impact on later learning success in South African schools (Van den Berg 2012:29) recommends that in-service training programmes provide teachers with opportunities to see and practice best teaching. This report suggests that teacher education programmes link teachers' knowledge to practice through observations, simulations, role-plays and working in contextually appropriate model environments, supported by ongoing on-site mentoring. The literature thus clearly emphasises that teacher education programmes should support the application of practice under the guidance of a mentor in order to ensure the development of applied teaching competence.

Self-directed and professional attitude

A third foundational principle of teacher education programmes that surfaced from the literature involves the development of a self-directed and professional attitude regarding own learning, and an awareness of the critical role of the Grade R teacher in preparing the learner for formal learning. Critique by Shulman (1987:20) regarding insufficient support for

teachers in developing greater autonomy and teacher leadership is echoed by various educationists. There is a worldwide call for teacher education programmes to better equip teachers as reflective professionals who can act autonomously in the best interest of their learners (Ball & Forzani 2009:498; Excell & Linington 2011:9; Morrow 2007:20; Sheridan *et al.* 2009:380).

The interdependence between self-directed learning (SDL) and the development of a self-directed teaching practice is apparent in the following definition by Knowles (1975) of SDL:

[*SDL*] ... is a process in which individuals take the initiative, with or without the help from others, in diagnosing their learning needs, formulating goals, identifying human and material resources, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (p. 18)

The implementation of SDL by teachers can thus be regarded as a prerequisite for the sustainability of a self-directed practice, whereby the quality of teaching, and consequently also the quality of learning by learners, will be secured. The relationship between teacher self-directedness, attitude and the ability to reflect is pronounced by Dewey, who further highlights that attitudes or beliefs greatly determine reflectiveness and the way a teacher will take active control over education (Dewey 1933, in Grant & Zeichner 1984). This belief is shared by various authors such as Ahmad *et al.* (2013:27–29), Bryderhup, Larson and Trentel (2009), as well as Welch and Gultig (2002:24). A self-directed disposition towards own practice thus implies the competency to identify own strengths and weaknesses through critical reflection and to look for required knowledge and sources for the enhancement of own teaching practice.

Reflection as an element of SDL not only serves as a cognitive strategy to fill the gap between theory and practice (Korthagen 2011:45), but also

encourages deeper learning and offers a relevant framework for the development of professionals who will be lifelong learners, committed to continuous improvement of their practice (Henderson, Napan & Monteiro 2004). Boud, Keogh and Walker (1985:19) describe reflection as ‘a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciation’. Reflection on practice can therefore be described as the intentional evaluation of one’s own actions as well as the actions of others. Korthagen (2011:35) furthermore emphasises that through reflection teachers may develop a personal practical theory of meaningful teaching, which in turn plays a critical role in enduring changes in teacher behaviour as a result of changes in their belief system.

Boud, Cohen and Walker (1993) designed a model for reflection based on the theory that learning from experience can be enhanced through both reflection *in* action (reflection which occurs in the midst of experience), and through reflection *after* an event (reflection *on* action). Development of a reflective practice, however, not only refers to reflection *in* and *on* action but includes reflection on contextual aspects and analysis of aspects that may hinder or promote effective teaching and learning. These reflections then guide the planning *for* and implementation *of* teaching and learning experiences.

□ Accommodation of student teacher context

The development of a self-directed practice is strongly influenced by the fourth foundational principle, namely the way a programme recognises and *accommodates student teacher context*. Lave (1996:150) concedes that learning is situated as it is a function of the learning activity, context and culture in which it occurs. Recognition of student teacher context and

background through programme design and content is of exceptional importance because of the obvious interrelationship between student teacher context and reflection, as has been referred to before and highlighted by Korthagen (2011:35). Reflecting on the implication of theory for the improvement of own practice becomes meaningful when student teachers can relate to the content. Biggs (2003:31) highlights this relationship as follows: '[a]n important aspect to effective teaching is reflective practice, using transformative reflection, which enables teachers to create an improved teaching environment suited to their own context'.

It is thus apparent that teacher education programmes should not only involve knowledge which accommodates the context within which the student teacher will eventually apply the knowledge, but also develop teachers as professionals who are able to reflect on the implications of situational determinants for their specific teaching practice and to plan accordingly.

The literature concurs on the impact of situated factors such as teaching context and teachers' prior knowledge, as well as their understanding of teaching on the outcomes of teacher education programmes (Biggs 1999:60; Merriam 2001:3). Timperley (2008:6) infers that 'daily experiences in their practice context shape teachers' understandings, and their understandings shape their experiences'. In a developing country such as South Africa, where the community comprises various cultural groups and socio-economic discrepancies greatly influence the teaching context, student teachers gain practical experiences in diverse contexts, which hold significant implications for DL programmes. Programme design and content should be in congruence with a diverse student teacher profile, and the delivery should support the mastering of relevant theoretical knowledge as well as relevant

practical experience of the diverse student teacher population to support the linking of theory to practice. Only then will learning outcomes result in professional competency of teachers who are equipped to make a difference in the standard of education in the varying teaching contexts in which they may find themselves.

The interrelationship between the four above-mentioned foundational principles in the development of applied professional competence is clearly illustrated by Creed's (2001:6, 10) interpretation of quality teacher education programmes: 'Teacher education is the product of iterations between theory, practice and research; it is for developing a teacher's capacity for self-reflection and professional decision-making'.

Professional decision-making grounded in a sound PCK and informed by critical reflection can be pronounced as the ultimate goal of teacher education, as it will play a determining role in all teaching and learning activities. Where programmes further accommodate the diverse backgrounds of student teachers, they will be more able to make informed decisions relevant to their teaching context and in the best interest of their learners.

Findings from the literature on WIL implemented in DL programmes

Since the DL delivery mode is gaining momentum in teacher education, criteria for quality DL programmes for preschool teachers such as Grade R teacher education was also explored. Martha Lea (2000) investigated the effectiveness of a DL programme for ECE teachers in Norway, Iceland and Scotland. Although this research is quite dated, Norway is regarded as one of the most advanced countries regarding education, and findings based

on this model seemed fit to serve as a benchmark for effective programme design. Lea (2000) affirmed that quality programmes for preschool teachers should develop professional and competent teachers who can demonstrate qualities such as ‘responsibility, self-reliance, ability to reflect on theory as well as practice, problem-solving and communication, and willingness and ability to collaborate’. These competencies clearly concur with the foundational keystones of applied competence previously identified from the literature. Lea further stresses that personal determinants such as student teacher prior knowledge and situational determinants such as relevant learning through experience play a critical role in the process of deeper learning, which she views as a prerequisite for professional development and applied competence.

A study conducted in Australia (Green *et al.* 2010) focused on the development of pedagogy in an online programme. The reconceptualising of the programme was underpinned by the sociocultural environments of the target teachers as well as aspects such as social, self-directed, reflective, and experiential learning. Green *et al.* (2010:261, 270) believe that a greater sensitivity to the teaching context within which teachers live and work will contribute to improved professional development of early childhood teachers in online teacher education.

When benchmarking programmes from developing countries against those of developed countries, the difference in student teacher context and background should be taken into account. However, valuable lessons can be learned from these findings. Although these models rely heavily on information and communication technology (ICT) for knowledge transfer, both Green *et al.* (2010) and Lea (2000) put emphasis on the important role of student teacher reflection for meaningful WIL. DL programmes in less industrialised countries understandably rely less on

design features involving technology when seeking ways to support applied competence. Bof (2004) and Joia (2002) report on the implementation of a DL programme for primary teachers in Brazil (The Proformação). This model incorporates tutors, reflective journals and audiovisual resources as mechanisms to support applied competence. Although these authors report on the value of this programme in delivering decentralised training opportunities to a large number of teachers, they also report on challenges posed by poor socio-economic factors to the development and assessment of applied competencies of teachers through the DL programme. Glennie and Mays (2008: 49, 61) further admit that effecting improvements in classroom practice may require additional strategies in DL programmes in the African context. They suggest site-based assessment and support to ensure a change in classroom practice.

The literature is thus clear on the way in which quality DL teacher education programmes should provide opportunities for guided implementation of relevant PCK in practice, and the development of self-directedness where inquiry and reflection enable teachers to make informed choices for a practice relevant to the specific context of their school and learners. Applied competence as a programme outcome will thus greatly depend on the way in which the programme content, delivery and design accommodate these foundational principles. The relationship between these principles is illustrated in Figure 7.

Grounded in knowledge constructed from related literature, a work-integrated component was designed as part of the Diploma in Grade R Teaching. Mechanisms employed in the WIL model to accommodate the four foundational principles of teacher-applied competence are motivated from the literature in the following section.

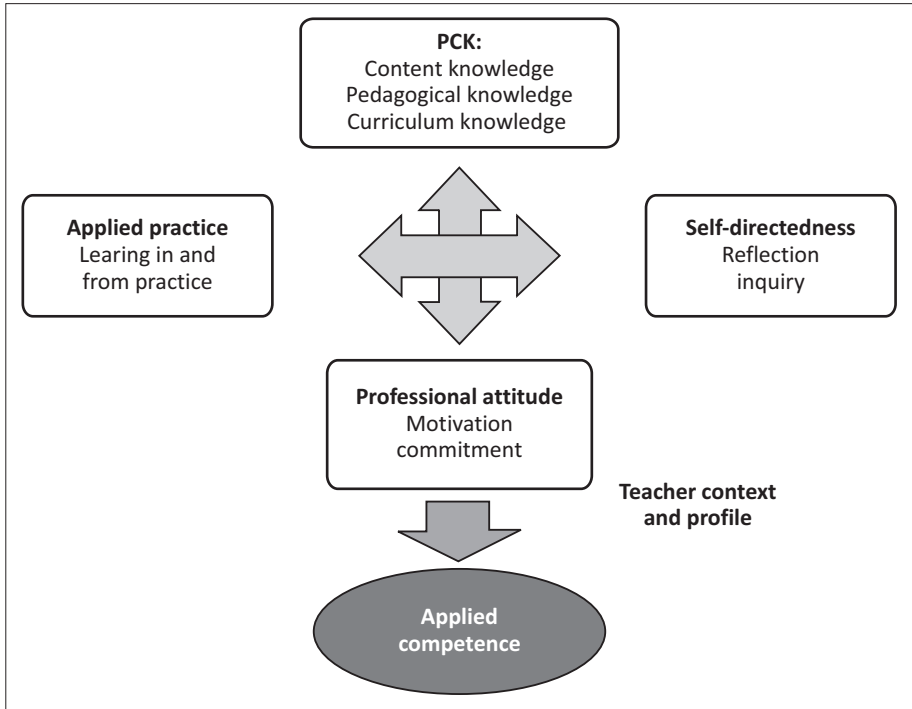


FIGURE 7: Foundational keystones of teacher applied competence [C. Kruger].

■ A model for WIL in an open DL programme for Grade R teacher education

The Diploma in Grade R Teaching, delivered via open distance learning (ODL) was launched by the HEI in 2013. This ODL model provides access to under- and unqualified practicing Grade R teachers in especially rural areas to attain an accredited qualification. In the ODL programme student teachers organise their own instructional timeframe and delivery modes increasingly use various forms of ICT for instruction. This particular ODL model includes synchronous design features – involving ‘real time’, simultaneous participation of student teachers and lecturers by means of

the interactive whiteboards implemented at more than 50² contact centres countrywide. Asynchronous design features that do not require simultaneous participation include detailed study guides and tutorials supporting the student teachers in self-regulated mastering of programme content contained in manuals and textbooks. Students can also access recorded presentations of modules and additional resources placed on the internet, whilst digital video disks with visual images of classroom practice and teaching and learning material further form part of the study material to support the linking of theory to practice in a self-regulated way.

However, the distance between lecturers and student teachers poses specific challenges in ensuring applied competence as a programme outcome and necessitates design features to substitute the teacher educator as mediator in the guided application of knowledge and skills in practice, as well as for formative assessment of applied competence. The utilisation of interactive whiteboards for direct transmission of lectures brought a whole new dimension to the ODL programmes offered by the HEI. This technology provides the opportunity for direct communication and interaction between student teachers situated in all parts of the country and their lecturers who are the specialists in the various academic modules. However, the open system of the DL programme, whereby student teachers organise their own studies and timeframe, as well as limited time available for whiteboard presentations, hamper the effectiveness of this technology as a mechanism to support applied competence.

Although this ODL model rates relatively high on student teacher support and delivery of programme content, sceptics in general question the ability of DL programmes to support the development of applied competence of Grade R teachers. The conventional ODL model of the HEI

.....
2. The number of centres is subject to change, depending on the student teacher population in specific areas.

also did not include guided WIL. The practice-based disposition of Grade R posed new challenges to programme designers. Educationalists advocate that programmes aimed at the professional development of ECE teachers should include WIL that will support the development of practice-based competencies as prescribed by PCK. The Department of Higher Education and Training (2015:52) furthermore requires that a WIL component forms part of the accredited Diploma in Grade R Teaching. Grounded in the theoretical framework, a WIL component was designed as part of the Diploma in Grade R Teaching at the HEI mentioned above. Figure 8

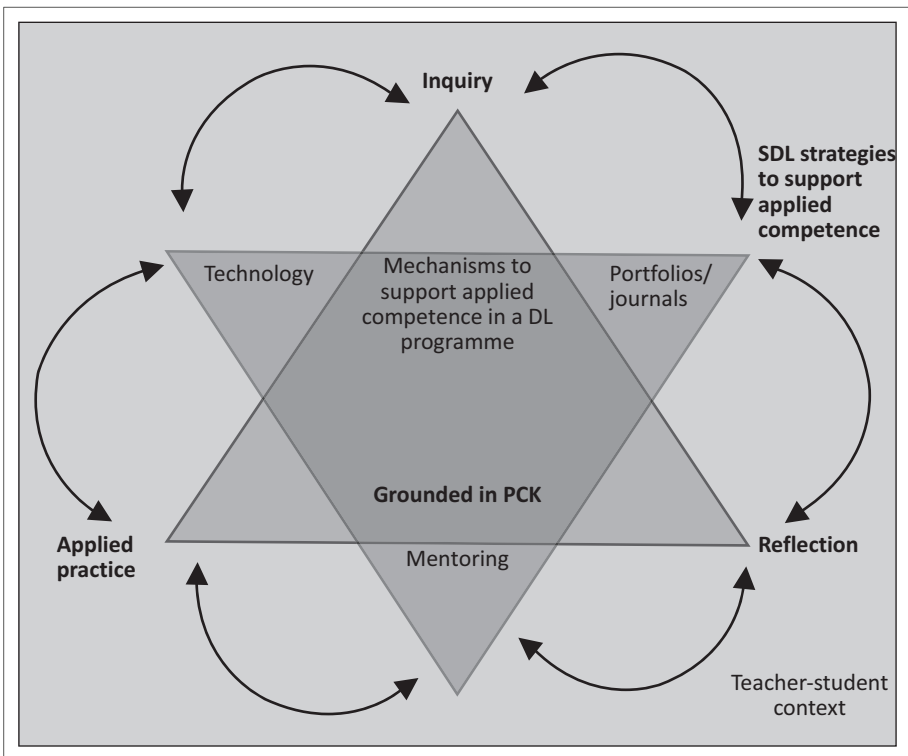


FIGURE 8: A work-integrated model to support applied competence in a DL programme for Grade R teachers [Kruger 2015:141].

illustrates the mechanisms employed to accommodate the four foundational principles of applied competence.

The upright triangle in Figure 8 represents the foundational principles with PCK central to all learning. The other keystones of applied competence entail opportunity for applied practice in a Grade R classroom as well as for inquiry and reflection as self-directed competencies. The student teacher context is ubiquitous and needs to be recognised by all programme design features as well as during assessment of WIL by the mentor and HEI assessors. The inverted triangle represents the mechanisms or strategies employed to incorporate the foundational principles and consequently applied competence. These mechanisms include technology, mentoring and a work-integrated portfolio.

Mechanisms to support implementation of the foundational components of applied competence

The importance of learning *in* and *from* practice in teacher education has already been explicated. According to Dewey (1938) experience influences the formation of attitudes of desire and purpose. Relevant and quality experience learning within a teacher education programme is recognised by various authors, such as Korthagen and Kessels (1999), Loughran (2007), Ortlieb (2013), Shulman (2003) and Tuli and File (2009), to name but a few. Student teachers need to be prepared to apply their knowledge according to the diverse context in which they may have to implement their knowledge and skills. The WIL component of the programme therefore includes a 15-day compulsory practicum period during each of the six semesters of the programme. Student teachers need to visit a Grade R class situated at a school registered with the DoE.

In order to guide, support and assess the development of applied competence and a reflective practice during the WIL period, programme

designers employ a WIL portfolio, a mentoring system as well as technology. These mechanisms are used coherently to support students in the application of PCK in practice as well as in the development of self-directedness through inquiry learning and reflection on theory and practice.

□ **The work-integrated portfolio**

A work-integrated portfolio is compiled by student teachers during the 15 days in practice for each of the six semesters of the 3-year programme. Although the portfolio serves as a means to provide evidence of learning in practice and as a mechanism to evaluate practical performance in relation to external evaluation requirements, it also serves to accommodate the keystones of applied competence.

The way in which a work-integrated portfolio could serve to scaffold the development of applied competence, and at the same time support a reflective practice and the development of a self-directed attitude, was explored by the programme designers. The value of a portfolio to support the development of applied competence through reflection has been documented by various researchers such as Orland-Barak (2005:27), Chetcuti, Buhagiar and Cardona (2011) and Monteiro (2003). Different portfolio models were compared with regard to purpose and design in order to identify critical and compatible features to form part of a WIL portfolio within the Diploma in Grade R Teaching.

For the purpose of the portfolio and as a way to link theory to practice, the academic modules that fall within a specific semester were grouped together to form 'module clusters'. Practical tasks were designed as an opportunity to apply relevant PCK contained in the respective modules of a cluster in practice. These tasks, set out in a work-integrated study guide, include observational tasks, practical teaching tasks as well as reflections on tasks and need to be implemented during the 15-day WIL period.

Apart from guiding student teachers in finding the relevant information to complete the tasks in a self-directed way through inquiry, these tasks also provide the opportunity for student teachers to develop an understanding of the integrated and holistic approach to teaching in Grade R. An example of such a cluster and integrated WIL task is demonstrated in Figure 9. A semester typically has two module clusters.

In compiling the portfolio student teachers need to provide evidence of:

- Reflection on theory and practice.
- Proof of implementation of work-integrated tasks.
- Formative assessment of work-integrated tasks by the mentor.
- Examples and artefacts of Grade R teaching and learning that illustrate their understanding of and critical reflection on effective practice.

Student teachers are guided in *reflection on theory* as well in *reflection on and in practice*. A reflective portfolio firstly guides the student teachers in their reflection on each academic module that forms part of the specific semester.

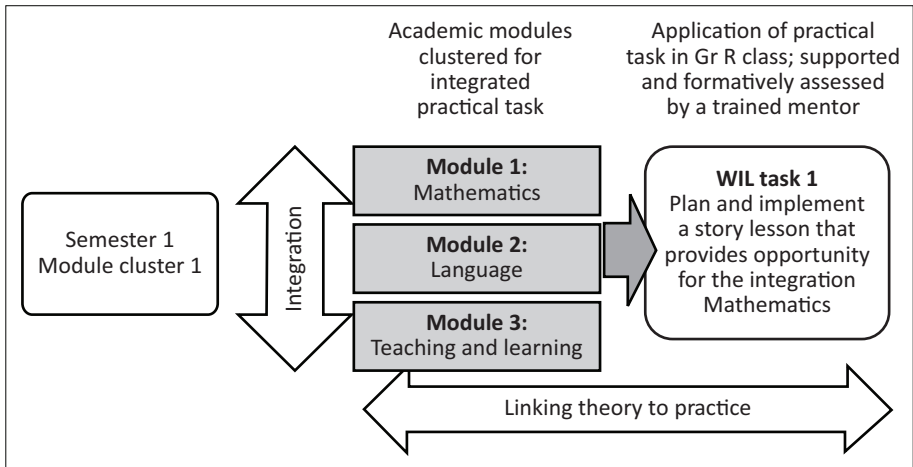


FIGURE 9: Example of a module cluster.

This reflection on theoretical content aims to lead student teachers to link theory to practice and to critically reflect on the implications of theoretical content for practice.

During the 15 days in practice (a minimum of three continuous weeks at a time) the student teacher also needs to keep a reflective journal by noting their daily reflections on their own learning *from* and *in* practice, as well as the learning taking place as a result of their teaching and observations of mentor teaching. Reflections are documented and filed in the WIL portfolio as evidence of a reflective disposition towards practice. The value of such a reflective journal for improved applied competence is acknowledged in the literature (Boud, Keogh & Walker 1996; Henderson *et al.* 2004). Dewey also noted that although experience plays a critical role in wisdom gathered by teachers, 'the store of one's wisdom is the result of the extent of ones' reflection' (Dewey, as quoted by Rodgers 2002:853). Keeping notes of one's experiences, critically reflecting on own strengths and weaknesses, and searching for ways to address deficiencies further support the development of self-directedness.

Student teachers are further guided to reflect on the context of the school. Reflection on aspects such as availability of resources, learners' background and possible strategies on how to adapt their teaching strategies accordingly aims to enhance learning and promote expert teaching. As confirmed by the literature (Korthagen 2010:102), reflection and experience are interrelated. The more student teachers are exposed to different teaching contexts and reflect on best practice for a specific context, the larger their future repertoire of solutions to choose from.

Shulman (2005) believes that higher education should not only focus on the development of 'habits of mind' but asserts that developing 'habits of the heart' plays an important role in all higher education as it results in

the marriage of reason, interdependence and emotion'. Student teachers are therefore also motivated to explore and reflect on their own feelings, values, beliefs and attitudes regarding Grade R education as collected over the 15 days practicum each semester. Various authors highlight the role of a portfolio in supporting the development of affective factors (Monteiro, Gomes & Herculano 2011; Orland-Barak 2005:27; Wade & Yarbrough 1996). Whereas a teacher's attitude and beliefs are informed by experiences and behaviour is in turn determined by beliefs, this reflection is believed to further support a self-directed approach to own teaching practice.

□ Mentoring

A qualified and experienced mentor should be available at the school where the student teacher implements WIL, as the mentor plays a crucial role in supporting and monitoring the development of applied competence in the student teacher.

Loughran (2006) highlights the important role of *reflection* and *shared learning* in the development of applied competence:

Learning through experience needs to be reflected upon and shared, as the nature of the deliberations within the teacher education learning community is critical to the development of pedagogy of teacher education. (p. 166)

Shared learning in the form of an experienced Grade R teacher who acts as mentor *for* and assessor *of* the student teacher's applied competence is implemented in this WIL model. Prescribed WIL tasks require collaboration between the student teacher and the mentor and thereby provide an opportunity for shared learning.

Apart from providing an opportunity for guided experience learning, mentoring also aims to support *reflective learning* within the context of the specific school. Where practical WIL tasks are based on specific academic

modules that form part of the semester; the mentor not only supports student teachers to reflect on their learning *in* and *from* the Grade R practice but also on the implications of theoretical content of the programme for practice. Where Loughran (2002:33) underlines the important relationship between time, experience, and expectations of learning through reflection, mentor assessment provides contextual anchors to make reflection on learning episodes more meaningful. Formative feedback by the mentor directly after teaching experiences provides a valuable opportunity for reflection *in* and *on* practice, which is otherwise not possible in a DL programme.

Fischer and Van Andel (2002:1) emphasise the value of a mentor who is prepared and equipped to support student teachers in their development of applied competence. The HEI therefore offers an accredited mentor training programme delivered to mentors in all parts of the country. Qualified and experienced teachers who are willing to act as mentors can register for the mentor training programme, after which they receive a mentorship qualification accredited by the South African Qualification Authority (SAQA). This training programme is delivered via the interactive whiteboard to relevant contact centres, and mentors also compile a portfolio as evidence of competence.

Lastly, the mentor is also responsible for formative assessment of student teachers' applied competence in practice. Banks, Moon and Wolfenden (2009:5) accentuate that assessment in DL programmes for teachers should relate to practice through formative modes of assessing, including the use of portfolios and competency models. Although the model proposed in this chapter requires student teachers to compile evidence of all aspects of applied competence in a portfolio which serves as a mechanism for summative assessment by the lecturer, mentor assessment serves as benchmark for the way in which the student teacher implemented specific WIL tasks in practice.

□ Technology

Although the implementation of ICT in the developing context has its limitations, interactive whiteboards as well as DVDs are utilised to support the development of student teachers' applied competence as far as possible. During arranged contact sessions lecturers explain the various WIL tasks to be implemented in practice via the interactive whiteboard. Presentations of academic modules typically make use of visuals such as video inserts based on classroom scenarios. During these presentations student teachers are not only guided to reflect on practice and theory, but also to link theoretical module content with practice. Student teachers have the opportunity to ask questions during real-time contact sessions as well as through email. Study guides furthermore continuously refer student teachers to visuals inserted on the DVD that form part of the study material. The audiovisual inserts of classroom practice as well as teaching and learning material on the DVD provides an additional opportunity for student teachers to reflect on practice and compare various practices and scenarios.

Student teachers are also beginning to use ICT as a means to provide evidence of their applied competence by placing additional visuals of their teaching experiences on a DVD or USB flash drive. Audiovisual recordings of student teachers' lesson presentations are also used for assessment of applied competence in cases where an accredited mentor is not available at the school where the student teacher is implementing WIL.

More research is needed to determine how ICT can successfully be employed to support and assess the development of applied competence of student teachers enrolled in a DL programme in a developing country such as SA. In cases where student teachers don't have access to ICT or lack technological competence, care should be taken that the use of ICT does not marginalise student teachers by hampering their progress or academic success.

■ Recommendations

Lessons learnt from the literature imply that the design of a DL programme for the training of Grade R teachers in the context of SA should not only include PCK but warrant meaningful learning *in and from* practice and consequent development of a reflective Grade R practice. This kind of learning requires a self-directed disposition towards own professional development and classroom practice. SA needs highly effective training programmes preparing all teachers to make a difference in the standard of education. The literature agrees that incorporating design features in a DL programme to accommodate the diverse profile of student teachers will support the development of a reflective practice within diverse contexts, and is anticipated to support all student teachers, irrespective of personal factors, to develop applied competence.

The literature confirms the value of social learning for improved applied competence. Student teachers enrolled for DL programmes often feel isolated, and ways should be explored to build a community of practice and for shared learning amongst student teachers. Mechanisms to support collaborative learning and peer support should be explored for possible accommodation in a revised model for WIL in a DL programme, such as:

- Forming of support groups so that student teachers in the same area can collaborate and reflect on theory as well as their classroom experiences.
- Using electronic social networks to provide a platform for student teachers to voice their problems and share solutions with peers.
- Blogs where student teachers can share their learning in practice and motivate peers to expand their applied competence.

As DL programmes require self-regulation and autonomous studies, further support regarding the development of self-regulatory skills such as critical reflection *on* and *in* practice as well as their academic literacy skills will contribute to the way in which these student teachers approach the DL course and consequent programme outcomes. Where teachers are motivated to use the opportunity for optimal professional development and become agents of change by laying a solid foundation for learning amongst the Grade R learners, this programme has the potential to make a huge contribution to the improvement of the educational standards of the country, if applied competence and reflective practice is ensured by the programme design and delivery.

Currently an investigation is under way to determine the level at which student teachers implement reflection in the reflective journal, in order to implement necessary support strategies to deepen reflective levels. Further follow-up investigations into ways to guide student teachers in developing meaningful critical reflection skills to secure the sustainability of applied competence as an outcome of a DL programme may be necessary.

Although the model has been grounded in literature, programme evaluation is critical to determine areas in need of revision and improvement. Feedback from student teachers and mentors will enable programme designers to revise features of the programme if necessary.

■ Conclusions

The ultimate aim of the programme is to develop Grade R teachers who are able to lay a sound foundation for learners at the threshold of their academic career. The design aims to provide the necessary support for student teachers to apply their knowledge in an informed way to address the specific needs of the learners in their specific teaching context. Basing

the aim of a teacher education programme on the philosophy of Dewey (1916:158), namely 'to teach for democracy', may better prepare teachers to support children to rise above their circumstances by supplying them with quality Grade R education. Dewey further outlined that teacher education programmes should aim to increase the capacity of individuals (in this case the Grade R teacher) to act as guardians of reorganised meaning. 'Reorganising of meaning' unavoidably requires the ability to reflect on theory, on the teaching context as well as on best practice for the specific teaching context in order to act in a manner which supports and encourages optimal learning by each 5- and/or 6-year-old.

Poor education standards have been hampering many learners' chances of a successful academic career. The ECE initiative of the DBE, namely to provide all learners with access to quality Grade R education, has the potential to turn around ineffective ECE programmes. However, time is running out for the thousands of learners waiting to enter the school system. Should HEIs fail to deliver quality Grade R teacher education programmes with the aim to equip these teachers as self-directed professionals who can make informed choices for best practice, this opportunity may be lost for future generations.

■ Chapter 7: Summary

Distance-learning programmes are increasingly used in SA for the in-service training of under- or unqualified early childhood teachers, in an initiative to provide all 5- and/or 6-year-old children with access to quality learning-readiness programmes in the year before they start formal schooling (Grade R). Ensuring professional competence of Grade R teachers poses challenges to a distance-learning programme in a developing country. This chapter reports on a work-integrated model as part of an

open distance-learning programme for Grade R teachers offered by a South African higher education institution. The model incorporates specific critical foundations of effective teacher education programmes as identified from the literature. Apart from relevant pedagogical content knowledge, these foundations include opportunity for guided application of knowledge in practice and the development of self-directed professional competencies such as a reflective and explorative disposition towards the teaching practice. The chapter concludes with recommendations for future research to further inform the work-integrated model.

Grade R teachers' knowledge regarding perceptual motor skills which may influence school readiness

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■ Introduction and background

To ensure school success in the formal learning phase, school readiness, which includes well-developed perceptual motor skills, is necessary in Grade R (Department of Basic Education [DBE] 2011c:34; Loubser 2015:19; Van Wyk 2012; Van Zyl 2011:84–85; Van Zyl & Van Zyl 2011:11). Researchers (Labuschagne 2005:56; Van Wyk 2012:34) report that it is crucial for perceptual motor skills to develop in totality in Grade R. Perceptual motor skills are often not developed effectively in learners, amongst others because teachers are ignorant regarding the development of these skills (Gligorovic *et al.* 2011:407). Fontaine, Torre and Grafwallner (2006) indicate that quality early childhood education is possible only when knowledgeable educators are involved.

■ Statement of the problem

Research by the United Nations Science and Cultural Organization (UNESCO) has confirmed that a large percentage of teachers involved in early childhood development (ECD) received little or no training (UNESCO 2007:147, 2012:35). Samuels (2010:23), involved with the DBE, further confirms that generally in South Africa (SA) quality teaching is not given by Grade R teachers. According to Chisholm (2005:19), 23% of ECD teachers in SA have not received any formal training for Grade R teaching and 88% do not have any qualification recognised by the Department of Education (DoE). Mathur and Parameswaran (2012:40) support these statistics with research done in the United States of America with immigrants, which indicated that the biggest problem is the teachers' lack of adequate knowledge, qualifications

and experience. In Jamaica research has also confirmed that 96.4% of children who are part of ECD do not receive quality teaching and stimulation (Roopnarine & Johnson 2011:169), and this can seriously influence the school readiness of learners.

Most educators involved in ECD have not been trained in this particular field, which means that their knowledge thereof is limited (Excell 2011:59). The DBE (2011b:55) reports that qualifications of current teachers in SA have improved from 64% in 1994 to 95% in 2010. The DBE, however, doubts the quality of these qualifications (DBE 2011b:55). National and international research by Westraad (2011:6) has revealed that the results of learner assessment indicate that learners do not receive adequate knowledge and skills in school, and consequently may not achieve success in school. This tendency could be ascribed to the knowledge level of the teachers.

Young learners (including Grade R learners) taught by skilled and knowledgeable teachers are often better equipped emotionally and socially and perform academically better in formal schooling (Andrich 2015:2; Fontaine *et al.* 2006:101). Fontaine *et al.* (2006:101) further indicate that learners in classes with well-trained teachers attain better results than those with teachers who received only in-service training. The opposite, however, is also true – the perceptual motor skills of learners who are not school ready may be influenced by the knowledge of the teacher.

In the research reported on below attention is given to the question of the relation between Grade R teachers' knowledge of perceptual motor skills and the school readiness of the learners.

■ Research orientation

The research was undertaken from a post-positivistic paradigm in the form of a survey by means of questionnaires with open- and closed-ended questions. The research was further undertaken from a phenomenological-interpretivistic perspective, which resulted in the research design being essentially functional (De Vos *et al.* 2011:309–311). This orientation was relevant to this kind of study since it considers interpersonality and enables the research, understanding and recording of participants. Phenomenology studies human consciousness and subsequently provides meaning to reality (Creswell 1998). With this orientation it was attempted to enhance the quality of the research by focusing on the knowledge and experience of participants, as well as to comprehend the significance which they ascribe to life skills.

The aim of this chapter is to report on the research directed towards the problem stated earlier. To achieve this, the following structure is used: the conceptual-theoretical framework on which the research is based is expounded, after which the empirical investigation is described. This is followed by an exposition of findings and results, a discussion of these, some conclusions and a general final conclusion.

■ Conceptual and theoretical framework

The investigation was approached from a phenomenological-interpretivistic perspective, according to which knowledge results from conclusions made pertaining to the responses of participants. Responses are approached from an interpretivistic paradigm, in the sense that the responses of participants are interpreted by the researcher.

This focus was further on social constructivism, according to which the teacher's knowledge of perceptual motor skills, which can influence the school readiness of the learner, is investigated. According to Vygotsky, man (the teacher) is the instrument which can assist the learner to develop and act as mediator between the learner and the social environment in which they develop (Loubser 2015:15). It is subsequently the responsibility of the teacher to guide the learner to school readiness. As mentioned previously, the focus was on the interaction between the teacher and the knowledge of perceptual motor skills. One variable influences the other, and thus the school readiness of the Grade R learners is influenced.

The informal preparation of the Grade R learner for more formal learning in Grade 1 can be described as school readiness. This preparation can be influenced by factors such as the lacuna in knowledge and/or training of the teacher (Excell 2011:28). The lacuna in knowledge leads to perceptual motor skills often not receiving sufficient attention, resulting in Grade R learners not being school ready (Andrich, Hill, Steenkamp 2015:4; Erasmus 2012:126; Pienaar, Barhorst & Twisk 2013:2).

According to the National Education Evaluation and Development Unit (NEEDU), more and more learners in impoverished schools (Quintile 1) already fall behind in their first school year (Zille 2013:2). The NEEDU reports (2013:2) that a 'large part of South African teachers can basically not teach, and many do not want to attempt to do so'. This lack of knowledge may be the main reason for the failure and backlog in school success (Zille 2013:2). Also, very few black teachers seem to want to work in the ECD sector (Rademeyer 2009:6). Lenyai, as quoted by Rademeyer (2009:6), states that classrooms in general do not have essential effective learning and teaching support material (LTSM), and that the majority of trained teachers involved in ECD are white teachers.

It seems as though teachers have neither the subject knowledge of the subject which they teach nor the required pedagogical skills (Drew 2010:19). Rossi and Stuart (2007:151) report that Grade 1 learners in SA are taught by unqualified teachers and recommends that all learners should be taught by suitably qualified teachers (Erasmus 2011:111; Samuels 2010:8), and that such teaching should focus on perceptual motor development. Sherry and Draper (2013:1294) report that the cognitive stimulation of the learners, their socio-economic environment and the teacher's knowledge are closely related to one another.

A large number of teachers in SA who are currently teaching Grade R were trained at one of 120 teacher training colleges (NEEDU 2013:55). In 2003 these institutions merged with universities, and since then the number of students as well as the quality of training has improved (Andrich *et al.* 2015:2; NEEDU 2013:55). Because quality training of prospective teachers is essential to improve the quality of teaching in schools, Minister of Education Motshekga suggested that teacher training should be thorough, with practice-aimed training as the main focus (Andrich *et al.* 2015:1; Barkhuizen & Steyn 2011:49). Lenyai, as quoted by Rademeyer (2009:6), questions the quality of teacher training presented by training institutions. The DBE realises that many un- or under-qualified teachers are teaching in Grade R, and that this problem should receive the necessary attention (DoE 2010a:13; Drew 2010:21). According to the DBE, training in SA should focus on teachers working in impoverished areas (Quintile 1 schools) (DoE 2010a:13). Drew (2010:19) emphasises that the DBE should now focus on quality teaching for Grade R learners by qualified Grade R teachers that are able to make a difference to education (Andrich *et al.* 2015:2).

Various organisations such as a private Caribbean organisation, UNESCO, the United Nations Children’s Fund (UNICEF), as well as the Minister of Education have suggested a worldwide approach to simplify the transition from ECD to formal schooling in order to sustain school success. To simplify this transition, thorough teaching and the improvement of ECD teachers’ training must be ensured (Roopnarine & Johnson 2011:172). It is essential for these teachers to have adequate knowledge, which can be considered the grounding of cognitive development (Gligorovic *et al.* 2011:407). Formal learning in Grade 1 will be successful if perceptual motor skills are developed effectively in Grade R (Kopcanova 2009:313).

Little research has been published investigating the knowledge of the Grade R teacher regarding the development of perceptual motor skills (Erasmus 2011:53; DoE 2010b:13). The aim of this research is to identify the knowledge of Grade R teachers regarding perceptual motor skills in order to improve school readiness, which can inherently improve successful formal learning in Grade 1.

■ Empirical investigation

■ Purpose of the research

The purpose of the research was to identify the knowledge of Grade R teachers regarding perceptual motor development, which can influence the school readiness of Grade R learners.

■ Research design

A mixed research method was utilised, viz. qualitative and quantitative research (Joubert *et al.* 2016:377; Leedy & Ormrod 2010:146;

Maree 2010:59). This combined method compensates for the inherent shortcomings which may result from using one method only. One of the shortcomings of qualitative research is that the respondents' direct manner of talking and understanding may not be adequately exposed by the research method. In qualitative research a shortcoming might be the subjective presence of the researcher as a participant, which could influence the research results and findings.

■ Strategy of research

The combined research was executed simultaneously in that the qualitative data were analysed at the same time by means of content analysis. A detailed and systematic investigation was undertaken of the data content in order to identify patterns or themes (Joubert *et al.* 2016:389; Leedy & Ormrod 2010:144; Maree 2010:101) to provide order, structure and meaning to the masses of collected information (Strydom & Delpont 2005:333).

■ Methodology

■ Research instrument

In order to establish the knowledge of the respondents regarding perceptual motor skills which could influence the school readiness of Grade R learners, data were collected by means of a self-compiled questionnaire with open- and closed-ended questions (Joubert *et al.* 2016:296). A concept questionnaire was first compiled and the input of experts on perceptual motor skills and staff from the Statistical Consultation Services of North-West University was obtained. Some changes were then effected.

The questionnaire comprised three sections. Section A comprised biographical information (9 questions) relating to the respondent's age, experience, professional qualifications and where these were obtained, training in Grade R teaching, compilation and number of learners in class, language of instruction and socio-economic environment of learners.

Section B comprised four sub-sections. B1 determined the attitude of the Grade R teacher. Section B2 focused on the knowledge of the respondent regarding the development of perceptual motor skills, and responses were indicated on a four-point Likert scale ranging from 1 = Not important at all to 4 = Extremely important. Section B3 comprised 16 scenarios, each depicted by a photo and a description where the respondent had to identify and discuss the correct perceptual motor activity. Section B4 expected the respondent to reply *yes* or *no* to 12 statements regarding the scholastic milestones a Grade R learner has to achieve, as set out in the Curriculum and Assessment Policy (CAPS; DoE 2007). Respondents' answers were marked as 1 = Correct or 0 = Incorrect.

Section C comprised qualitative data obtained from 8 open-ended questions focusing on the development of perceptual motor skills, where respondents had to express their insight (Loubser 2015).

Population and sample

A convenient sample was used (Joubert *et al.* 2016:102; Maree 2010:79). Questionnaires were distributed to 32 ($N = 32$) selected Grade R teachers in the Tlokwe (Potchefstroom) district. Four respondents relocated and 3 failed to fill in any information ($n = 7$). Twenty-five ($n = 25$; 78%) Grade R teachers teaching in Quintile 1–5 schools voluntarily completed the questionnaires. The DoE (2007) graded

schools into quintiles according to availability of LTSM as well as the environment in which the schools are situated. Quintile 5 schools are the best equipped, and Quintile 1 schools have few resources and are situated in low socio-economic environments. Schools from Quintiles 1 and 2 were chosen since they were in similar socio-economic environments, whilst schools from Quintiles 3 to 5 established the knowledge of trained teachers regarding the development of perceptual motor skills. Subsequently the entire spectrum of current South African schools was covered.

■ Ethical considerations

Written permission was obtained from the DBE and ethical permission to execute the study was obtained from the Ethics Committee of the university under the auspices of which the research was done.

■ Validity and reliability aspects

In order to enhance the reliability and validity of the questionnaire, it was discussed with the Statistical Consultation Services at the university. To provide content validity to the questionnaire, a pilot research team consisting of a group of knowledgeable and experienced Foundation Phase colleagues evaluated a concept questionnaire to establish whether it was relevant and met the requirements. Items which were not formulated clearly and were not relevant were identified and changes and improvements were effected. Through item analysis, items for the final questionnaire could be selected. The reliability of the questionnaire was defined as the degree of consistency or stability with which the questionnaire measures what it is supposed to measure over a period of time (Leedy & Ormrod

2010:93). In this study Cronbach's alpha coefficient, a reliability coefficient indicating the internal consistency of the questionnaire, was established at a value of 0.74.

■ Collection of data and data processing procedures

Questionnaires were delivered personally to respondents ($N = 32$) in the Tlokwe (Potchefstroom) district, and collected again after a week. Respondents were able to complete the questionnaires in their own time and at their own pace.

Data from the questionnaires ($n = 25$) were analysed statistically and by means of ATLAS.ti™ by transcribing the answers of the respondents verbatim, after which categories and codes were identified via a search for patterns (Bogdan & Biklen 2007:153). ATLAS.ti™ is a software program that uses codes attributed to important aspects within the verbatim transcriptions. A code is a word or phrase which symbolically captures the essence of the description of a part, language or visual data (Saldaña 2009:3). These codes are utilised to make connections. Codes which are related are connected to create networks. Networks are built to strengthen codes, and data analysis is performed by means of the networks. Each network is discussed as a main component, including quotations from the verbatim transcriptions connected to it (Joubert *et al.* 2016:121). Coded transcriptions were also given to an independent analyst to analyse. A consensus dialogue took place with the independent analyst, and on the basis thereof final categories were identified and findings were made (Saldaña 2009:8).

Questionnaires from respondents were marked, and marks were allocated according to correctness. Answers from respondents were

assessed by the researcher according to whether they were 2 = Correct, 1 = Partially correct, or 0 = Incorrect. Sections A and B were analysed as quantitative data. All data analyses were performed with IBM Statistical Program for Social Sciences (SPSS) Version 22.0, and descriptive statistics (frequencies and percentages) were calculated.

■ Findings

This section comprises findings deduced from the responses of participants ($n = 25$) who truly participated in the survey. Biographical information of the participants indicated that 20% of the respondents were younger than 30 years, whilst the majority were in the age group 30–50 years. Forty per cent of the respondents indicated that they had less than 3 years' experience as Grade R teachers. Eighty per cent of respondents only had a Grade 10 qualification, whilst two respondents had a BEd Foundation Phase degree, which is considered to be adequate to teach Grade R. Ninety-six per cent of respondents indicated that they had training in the CAPS. Most of the classes of respondents were attended by Setswana-speaking (71%) black learners (84%). More boys (51%) than girls (49%) attended Grade R teaching, and most of the learners came from average to lower average socio-economic environments.

Results based on 9 questions which were analysed on a 4-point Likert scale to establish the teachers' knowledge, yielded the following: respondents had to indicate whether basic motor skills such as running, jumping, balance, rhythm and coordination, which have to be learnt in Grade R, can be considered an important grounding for school success in Grade 1. Forty per cent of the respondents indicated that it is important

that, if a learner can read, write and do Mathematics, he or she will be able to achieve most of the outcomes, whilst 36% indicated that it is extremely important. Seventy-six per cent of respondents indicated that the role played by the Grade R teacher in the presentation and development of perceptual motor skills is extremely important, whilst only two respondents ($n = 2$) indicated that the role played by the Grade R teacher is not important at all.

Thirty-two per cent of the respondents indicated that without mastering perceptual motor skills, such as auditory and visual perception and good proprioceptive skills, the Grade R learner will still achieve success in formal learning in Grade 1, whilst 32% of the respondents indicated that it is not important at all. If perceptual motor skills do not have to be taught and developed to prepare the learner for more formal reading skills, 44% of the respondents indicated that this is important, whilst 8% indicated that it is not important at all. On the question on mastering perceptual motor skills for total development of the Grade R learner, 48% of the respondents indicated that it is extremely important, whilst 44% indicated that it is important. Forty-four per cent of respondents indicated that it is important that development of perceptual motor skills can occur only during the teaching of Life Skills, whilst 16% of the respondents indicated that it is not important. Assessment of Life Skills is considered by 52% of the respondents to be just as important as assessment of Mathematics and Language, whilst 48% consider it to be extremely important. Forty-eight per cent of the respondents indicated that the large number of learners, to a small extent, makes the presentation of perceptual motor skills difficult, whilst 28% indicated that the number of learners in a class is an extremely important factor in teaching Life Skills.

From 16 scenarios which were depicted by means of pictures and descriptions, respondents had to link the correct perceptual motor problem to each and discuss it to show their perceptual motor knowledge. Table 11 presents descriptive results of examples of scenarios pertaining to the number of correct, partially correct and incorrect responses expressed in percentages for the 16 subquestions answered in the questionnaire. The majority of respondents were only able to identify the questions regarding balance (56%), body image (60%) and pencil grip (76%) correctly. Underlying problems in the scenarios pertaining to visual foreground background and laterality could not be identified correctly by any of the respondents. With the rest of the questions (hand-eye coordination – 28%; dominance – 16%; auditory discrimination – 12%; auditory memory – 8%; spatial orientation – 8%; midline crossing – 20%; visual discrimination – 16%; form consistency – 8%; visual memory – 8%; gross motor development – 12%), fewer perceptual motor scenarios were identified correctly.

Section B4 comprised 12 statements where respondents had to reply with *yes* or *no* to aspects; hence possible limitations could be determined in the Grade R learners' knowledge regarding milestones they should reach as set out in the CAPS. Most of the respondents gave the correct answer to all 12 questions. Only with regard to Question 3 ('a Grade R learner should be able to hop ten times'), Question 4 ('a Grade R learner should be able to jump ten times with both feet with a skipping rope') and Question 8 ('be able to balance on one foot for five seconds') did more respondents give wrong answers.

From the responses to Section C, five themes were identified which had developed from the question as to which factors could hamper the possible development of perceptual motor skills in Grade R. Respondents identified parent involvement and LTSM, which includes a lack of adequate

TABLE 11: Descriptive results of questionnaire B3, based on scenarios.

Sub-question	Correct reply for statement	Total (<i>M</i>)	No. correct		Partially correct		No. in-correct	
			<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
1	Balance	25	14	56	3	12	8	32
2	Hand-eye coordination	25	7	28	7	28	11	44
3	Body image	25	15	60	0	0	10	40
4	Dominance	25	4	16	4	16	17	68
5	Auditory discrimination	25	3	12	4	16	18	72
6	Pencil grip	25	19	76	0	0	6	24
7	Auditory memory	25	2	8	8	23	15	60
8	Visual foreground background	25	0	0	6	24	19	76
9	Spatial orientation	25	2	8	6	24	17	72
10	Midline crossing	25	5	20	3	12	17	72
11	Visual discrimination	25	4	16	1	4	20	80
12	Form consistency	25	2	8	6	24	17	68
13	Laterality	25	0	0	5	20	20	80
14	Visual memory	25	2	8	5	20	18	72
15	Gross motor development	25	3	12	5	20	17	68
16	Gross motor development	25	3	12	4	16	18	72
Total		.	85	.	67	.	248	.

resources, as factors. Furthermore, the knowledge and training of teachers, which includes inadequate teacher training and good qualifications, was indicated. The environment, which should be sufficiently spacious, was indicated as another possible factor.

Four aspects related to recommendations to improve the teaching of perceptual motor skills were indicated by respondents. LTSM, including a variety of affordable and suitable resources and toys, was also identified. The environment in which the Grade R learners have to move should also be adapted. Parent involvement should be promoted, and parents should be guided to become more involved in the development of learners. Training of teachers, where they could improve their knowledge by means of workshops and in-service training, was also identified.

In the question focusing on LTSM required for teaching, respondents identified two main aspects. Educational LTSM included threading, building blocks, puzzles and Lego, and creative art activities included cutting and pasting, drawing, colouring, painting, colour cards and playing with clay. Aspects like free play outside, running and jumping, riding pushbikes, jungle gym activities, balancing, sliding, playing in the sandpit and swinging were also identified as related to visual perception and regarded as partially correct because respondents did not seem to understand where visual perception fits into these activities. Incorrect answers such as group activities, Mathematics and counting, stories, singing, and pets are not directly related to the development of visual perception and can be regarded as incorrect.

The question was posed as to how often Grade R learners (days per week, and hours per day) should be exposed to activities that will promote perceptual motor skills. Respondents replied with answers ranging from 1 day per week to 5 days per week, and various durations, from 45 minutes

daily to 120 minutes daily. The CAPS gives clear guidelines for the time awarded to teaching Life Skills where creative arts and physical education focus on perceptual preparation (DBE 2011a).

With the question which deals with a lack of perceptual motor skills, which may later contribute to the learners' inability to read and write, five categories with subcategories were identified by 64% of the respondents. From the subcategory perceptual motor skills, laterality and midline crossing, small muscle coordination and visual perception were identified. From the subcategory language, writing and reading with books, sound recognition, listening to stories, looking at pictures and paging through a book were identified. From the subcategory Mathematics, recognition of numbers, writing numbers and counting were identified. Answers irrelevant to the question, for example, 'child does not do anything', 'is tired and sleepy' and 'is too small', were indicated as incorrect.

Regarding factors which will hamper effective use of the outside play area to develop perceptual motor skills, respondents identified three subcategories. The environment, with aspects such as insufficient space, learners who have to participate, rain which limits outside play, Grade R learners who have to share the playground with older learners, and no outside activities, was indicated. A further subcategory is where very little time is given to learners to play outside. Here LTSM was a lack of resources and playground equipment, and insufficient educational toys and apparatus, material which must be safe and strong, defective equipment which needs to be fixed and limits participation, a lack of swings which would strengthen learners' muscles, were all indicated by respondents.

Most respondents identified the suitable equipment required to develop gross motor activities: fixed constructions comprising slides, swings, a sandpit, see-saw, water feature, swing bridge and tunnel commando net,

balancing beam and jungle gym; loose equipment comprising skipping ropes, balls, hoops, tyres, ladders and jumping castles. Only four factors which are not equipment were indicated as indirectly correct: balance, playing, jumping and running.

■ Discussion

The biographical information of the respondents showed that most of them are older teachers (64%) with Grade 10 only (80%), less than 3 years' Grade R experience and consequently no formal after-school training to teach Grade R (Lovemore 2012:1; Westraad 2011:3). Most of these teachers have in fact received CAPS training, but seem unable to apply this training practically (Erasmus 2011:60). The respondents taught mostly black (84%) Setswana-speaking learners (71%), from a low (32%), lower average (20%) and average (48%) socio-economic environment, where more boys (51%) than girls (49%) attend Grade R schools. The UNESCO report determined that in deprived environments more boys than girls attend ECD; the poorer the environment, the fewer girls form part of ECD (UNESCO 2007:139) and the bigger the risk that learners will not be school ready (Ramey & Ramey 2007:471).

Limitations in knowledge regarding subject content were evident from this research, as was the importance of development of perceptual motor skills in Grade R (Erasmus 2011:59; Mathur & Parameswaran 2012:5; Sherry & Draper 2013:1298). Of the respondents 48% realise that skills such as running, jumping, rhythm and coordination create an important foundation for children to achieve success in Grade 1 (Sherry & Draper 2013:1304), but they do not realise that perceptual motor skills such as auditory and visual perception and proprioception are equally crucial. A further shortcoming regarding knowledge of the teachers becomes clear,

viz. that teachers (80%) have not been adequately trained to develop perceptual motor skills in learners. This results from ineffective ECD teacher training programmes (Ramey & Ramey 2004:487).

A further lack of knowledge manifested where respondents had to identify perceptual motor scenarios with descriptions. Only with more familiar scenarios such as balance (56%), body image (60%), and pencil grip (76%) were correct responses given. With aspects such as visual foreground, background and laterality, no correct answers were indicated. The result of this inadequate knowledge of perceptual motor skills may be that learners with a problem may not be identified correctly, which may limit early intervention and influence school readiness (Sherry & Draper 2013:1300; Van Zyl 2004:85). This study confirms a close relation between research performed by Roopnarine and Johnson (2011:172) and that of Erasmus (2011:59, 60), both of which studies established that a large number of teachers are not well trained, and that this may have a direct effect on perceptual motor development and readiness of learners and may also influence effective intervention.

Since all subjects have been integrated in Grade R, the focus cannot be on one subject only (DBE 2011a) within a specific period. Teaching time for presenting Physical Education, which includes perceptual skills, is indicated by CAPS as 2 hours per day (DBE 2011a:6). Creative Art also develops perceptual motor skills and is also indicated as receiving 2 hours of attention per day. No respondent indicated the correct time allocation, which shows that there is inadequate knowledge of the CAPS regarding perceptual motor skills in Grade R.

Most of the outcomes set out in the CAPS will be attained if learners can read, write and do Mathematics (Samuels 2010:6), but the outcomes which form part of Life Skills will not be developed by themselves and

cannot be developed during the teaching of language and Mathematics (Andrich *et al.* 2015:6; Benson 2005:2; Orban 2003:2). Respondents realise the importance of language and Mathematics, and the overemphasising of poor assessment results in these may contribute to the awareness that perceptual motor skills can influence the development of formal reading and writing skills (Sherry & Draper 2013:1302–1304). Since perceptual motor skills serve as building blocks for reading and mathematical abilities, they should be part of daily activities (Excell 2011:39).

This study shows a close relation with research by Erasmus (2011:59) where factors such as parent involvement, LTSM and environment were identified as possibly influencing the development of perceptual motor skills (Erasmus 2011:56, 59, 60; Ercan, Ahmetoglu & Aral 2011:724, 725; McGettigan & Gray 2012:26). Limitations in the knowledge of respondents regarding LTSM which would stimulate perceptual motor development were identified in order to limit intervention, and will not overcome the perceptual motor backlog of learners.

To develop perceptual motor skills, learners have to be actively engaged (Erasmus 2011:60; Hinkley *et al.* 2008:435; LeGear *et al.* 2012:3; Sherry & Draper 2013:1305) in an environment where outside play is important and the maximum time can be spent on it. If the teacher has received no or inadequate training, learners will not be active and perceptual motor skills to ensure school success will not develop (DBE 2011a:11).

Factors which impede effective use of the outside playground (for the development of perceptual motor skills) are indicated as the environment, with insufficient space (Erasmus 2011:56, 59; Sherry & Draper 2013:1305) and LTSM (Sherry & Draper 2013:1304–1305). Although respondents are aware of materials which will develop gross motor skills (DBE 2011a:26–29), they lack sufficient items of such equipment, which will

influence the development of perceptual motor skills negatively (Pienaar *et al.* 2013:2).

This research attempted to identify further factors, apart from the knowledge of the teacher, which could hamper perceptual motor development of Grade R learners. It revealed that teachers need more parent and teacher involvement (Ercan *et al.* 2011:721), more LTSM and quality training (Andrich *et al.* 2015:2; Sherry & Draper 2013:1304).

This study identified within Grade R teachers limitations in knowledge regarding the development of perceptual motor skills. This study links to research by Erasmus (2011:61), which confirms that limitations in the Grade R teacher's knowledge could influence the perceptual motor development of the learner.

■ Recommendations

Qualitative and quantitative analysis has shown that there is indeed a lack of knowledge amongst Grade R teachers regarding perceptual motor skills. Factors such as parent involvement, LTSM, the direct environment in which the child grows up, and lack of knowledge and inadequate training might influence the development of perceptual motor skills. In the case of 80% of respondents, inadequate training was identified. This (inadequate training) no doubt leads to lacunae in their equipment as Grade R teachers. Insufficient knowledge of the requirements that Grade R teachers have to meet, as stated by the CAPS, could influence the identification and development of perceptual motor skills in Grade R learners, since teachers would not know how to apply the information prescribed by the CAPS.

Teachers have to be guided by thorough intervention and in-service training to make adaptations and create new learning opportunities in

order for perceptual motor skills to develop optimally in their Grade R learners. If teachers had more knowledge of the importance of perceptual motor skills and how to attain these, they might pay more attention to the development of such skills.

This research focused on only a limited number of Grade R teachers ($n = 25$), which can be considered a limitation. Some questions may not have been posed clearly enough and perceptual motor perceptions which have not been recognised because of this may have contributed to the limitations which have been identified. It is recommended that interviews be conducted with more and different respondents, as these might yield different results.

■ Conclusion

The results of this research confirm that the development of perceptual motor skills in Grade R learners could possibly be influenced by the knowledge of the Grade R teachers regarding perceptual motor skills. The expertise and knowledge of the Grade R teachers are thus important components regarding the development of perceptual motor skills in the Grade R learners, which are crucial for later successful learning. The teachers have to utilise their knowledge to create an atmosphere in which Grade R learners can learn and develop their perceptual motor skills.

■ Chapter 8: Summary

The success of formal learning in Grade 1 (for the purposes of this article the term Grade R will be used, although it is referred to as kindergarten in the early childhood development context) depends on the perceptual motor readiness of the learner entering the school. The knowledge of the

Grade R teacher regarding perceptual motor skills may be detrimental to effective teaching thereof. A convenient sample was used to identify the respondents for this study, who represented various socio-economic environments. The investigation was undertaken from a post-positivistic paradigm and executed from a phenomenological-interpretivistic perspective. Questionnaires with closed- and open-ended questions were used as a measuring instrument to assess the knowledge of 25 ($n = 25$) Grade R teachers in the Tlokwe (Potchefstroom) district regarding the development of perceptual motor skills of Grade R learners. The data were collected and statistically analysed by means of Atlas.ti™. Internal item correlation was used, and a Cronbach alpha coefficient with a value of 0.74 was determined, based on the statistical analysis. Results indicate that Grade R teachers' knowledge is deficient in various areas related to perceptual motor development. In 80% of the respondents inadequate training was identified, and no respondent could identify scenarios depicting laterality and visual foreground background. If the deficiencies of Grade R teachers' knowledge regarding perceptual motor development could be addressed and eliminated, the Grade R learners that they teach might be more school ready.

Scaffolding teacher professional development and teachers' ability to use inquiry-based approaches in the Life Sciences classroom within communities of practice

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■ Teacher professional development within a framework of continuous change

Globally science education has embraced many curriculum transformations since the 1950s (Biological Sciences Curriculum Study 2009). Wallace and Louden (1998) identified three waves of reform, namely: (1) a focus on science as discipline knowledge in the 1950s and 1960s, (2) science as relevant knowledge in the 1970s (with an emphasis on scientific literacy and a science-technology-society approach) and (3) science as imperfect knowledge, with an epistemological shift towards cognitive science and more constructivist approaches since the 1980s and 1990s. More recently researchers like Gibbons (2000) started to advocate for ‘Mode 2’ knowledge production (which is in contrast to Mode 1 knowledge production where subject content is not always well contextualised):

[S]ociety can (and will with increasing frequency) ‘speak back’ to science. The idea of science communicating with society is familiar enough. Now, society is speaking back to science. Reverse communication is generating a new kind of science, let us call it context-sensitive. In epistemological terms, context-sensitive science is new in the sense that it produces socially robust knowledge that is, knowledge likely to be reliable not only inside but also outside the laboratory. (p. 161)

An example of such Mode 2 knowledge production is the current call for the decolonisation of the curriculum and for more Afrocentric approaches emphasising indigenous knowledge. Mbembe (2015) writes that there is something profoundly wrong when syllabi designed to meet the needs of colonialism and apartheid continue well into the post-apartheid era. There is also a realisation that we should instil self-directed learning skills in learners, in order to prepare them for the demands of the 21st century. Problem-based learning and cooperative learning are becoming increasingly important teaching and learning strategies to foster 21st century skills within learners. It is therefore likely that science

education in South Africa will in future also have to reflect these sentiments. These continued curriculum transformations highlight the importance of continuous and effective teacher professional development programmes

Following international trends, inquiry-based approaches, i.e. open-ended learner-directed types of activity, also found their way into South African classrooms where Science teaching and learning was previously characterised by authoritarian teacher-centred lessons. Experimental work in Life Sciences was criticised for comprising little more than cookery book activities (Department of Education [DoE] 2010; Fraser 2006; Rogan 2004a). Previous curricula were fundamentally content-driven. The first post-apartheid curriculum, Curriculum 2005 (C2005), introduced in 1997, was a highly idealistic policy document incorporating outcomes-based education and learner-centred teaching learning approaches (Rogan 2015). C2005 was followed by the National Curriculum Statement (NCS) in 2006 and the Curriculum and Assessment Policy Statement (CAPS) in 2012 with a focus on more inquiry-teaching learning approaches.

The Subject Assessment Guidelines for Life Sciences (DoE 2008) makes provision for a minimum of two practicals, of which one must be a 'hands-on' practical and the other a hypothesis-testing experiment based on the scientific method of inquiry. In addition, Grade 12 learners are to be assessed on their ability to make deductions and evaluations. Despite the advantages of these approaches and initiatives to promote them, research reveals that many science teachers in South Africa still do not implement the curriculum in such an inquiry-based and learner-centred way, and hence marginalise scientific investigation in favour of transmission learning (Cronje 2011; DoE 2010; Fraser 2006; Ottevanger,

Van den Akker & De Feiter 2007). Also worrying is that teachers do not frame scientific investigations with regard to local community problems, thus ensuring context-sensitive science (De Beer & Ramnarain 2012). The ideal would be that teachers have the necessary pedagogical content knowledge (PCK) to facilitate inquiry approaches based on local issues or problems.

■ Shortcomings of teaching in a teacher-centred way

Several factors may have contributed to the continuation of teacher-centred classroom practices. The Centre for Development and Enterprise (CDE) (2011) names three reasons for this condition when they acknowledge that, (1) ‘many teachers have been badly trained’, (2) ‘existing teachers spend too little time in the classroom’, and (3) ‘many teach badly when they do’. Apart for these factors, we also identify three additional contributing factors.

A possible fourth reason is that many teachers do not possess the necessary content knowledge (Ottevanger *et al.* 2007). Research by De Beer and Ramnarain (2012) has shown that teachers’ content knowledge in themes like genetics, molecular biology and evolution are often underdeveloped, and when it comes to new curriculum themes like Indigenous Knowledge, teachers do not have the necessary content knowledge to introduce practical work in a way that will honour the tenets of the nature of science (Cronje 2015). The concept of ‘content knowledge’ will be dealt with later in this chapter.

A fifth reason for the current state of transmission-mode teaching may be that with implementation of the NCS teachers focused more on the ‘what’ than the ‘how’ of the curriculum. Policy documents contain many visionary and educationally sound ideas, but in reality implementation has been much slower than anticipated and has not always been translated into

good classroom practice (CDE 2011; Ottevanger *et al.* 2007; Rogan & Grayson 2003). A notable example is Indigenous Knowledge Systems: it is emphasised in the CAPS, but research (Cronje 2015; Cronje, De Beer & Ankiewicz 2015; De Beer & Ramnarain 2012) indicates that teachers pay lip-service to this by perhaps mentioning an example or two such as medicinal plants like the 'cancer bush' or *duiwelsklou*.

Another reason, linked to the 'what' rather than to the 'how' of the curriculum, is the exam-driven education system which favours the 'product' instead of the 'process' of teaching learning. In this regard Rogan (2015) argues that the fundamental emphasis on the matriculation examination promotes teacher-centred approaches where rote memorisation of content is part of the order of the day, culminating in the production of passive, non-thinking citizens. Teachers are merely seen as technicians rather than professionals. Following more of a product approach in teaching and learning paves the way for learners not learning valuable knowledge, skills and values as their focus is more on high marks and not on the 'hidden' and lasting 21st century skills such as problem-solving and critical and creative-thinking skills.

A seventh possible reason emerging from the literature is that teachers' continuous professional development (CPD) programmes are too generic and do not cater for the diverse needs of South Africa's teacher population (DoE 2010; Pretorius 2015). The CDE refers to them as 'piecemeal, workshop-type development programmes which are not effective' (CDE 2011). Teachers prefer short learning programmes where their content knowledge is developed for specific (and problematic) curriculum themes, and where they can go and experiment with the new pedagogies the day after the workshop or short learning programme. Another factor that should be taken into consideration is what is known as the 'washing out

effect' (Zeichner & Tabachnick 1981). Lortie (1975) speaks of the 'apprenticeship of observation': our teachers were all also learners for 12 years in school, where they observed the teaching practices of their teachers. For example, Kennedy (2015) confessed that she unconsciously modelled her teaching style on that of the teachers she had, which is telling people things.

It is thus safe to assume that many teachers observed transmission mode practices and little inquiry learning. Research shows that new pedagogies learnt during professional development programmes are often disregarded since teachers fall back on well-established practices. For this reason it is essential that we engage teachers more in authentic laboratory research during professional development programmes.

So, many years after inquiry-based teaching approaches started to form an integral part of the South African curriculum, South African classrooms are to a great extent still trapped in an educational system characterised by transmission mode teaching and 'cookbook' laboratory activities. This is in spite of a curriculum which stipulates that it should be otherwise. The challenge thus lies in developing teachers' content and pedagogical knowledge to teach science, including Life Sciences, using inquiry-based approaches. This also poses the challenge of providing teachers with a more nuanced understanding of the tenets of the nature of science (Cronje *et al.* 2015).

This chapter reports on research carried out on how a group of eight Life Sciences teachers had been implementing the inquiry-based NCS curriculum and the challenges they faced, how they applied inquiry-based teaching approaches in the classroom, and how a functional community of practice (CoP) could be used as a platform for CPD. To reach this aim the following research question was

formulated: How did Life Sciences teachers apply inquiry-based teaching approaches in the classroom whilst implementing the inquiry-based NCS curriculum, and in what way can a functional CoP be used as a platform for their CPD?

The remainder of this chapter is structured as follows. Firstly, a conceptual-theoretical framework is outlined, followed by an exposition of the research method that was applied. The findings are then listed, followed by a discussion in view of the conceptual-theoretical framework. The chapter concludes with some recommendations on how teacher professional development could best be facilitated within a CoP.

■ Conceptual-theoretical framework

This paper describes how Life Sciences teachers have implemented the inquiry-based curriculum, and the challenges they faced whilst doing so. According to Hmelo-Silver, Duncan and Chinn (2007):

[I]nquiry-based teaching has its origins in the practices of scientific inquiry and places a heavy emphasis on posing questions, gathering and analysing data, and constructing evidence-based arguments. Students learn content as well as discipline-specific reasoning skills and practices by collaboratively engaging in investigations. (n.p.)

The Biological Sciences Curriculum Study (2009) argues that:

[I]nquiry-based instruction offers an opportunity to engage student interest in scientific investigations, sharpen critical-thinking skills, distinguish science from pseudoscience, increase awareness of the importance of basic research, and humanize the image of scientists. (n.p.)

These arguments echoed one of the principles on which the current curriculum is based, namely 'encouraging an active and critical approach to learning rather than rote and uncritical learning of given truths' (Department of Basic Education 2011).

As mentioned earlier, the fact that many teachers do not possess the necessary content knowledge might also be a contributing factor as to why most science teachers still use mostly teacher-centred methods. Shulman (1986) distinguishes between different categories of content knowledge, namely content knowledge (we will refer to content knowledge as subject content knowledge [SCK]) and pedagogical content knowledge (PCK). SCK refers to the actual knowledge that a teacher must have regarding the subject (Ball, Thames & Phelps 2008; Kleickmann *et al.* 2012).

Shulman (1986) describes PCK as ‘subject matter knowledge for teaching’. It implies that teachers must have many different forms of representing the subject content knowledge in order to make it comprehensible for the students (Hill, Ball & Schilling 2008). In addition, the teacher must also have an understanding of what makes the learning of specific topics easy or difficult. As Kleickman *et al.* (2012) aver, ‘Literature on PCK identified two core facets of that knowledge: knowledge of students’ subject-matter conceptions and misconceptions as well as knowledge of subject-specific teaching strategies and representations’. The one informs the other. Part of a teacher’s knowledge base should also be a good understanding of the tenets of science, such as that science is empirically based, scientific knowledge is creative and theory-laden, science is socially and culturally embedded, and there is no one scientific method (the myth of ‘the scientific method’) (Cronje *et al.* 2015). Teachers’ views of the nature of science might hinder inquiry-based learning in the science classroom. It is therefore essential in teacher professional development interventions to also provide teachers with a more nuanced view of the nature of science.

Both SCK and PCK can be developed through CPD programmes. Before CPD programmes can be developed, it is essential to conduct an

in-depth examination of the needs of teachers (DoE 2010; Pretorius 2015). This needs analysis may serve as a starting-point to design programmes where teachers' professional development can be facilitated within the current professional development groups (the old cluster systems, or groups of subject teachers). The CDE also argues that teachers learn best through interactions with other teachers and with experts acting as 'critical friends' (CDE 2011; White 2012). The authors define these interactions as a 'community of practice' (CoP).

Wenger (2006) views a CoP as 'groups of people who share a concern or a passion for something they do, and learn how to do it better as they interact regularly'. In this paper we use Nardi and O'Day's (1999) definition that describes (information) communities as a frame of reference to compare our findings:

An (information) community is a complex system of parts and relationships. It exhibits diversity and experiences continual evolution. Different parts of an community coevolve, changing together according to the relationships in the system. Several keystone species necessary to the survival of the ecology are present. Communities have a sense of locality. (n.p.)

A keystone species is somebody who possesses excellent SCK and PCK, applies best practice, and continually reflects critically on his/her own practice. The function of such a keystone species, amongst other things, is to facilitate the activities of the community, identify challenges, and create a safe environment conducive for teaching and learning. The CoP in this study refers specifically to the single professional development group (cluster) of Life Sciences teachers in a particular area or locale at the time of the study. Rogan (2004a) is also of the opinion that professional development should best take place within a well-functioning CoP. This is emphasised by the World Bank's report on science teaching, which argues

that peer coaching can be potentially effective in CPD programmes (Ottevanger *et al.* 2007).

We used Rogan and Grayson's (2003) framework as a lens to analyse our findings regarding a certain group of teachers. Rogan and Grayson developed this framework because they believed that the focus in SA was more on the development and adoption of the curriculum (C2005 and NCS) than on its implementation (Rogan & Grayson 2003). The framework consists of three constructs: the profile of implementation, the capacity to innovate and the outside influence. They postulated that there is a cause and effect relationship amongst these constructs. Over the past years different studies (Aldous & Rogan 2009; Cronje 2011; Hatting, Aldous & Rogan 2007; Rogan 2004a; Rogan 2007) have used this framework to analyse their findings. All these studies were concerned with implementation of C2005 in the Natural Sciences in Grades 8 and 9. Our study is different in that it focused on the implementation of Life Sciences of the NCS in Grades 10 to 12.

Rogan and Grayson describe their profile of implementation construct as an attempt to express the extent to which the ideals of a curriculum are being put into practice (Rogan & Aldous 2005). This profile describes different levels of implementation on four different dimensions with regard to classroom practice (Levels 1–4 in Table 12). Level 1 in their profile describes a teacher who uses teacher-centred and transmission approaches with relative confidence and success, whereas teachers on Level 4 follow a more learner-centred, science as inquiry approach (and having a more nuanced understanding of the nature of science), characterised by open-ended inquiry.

Our experience clearly indicated that many teachers who participated in this study did not possess good SCK and PCK, hence the need to

adapt Rogan and Grayson's profile of implementation. We introduced a Level 0 (see Table 12) to give a more nuanced description of the teachers' knowledge and skills (or lack thereof). This adapted profile of implementation can be used as a tool to determine the needs of teachers. The information gathered from this needs examination can be used as a situation analysis that can inform the designers of CPD programmes.

Rogan and Grayson (2003) argue that a teacher's knowledge and skills can be developed only from his or her existing level to the following level, provided enough support is given to guide the development. They build their assumption on a 'zone of feasible innovation' (ZFI), which Rogan (2004b) describes as innovation that 'is most likely to take place when it proceeds just ahead of existing practice. Implementation of an innovation should occur in manageable steps' (Rogan 2004b). Rogan's ZFI builds on Vygotsky's (1986) zone of proximal development (ZPD) embedded in cultural historical psychology theories (Glassman 2001). The ZPD explains how a person can reach a potential development (as compared to actual development) through the scaffolding of an adult or more competent peer. This scaffolding, within the ZFI, could be achieved through short learning programmes, where a facilitator would assist with SCK and PCK development or through mentorships where teachers support each other. Ramaila (2012) calls this the mentee-mentee relationship, where teachers learn from one another. These sentiments are also echoed in the recent CDE (2011:23) report which states that 'a focus on instructional priorities over a long period of time is most effective'.

In practice Rogan and Grayson's profile of implementation means that curriculum implementation strategies such as CPD programmes are effective only when they proceed just in advance of current practice,

TABLE 12: Profile of implementation of science teachers (Rogan 2004b:159).*

Level	Classroom interaction	Science practical work	Science in society	Assessment
0	<ul style="list-style-type: none"> - Teacher presents transmission-type lesson in an unstructured way and reads mostly from the textbook; - Limited and ineffective media usage; - Learners passive and not engaged. 	<ul style="list-style-type: none"> - Practical work is seldom done; - Teacher uses limited and not well-planned demonstrations to assist in the explanation of concepts. 	<ul style="list-style-type: none"> - Teacher seldom uses examples from the learners' daily lives, and if used these are incoherent. 	<ul style="list-style-type: none"> - Written tests on lower cognitive levels; - Tests marked and handed out to learners.
1	<ul style="list-style-type: none"> - Teacher presents organised lessons; - Uses textbook effectively; - Learners are engaged and respond to questions. 	<ul style="list-style-type: none"> - Teacher uses classroom demonstrations to help develop concepts. 	<ul style="list-style-type: none"> - Teacher uses examples from everyday life to illustrate scientific concepts. 	<ul style="list-style-type: none"> - Written tests are given; - Most questions of recall type; - Most tests marked and returned promptly.
2	<ul style="list-style-type: none"> - Textbook used along with other resources; - Engages learners with questions that encourage deeper thinking and meaningful group work. 	<ul style="list-style-type: none"> - Teachers uses demonstrations to promote a limited form of inquiry; - Learners participate in 'cookery book' practical work. 	<ul style="list-style-type: none"> - Teacher bases lessons on specific problems faced by community. 	<ul style="list-style-type: none"> - Written tests include 50% of higher cognitive level questions.
3	<ul style="list-style-type: none"> - Teacher structures learning along 'best practice' lines; - Learners engage in minds-on learning activities. 	<ul style="list-style-type: none"> - Practical work to encourage learner discovery of information. 	<ul style="list-style-type: none"> - Learners actively investigate the application of science & technology in their own environment. 	<ul style="list-style-type: none"> - Written tests include 'guided discovery'-type activities; - Assessment includes other forms such as reports.

Table 12 continues on the next page →

TABLE 12 (Continues...): Profile of implementation of science teachers (Rogan 2004b:159).*

Level	Classroom interaction	Science practical work	Science in society	Assessment
4	- Learners take major responsibility for own learning and undertake long-term investigations and projects; - Teacher facilitates learning.	- Learners design and do open investigations.	- Learners actively undertake a project in their local community and explore long-term effects of community projects.	- Open investigations and community-based projects included in final assessment; - Learners create portfolios.

*, Summarises Levels 1–4 of Rogan and Grayson’s profile of implementation. We added a further Level 0 to include teachers with insufficient SCK and PCK (Petersen 2011).

meaning from one level to the next level. In the discussion of this paper the authors use the adapted profile of implementation to classify the participants’ teaching practice in the different levels.

In addition to the profile of implementation, Rogan and Grayson’s framework also includes the capacity to innovate and employ influence as two further constructs. They describe these constructs separately under four levels. We refer here just to Levels 1 and 4 as the opposing ends of the continuum; Levels 2 and 3 are variations in-between.

In the capacity to support construct in their Level 1, the physical recourses of the school are basic buildings, only some learners have textbooks, the teachers are usually unqualified, underqualified or teach a subject they were not trained to do, and school management is usually poor. At Level 4, by contrast, the buildings are excellent, all learners have textbooks, there is an equipped library and an equipped laboratory, teachers are in many instances well qualified, and there is generally excellent school management (Rogan & Grayson 2003). We must, however, guard against making the conclusion that if a school has a fully

equipped laboratory, practical work is appropriately done. For example, a study by Hattingh *et al.* (2007) found that a school with four equipped laboratories did no practical work.

In Rogan and Grayson's outside support profile, the professional development of Level 1 is limited to poor one-shot workshops, and monitoring and accountability are with the authorities. At Level 4 teachers take full responsibility for their own professional development, and all monitoring is undertaken by school-based personnel (Rogan & Grayson 2003).

The empirical research reported in the following section is based on the insights flowing from the above conceptual and theoretical framework.

■ Research methods

The authors' qualitative investigation followed an ethnographic design within an interpretive paradigm, since this study was an attempt to understand and describe the experiences of Life Sciences teachers within their natural working environment. The investigation formed part of a larger research project that recorded Natural, Physical and Life Sciences teachers' experiences in implementing the learner-centred NCS, and the problems they experienced. This chapter reports on the findings relative to the Life Sciences teachers.

The method of sampling was purposive, since the participants were chosen with specific criteria in mind. Initially, all the high schools that offer Life Sciences from Grades 10 to 12 in the Potchefstroom (Tlokwe) area were approached, but only four principals gave permission to conduct the study at their schools. Two Life Sciences teachers at each of these four

schools gave their voluntary consent to take part in the investigation. All were informed that we would visit their classrooms, interview them and study their personal documents and their learners' workbooks; they were assured that the data would remain confidential and that their real names would not be used, but pseudonyms. All of the participants were by coincidence female and between the ages of 30 and 49 years, except for one teacher who was over 50 years old. Five of the teachers were black and three were white. The race of the participants was a consequence of the schools available to the study and not purposefully selected. In addition to the above-mentioned ethical considerations, the respondents gave written consent which indicated their willingness to participate. They were informed that the data would not be used to their detriment and that they could withdraw from the study at any time. After the study the data were made available to them to determine if they were a true reflection of the observations and interviews.

This qualitative study involved a small number of teachers ($n = 8$), from which we do not make large-scale generalisations, because qualitative studies need to be understood within the context in which the fieldwork was carried out. Shenton (2004), however, argues that 'the findings may be true of people in other settings, similar projects employing the same methods but conducted in different environments could be of value'. It is interesting to note that the general findings of this study are also supported by other studies, for example, Cronje (2011) and Ramnarain and De Beer (2013). Onwuegbuzie, Johnson and Collins (2009) refer to this type of generalisation as case-to-case transfer. According to Shenton (2004), the purpose of such a study should not be to get the same results, but rather to get an overall picture of the phenomenon or group of people under study. We believe that this may well be the case with the findings of our research. Onwuegbuzie *et al.* (2009:120) also refer to another type of generalisation

that may apply to this study, namely naturalistic generalisation, which to them ‘leaves it to the reader of the article to make generalizations entirely, or at least in part, from their personal or vicarious experiences’.

Multiple qualitative methods were used, and information was collected over a period of 2 years. We observed the classroom practices of Life Sciences teachers, conducted individual semi-structured interviews, and studied artefacts including their lesson plans and their learners’ workbooks. The transcribed interviews and field notes of the class visits were coded and analysed mainly through an inductive approach. Lessons were analysed by using a standardised instrument, the Reformed Teacher Observation Protocol, or RTOP (Arizona Board of Regents 2000). The lesson plans and learner workbooks were scrutinised for evidence typical of a learner-centred inquiry approach, especially the formulation of a hypothesis and planning of a prescribed experiment. During the analysis thick descriptions were used to describe the practice of the participating Life Sciences teachers in order to understand, interpret and reflect on their daily practice with regard to the implementation of the NCS and their functioning in the CoP. To maintain objectivity we were careful during the analytical phase not to impose our own ideas, but to be led by the information. The use of multiple methods, triangulation and the thick description contributed to the credibility of the study.

■ Findings and discussion

Based on the available information the authors identified three major factors that might have impaired curriculum implementation and effective teaching, namely, (1) teachers’ limited SCK and PCK and inadequate understanding of the nature of Science, (2) the constant curriculum change that teachers experienced as disempowering and (3) an ill-functioning CoP

or pseudo-CoPs that inhibit professional development (Whitelaw 2008). Table 13 summarises these findings. The authors mainly used the information that was collected to compile this table. Some of the findings in Table 12 are also based on the transcripts of the observation field notes, that will form part of the discussion below.

Teachers' lack of SCK, PCK, and inadequate understanding of the nature of science

The following paragraphs contain evidence of the teachers' lack of SCK and PCK. Teacher F explained the microscopic structure of the kidney on the chalkboard. The learners were passive during the class. She started by reading the section on the nephron from the prescribed textbook. She copied the diagram of the nephron onto the chalkboard, but the illustration was grossly out of proportion and biologically incorrect. For instance, the afferent and efferent blood vessels were not shown as being part of the glomerulus, but as part of Bowman's capsule. Her diagram paved the way for all sorts of misconceptions amongst learners. One of the unifying themes running like a golden thread through Life Sciences, namely the complementarity between structure and function, was not discussed at all.

In another example Teacher D and her learners (Grade 10) were busy doing corrections of homework on the digestive system. Whilst answering one of the questions, Teacher D gave a wrong answer (epiglottis, instead of salivary gland), and in another case she indicated that the oesophagus consists only of skeletal muscles (instead of indicating that the lower two-thirds contains smooth muscles).

The participating teachers acknowledged their shortcomings, especially for some of the new themes (such as Molecular Biology,

TABLE 13: Summary of findings.

Knowledge	Teachers	Findings
Grades taught versus qualifications	Teachers A, B, C, & E	- Four teachers were trained as Further Education and Training (FET) teachers, and taught in the FET phase.
	Teachers D, F, G & H	- Four teachers were trained as GET teachers, and taught in the FET phase.
SCK	Teachers B, C & E (37.5%)	- They possess very good subject knowledge. - Evidence of critical engagement with the subject matter.
	Teachers A, D, F, G & H (62.5%)	- Inadequate subject knowledge; the teachers did not clarify concepts, nor did they really engage with learners' questions. In many instances factual errors were made by the teachers.
PCK	Teachers B, C & E (37.5%) All white teachers	- Very good transmission mode teaching; the teacher is good at 'chalk and talk', and uses media effectively. - Lesson plans adequate. - Questioning techniques adequate (cover all levels of Bloom's taxonomy). - Facilitation of practicals/group work boils down to 'cookbook' activities, if done at all. Inadequate use of inquiry-based methods. - Learners actively participate in lessons mostly by means of answering questions or hands-on activities during 'cookbook' practicals. - At times Teacher B used an experiment with inquiry-based methods with great success.
	Teachers A, D, F, G & H (62.5%) All black teachers	- Inadequate transmission mode teaching methods; mostly 'chalk and talk'; an offhand reading from the textbook without any real engagement by learners. - Poor lesson planning in the form of a workbook similar to that of their learners' workbooks. - Little and poor use of media. - Inconsequential use of questioning technique. Sometimes with great success, but most of the times inadequate (cover mostly low levels of Bloom's taxonomy). - Inadequate facilitation of practical/group work (when occasionally done). - If learners actively participate in lesson it is mostly by means of question and answer or hands-on activities during 'cookbook' practicals.

Table 13 continues on the next page →

TABLE 13 (Continues...): Summary of findings.

Knowledge	Teachers	Findings
CoP and teacher professional development	All these teachers occasionally attend professional development groups (cluster) meetings, the main focus of which, facilitated by the subject adviser, is assessment (learners' portfolios) and sometimes training. The assessment focus was criticised by teachers, and they all expressed the need for more training opportunities. Although the professional development group has all the elements of a CoP (see Figure 10), it does not function as such. Teachers felt that the school did not contribute much to their sustained professional development. If subject meetings are held in the school they mainly focus on administrative issues and policies, and hardly any attention is given to professional development, teaching and learning.	

Biotechnology, Evolutionary Biology and Indigenous Knowledge Systems) that had been introduced into the Life Sciences curriculum. The five teachers with limited SCK and PCK lacked in-depth SCK to teach these themes effectively. International studies show that Life Sciences teachers globally also find it difficult to teach these topics (Cossa *et al.* 2008), which indicates that the problem is widespread. This study supported such findings: most teachers (five of the eight) in this sample read directly from the textbooks and in various instances were not able to answer learners' follow-up questions. In this regard Ball *et al.* (2008) argue that such teachers lack specialised SCK as they cannot explain the origin of the mistakes or misconceptions made by the learners. Entries in the learners' workbooks further supported these findings. A large part of the learners' activities were just paragraphs and drawings reproduced from the textbooks. There was evidence of typical examination questions that had been tried out, but in some cases the answers were wrong (Teachers D and H).

Linked to teachers' limited SCK and PCK was their lack of understanding of the true nature of science. The nature of science portrays science as a way of knowing, and the values and beliefs

embedded in science (Lederman 2007). In most of the observed classrooms the teachers did not comply fully with the requirements of the DoE regarding practical work. It was expected from teachers to do both structured ('hands-on') and unstructured investigations (hypothesis testing) as set out in the Assessment Guidelines for Life Sciences (DoE 2008). Activities in the learners' workbooks (of Teachers A, B, C, E and G) such as worksheets also emphasised the fact that practical activities were mostly of the 'cookbook' ('hands-on') kind, with little cognitive engagement. Also worrying is the fact that there was very little focus on what Gibbons (2000) calls contextualised science (the 'Science and Society' column in Rogan and Grayson's profile of implementation). Practical work was not contextualised with regard to the relationship between science and society. Teachers D and H did not even do structured practicals with their learners. Only Teachers B and C's learners' books showed evidence of learners also having to formulate hypotheses and being involved in designing experiments with the teacher's help. These findings are supported by the research of Cronje (2011, 2015), where teachers often showed a naïve understanding of the tenets of the nature of science.

We used Rogan and Grayson's adapted profile of implementation with our addition of a Level 0 (Table 12), as a scale to classify the eight participants' (Life Sciences teachers') respective levels of SCK and PCK in their classroom interaction, practical work, science in society and assessment. We used the information from Table 13 to classify the teachers' SCK and PCK as written up in Table 14. We argue that such an exercise was needed before a CPD programme can be designed. In this case, the adapted profile of implementation may be useful as a tool to identify the specific needs of individual teachers.

TABLE 14: Classification of participant Life Sciences teachers' profile of implementation.

Schools	Teachers	Profile of Implementation																									
		Classroom interaction					Science practical work					Science in society					Assessment										
		0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4						
1	B	-	-	-	X	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	
	C	-	-	X	-	-	-	-	X	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-
2	A	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
	D	X	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
3	E	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-
	F	X	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
4	G	X	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-
	H	X	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-

Table 14 indicates that five of the eight teachers had limited SCK and PCK (mostly within Levels 0 and 1). Their limited SCK and PCK might have contributed to their inadequate implementation of the Life Sciences curriculum (NCS). The other three teachers' (B, C and E) SCK and PCK can be classified at Levels 2 and 3. According to Rogan and Grayson's profile of implementation it means that they had good teacher-centred teaching skills. It also implies that the other five teachers (all black) who participated in this study did not possess sufficient SCK and PCK to implement the NCS effectively (see Table 14). We acknowledge the fact that the teaching situation is too complex to just refer to cause and effects. It remains, however, that for any teacher to possess good PCK, very good SCK is not negotiable.

Many historical reasons might have contributed towards this situation, amongst others Bantu education during the apartheid era in SA, the tendency to teach as one was taught (Lortie's apprenticeship of observation) and weak pre-service training (Murphy 1992; Ottevanger *et al.* 2007; Rice 2010). The latter issue is also highlighted by the Ministerial Task Team (Department of Basic Education 2013). The in-service professional development programmes are also often ineffective (CDE 2011), which applies to both SCK and PCK.

In terms of Rogan's ZFI, we argue that such programmes were not successful because the gap between current practice and the desired practice of the teachers was too wide. We agree with Rogan (2004a) who reasons that the missing link is often a well-planned professional development programme and that curriculum implementation strategies should be within the individual teachers' ZFI. We argue further that such professional development programmes can be more effective if driven from the platform of a functional CoP.

Curriculum change and teacher professional development

The past 20 years of South African education were characterised by many curriculum reforms. Before 1994 the official syllabus of the country was NATED 550. This was followed by the interim transitional syllabus (1994–1996). Although not prescribed, both of these syllabi were delivered predominantly through teacher-centred methods. In 1997 came C2005, which was supposed to be fully implemented in Grade 12 in 2005. Because of many challenges, the authorities were forced to revise C2005. The Revised NCS for the GET phase was released in 2002. From 2006, the NCS for the FET phase was introduced. A new content framework for Life Sciences was implemented in 2009 in Grade 10 and 2011 for Grade 12. In 2011 the DBE phased in another supplement to the curriculum, the CAPS in Grade 10 (Chisholm 2003; Chisholm 2003–2004; DBE 2011; DoE 2009; Western Cape Education Department 2008). One should not be surprised if, in an era of more and more calls for the 'decolonisation of the curriculum' we soon see a new curriculum with a stronger focus on indigenous knowledge. The constant factor during the last two decades, however, is the insufficient teacher professional development. This illustrates Rogan's point that too much emphasis is given to the 'what' of the curriculum, and not to the 'how'.

These changes required more learner-centred and inquiry-based teaching methods and an array of new terminologies (Chisholm 2003–2004). To prepare teachers for the changes, support was given through workshops and administrative support by office-based educators, which Rogan and Grayson (2003:1180) call their 'capacity to support innovation'. Many schools were also provided with physical resources, which these authors refer to as 'profile of outside support' or learning and teaching support material (LTSM), as it is known by teachers.

Teachers reacted differently to the challenges of implementing the new curriculum, as the following comments imply:

‘I still struggle with the completion of lesson plans. I think that is why I don’t make any progress with either transmission or inquiry teaching.’

‘One feels intimidated by the document (the NCS). Just paging through the document asks for a lot of energy, but once you have done it, you realise that it is something that can be understood. The documents are not very user-friendly.’

‘Those documents are written in a difficult language. As I have said I am not yet ready to use all those terminology. The problem with the NCS is that it has lots and lots of terms, some of which you don’t understand.’

Teachers also struggled with the fact that there were continuous changes in the curriculum. As one teacher put it:

‘I am totally positive, but the problem is that the curriculum continuously changes. Changes are also not always properly communicated. The other day I realised I started with the wrong content. It is now 3 years that we usually start with cells. Now, all of a sudden, we must start with environmental studies, but it was never communicated to me. That made me angry because it seems that I don’t do my work properly.’

Other participants mentioned that sufficient training did not always take place and that there were discrepancies in the feedback and suggestions of different subject specialists.

The above findings can be enlightened by using the other two constructs of Rogan and Grayson’s framework, namely the capacity to support innovation and the outside support profile. We used the observations and interview information to classify these two profiles of the four participating schools. Table 15 summarises our findings.

There is evidence of a cause and effect relation between the two profiles in Table 15, and the profile of implementation in Table 14: School 1 supports the teachers sufficiently (the X’s range between levels 3 and 4) in

TABLE 15: Classification of capacity to support innovation and the outside support profiles.

Schools	Teachers	Profile capacity to support innovation												Profile of outside support											
		Physical resources				Teacher factors				School ethos & management				Professional development			Monitoring & accountability								
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4				
1	B	-	-	-	X	-	-	X	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	X
	C	-	-	-	X	-	-	X	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	X
2	A	-	X	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
	D	-	X	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
3	E	-	-	X	-	X	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	X	-	-	-
	F	-	-	X	-	-	-	X	-	-	X	-	-	X	-	-	-	-	-	-	-	X	-	-	-
4	G	X	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-
	H	X	-	-	-	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-

implementing the curriculum. It is thus not strange to see (Table 14) that Teachers B and C (both with a 3-year degree and a 1-year teachers' diploma) are also mainly the two teachers who implement the curriculum with great success. Their levels imply that they are good teachers who can render quality education. The other side of the coin is also true: schools 2 to 4 do not support their teachers sufficiently to render quality education. All these teachers were in possession of a 3-year teachers' diploma except for Teacher E (see X's in Table 14). This teacher, however, has a 3-year degree and a 1-year teachers' diploma with good SCK and PCK. We believe that she used these characteristics to counteract the lack of support.

If the conclusions as described in the previous paragraph are read with the classification in Table 14, the cause and effect relation between the different profiles of the framework becomes clear: Teachers B and C get the necessary support, are well qualified, and therefore have a good profile of implementation. With regard to the other participating teachers, the opposite is true.

In a South African context such a phenomenon is not strange: School 1 was a former white school with historically better support structures, whereas schools 2–4 were township (black) schools with traditionally little or no support structures. The participating township schools, according to our information, had relatively little capacity to support their teachers. This scenario gave rise to these challenges, in addition to other factors such as teachers (Teachers D, F, G and H) who need to teach in the FET phase whereas they were trained for the GET phase; substandard initial training (of Teachers A, D, F, G and H); teaching under pressure as a result of continuous disruptive curriculum reform; and teacher unions that constrain the government from pursuing policy objectives (Carnoy, Chisolm & Chilisa 2011).

Professional development within a CoP

Literature shows that occasional workshops (and other 'shot in the arm' approaches) have limited impact on teachers' classroom practices and professional development (CDE 2011; Pretorius 2015). Rogan (2004a) believes that professional development should best take place within well-functioning CoPs, a sentiment echoed by the latest CDE (2011) report.

Most of the teachers (five of the eight) in our sample did not consider their own schools, or the professional development (cluster) group, as useful CoPs to enhance professional development. They indicated that they supported their colleagues at school mostly in administrative tasks, and little support was exchanged regarding professional development. Regarding the cluster groups, teachers had mixed views. Six of the eight participants did not view the focus on assessment practices (e.g. learner portfolios) as helpful, but they all valued the occasional workshops that focused on SCK. This finding was supported by the following comment by one of the participants:

'You know I don't like the cluster meetings because we as teachers must look at each other's work. I like more the idea that the subject adviser must come and sit next to you to go through your files, even though it means that he points out your mistakes. When he does that you know what is going on, but it is not the case if we look at each other's work. It feels to me like a punitive exercise, where we are policing each other. Often you don't get any positive remarks to help you in the future. The hard-working teachers' work is done, most of the times. Some other teachers just compile lots of stuff – not something that is kept up to date.'

Another comment was:

'We are very fortunate to have a subject specialist who brings us together on a regular basis. He is somebody who is really very serious about his work and puts lots of effort in everything he does. We have just attended a 2-day workshop on evolution – a new thing in the Grade 12 syllabus. We really gained by attending the workshops.'

We argue therefore that the CoPs in our study contain all the elements of a CoP as described by Nardi and O'Day's (1999) definition (mentioned earlier), but that its functionality leaves much to be desired. In the context of this study we therefore refer to such less functional CoPs as pseudo-CoPs (Whitelaw 2008). Figure 10 is a summary of the findings of the CoP, based on the five elements of Nardi and O'Day's definition.

We argue that one possible reason for pseudo-CoPs is the tensions within the activity system(s) of a school(s)/cluster(s). In this particular CoP there is not much evidence of a systemic approach to teacher development. Unlike the findings of Pretorius (2015), there is not a planned intervention to expose teachers to experience working in a real

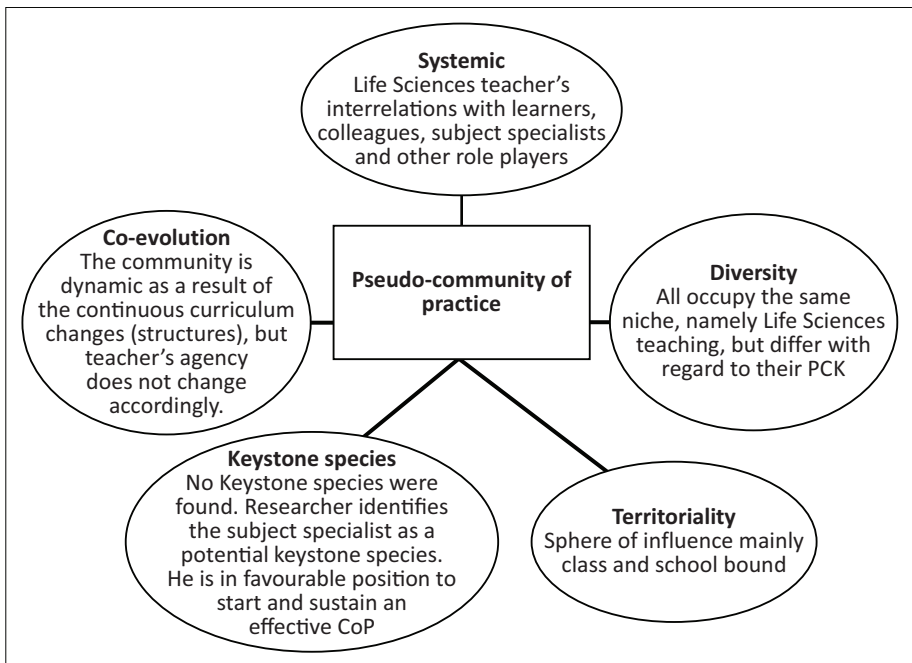


FIGURE 10: Findings of this study indicate teacher participation within a pseudo-CoP [Petersen 2011].

research laboratory, for example. There is also not a keystone species that could scaffold teacher professional development. Below we indicate how teacher professional development could be facilitated within well-functioning CoPs.

■ Scaffolding professional development within CoPs

When planning professional development support in such pseudo-CoPs it will be wise to be guided by the different stages identified by Warford (2011). This scaffolding during professional development across the zone of proximal teacher development (ZPTD) will enhance teachers' PCK. In Table 16 the four stages in the scaffolding across the ZPTD are indicated.

From the interviews with teachers it is clear that such a systemic approach to professional development is not followed in the professional development groups. Warford's (2011) research has shown that teachers should be provided with the opportunity to reflect on their own teaching philosophies and prior beliefs, and their views on the nature of science (see the 'self-assistance' phase). Based on teachers' needs, tailor-made interventions should then be planned, and teachers should be assisted in their own PCK development and to develop a more nuanced view of the nature of science (Stage 2, the 'expert other' assistance). This could also include apprenticeship models, where teachers for instance spend time in

TABLE 16: Scaffolding teacher professional development across the ZPTD [Warford 2011:254].

Stages within the ZPTD	Interventions/ activities
1. Self-assistance	Preparing learner autobiographies; introspection on own teaching philosophies and beliefs (e.g. also on the nature of science)
2. Expert other assistance	Analysis of teaching practices; sharing best practices
3. Internalisation	Journaling; discussion; dialogic partners
4. Recursion	Critical reflection; establishing online fora

laboratories, to develop more nuanced views of the nature of science. Pretorius (2015) has shown that teachers spending a few weeks in a research laboratory develop more nuanced understandings of the tenets of the nature of science and become more willing to implement inquiry approaches in the classroom. Teachers should then be encouraged to become more reflective, for example, by keeping a teaching journal (stages 3 and 4). Once again, Pretorius (2015) has shown that teacher reflection is of the utmost importance in teachers' professional development. Such an approach will be more successful than the current approaches in teacher professional development.

■ Recommendations

More than 60 years after the Biological Sciences Curriculum Study alerted South African science educators to the need to change from a transmission mode to a context of science as inquiry, and after billions of rands have been spent on educational transformation (SouthAfrica.info 2011), the *status quo* remains, as this chapter reports: that inquiry-based teaching is still marginalised by the predominance of transmission teaching approaches for the participating Life Sciences teachers. There is an urgent need to develop teachers' SCK and PCK, and their views on the nature of science, and to foster inquiry-based approaches in the Life Sciences classroom. Venkat *et al.* (2009) found evidence that 'content knowledge for effective teaching needs to connect with in-depth understanding of how specific content is learned, and ways this content needs to be offered to learners'. We propose that the envisioned professional development programmes must cater for the specific needs of teachers. Such a professional development programme has to fall within the teachers' ZPTD (Warford 2011) in order for their SCK and PCK to improve from one level to the next.

Despite curriculum changes and high financial expenditure to improve science education over the past 60 years in SA, it seems as if little progress has been made. Apart from reasons already mentioned, another might be that the platform from which teacher professional development takes place is not conducive to effective learning. We recommend that well-functioning CoPs at each professional development group (cluster) may serve the purpose of professional development optimally. Warford's suggested interventions during four stages in teacher professional development across the ZPTD might assist teacher educators to better train teachers for the demands of the 21st century.

According to Nardi and O'Day (1999), all well-functioning CoPs must have a 'keystone species' to ensure the survival of the community. We propose that the local subject specialist acts initially as a keystone species and a catalyst to turn an existing pseudo-CoP into an optimally functional one. It seems a viable option because the teachers who participated in this study displayed appreciation of the role the local subject specialist played, especially in training sessions during cluster meetings. They had high regard for his/her SCK and PCK and confidence in the subject specialist as a professional. The research of White (2012) has shown how this was done successfully in Tswane in Gauteng.

The subject specialist's role as catalyst would be useful, especially in the beginning, until a well-functioning CoP is established. It is of the utmost importance that more teachers in the CoP be developed as new keystone species in order to lead the CoP in future in a sustainable way. Ottevanger *et al.* (2007) suggested that this may be done by a well thought through professional development programme that caters for specific needs of teachers. Such an initiative should take the existing SCK and PCK levels (according to Table 14) of teachers into consideration in order to develop

a professional development programme within the teachers' ZFI. In this regard the adapted profile of implementation of Rogan and Grayson may be of value. This may lead to the development of sustainable CoPs and serve as an ongoing support for schools and teachers (Ottevanger *et al.* 2007). This will come with its own challenges, but if managed well it may improve teaching of Life Sciences in this particular CoP.

We propose a three-phase teacher professional development programme, running over a period of 3 years, and which is context-specific to cater for the individual needs of Life Sciences teachers in order to enhance their PCK. The proposed in-service teacher professional development programme can be done as an ongoing action research project, of which the results can be evaluated over the 3-year period and beyond. Of course, the practical feasibility and available sources must be taken into account. In the paragraphs that follow the three phases will be unpacked, and they are summarised in Table 17.

Phase 1: The pre-developmental stage

The primary purpose of this phase is to identify and understand the actual needs of teachers (observation that focuses on gaining understanding and insight, rather than on judgement and interventions). With regard to Giddens' (1984) theory, it implies that the teachers' existing levels of agency can be determined as well as all the structures (rules, policies, facilities, sources) that have an influence on their agency to render quality education. It also builds on the unfreezing phase of Lewin's change theory which implies that teachers need to be prepared for the envisioned change. According to Lewin it can only happen if teachers realise the need for change (Burnes 2004; Change-Management-Coach.com; Schein 1996). With regard to the professional development component of the Bell and

TABLE 17: Three-year teachers' developmental programme.

Other Theories	Kurt Lewin (change theory)	Giddens [structuration theory]	CoPs	Rogan (as interpreted by Petersen)	Bell & Gilbert (holistic teachers' development programme)	Warford's ZPTD
Phase 1	Unfreeze phase	Determine existing agencies and structures	Identify elements of CoP	Classifying of teachers	Personal levels 1 & 2	Self-assistance: Introspection on own beliefs
Phase 2	Trans-formation phase	Agency	Establishment of elements. Continuous development and deepening of SCK and PCK with the main purpose to cultivate keystone species. Subject specialist can act as a catalyst to get the CoP going, but must withdraw increasingly as teachers become more empowered.	Levels 0 – 1 in all dimensions	Professional 1, social 1 – 3	Expert other assistance: sharing best practices
		Agency		Levels 1 – 2 in all dimensions (consolidation)	Professional 2, social 1 – 3	
		Agency		Levels 2 – 3 in all dimensions (consolidation)	Professional 2, social 1 – 3, personal 3	
Phase 3	Re-freeze phase	Agency and structure	Functional CoP	Consolidation of levels 2 – 3 in all dimensions and possible levels 3 – 4	Personal 3, social 3, professional 1 – 3	Internalisation and recursion and critical reflection

Gilbert programme, it means that the teacher experiences certain aspects of his or her teaching as problematic (Bell & Gilbert 1994). This could also be linked to Warford's (2011) stage of self-assistance, where teachers will be engaged in autobiographies and inspection of own philosophies and beliefs (see Table 16). The information gathered in this needs pre-developmental phase will be used to classify the teachers' PCK according to Rogan's profile of implementation Levels 1–4, and the author's Level 0.

Simultaneously or concurrently the professional development groups of Life Sciences teachers need to get ready to function. During this phase the members of the CoP need to identify a suitable venue which is easily available and accessible, contains an equipped laboratory/classroom and teaching media. This venue must be their 'safe haven' for the next 3 years. We propose that the subject adviser will in some instances be in a favourable position to perform this role.

Phase 2: Developmental stage

In this phase the teachers' SCK and PCK will be developed (agency); this builds on Lewin's transformation phase and is where, according to Bell and Gilbert (1984), the teachers' professional and social development can take place. We propose that it can be done in continuous reflection cycles (Figure 11). This also corresponds with the stage of 'expert other assistance' in Warford's construct of the ZPTD.

The foundation of this phase is the teacher's reflective practices, whilst curriculum content and suitable methodologies should be addressed simultaneously. Since the teacher's professional development programme will run over 3 years, a teacher can be developed alternately and respectively in Grades 10–12 curriculum content. During the first year teachers will be empowered on Rogan's Level 1 skills and values.

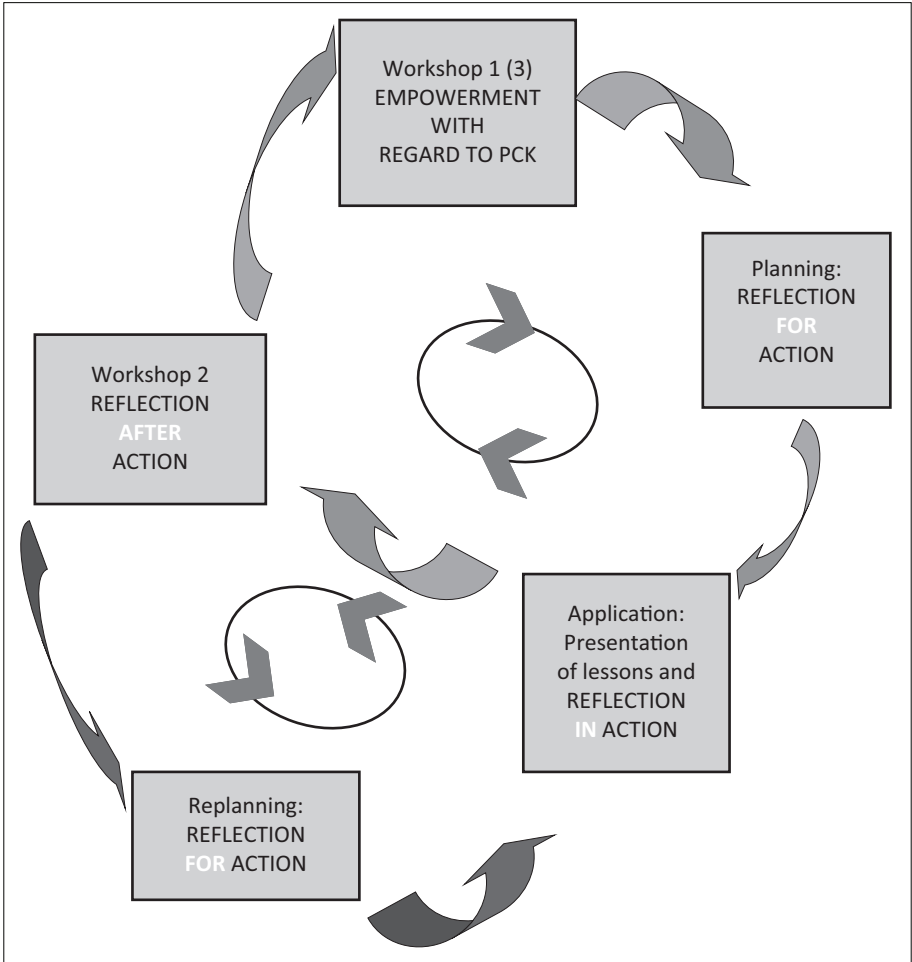


FIGURE 11: Reflection cycle.

In the following discussion we will explain the process of one reflection cycle (Figure 11). Depending on the performance of the individual teachers, the second year can focus on Rogan’s Level 2 skills and values. The third year can be used to consolidate the Levels 1 and 2 skills. A teacher needs to enter the programme for the grade they are currently teaching that year. Although we can anticipate certain logistical

challenges, it does not mean that all the teachers need to start with Grade 10 work in the first year. The aim is to develop teachers that will be competent in teaching any of these three grades in the FET phase and that they can function at least on Rogan's Level 3 and Warford's internalisation and recursion and critical reflection phase.

□ Workshop 1

This can be regarded as the first opportunity where the Life Sciences teachers meet one another as members of a CoP to start the teachers' professional development programme. During this workshop a particular theme, according to the year planner, is chosen. The facilitator will lead the discussion and appropriate teaching method(s) will be chosen with the participating teachers. The pros and cons of such a teaching method(s) will also be discussed as well as possible difficult content. Attention may also be given to appropriate teaching and learning opportunities that can be designed and how the content can be linked to real-life situations.

□ Planning and reflection for action

With the knowledge and skills acquired during their first working session(s), the teachers have to design their own individual lesson plan(s). Planning includes, amongst others: the completion of a lesson plan(s), choosing appropriate teaching aids, and the design or selection of suitable learning materials, such as a worksheet and so on.

□ Application and reflection in action

This is the stage when individual teachers conduct the planned lessons and simultaneously reflect (**reflection in action**) during the course of the lesson. This can be done at their respective schools with colleagues and at the next meeting of the CoP.

□ **Workshop 2 and reflection after action**

The second workshop mainly deals with how the first lessons were conducted, it is reflection *after* action. During this workshop teachers will be given the opportunity to share their own critical reflections of their own experiences. Suggestions and best practices can be identified and exchanged, which can be of use in other appropriate situations in their CoP. If it happens that a teacher realises that he or she has not yet mastered a particular teaching method or knowledge, he or she can replan and apply it again in the next lesson. If all goes well, he/she can proceed to the next cycle to tackle the next theme in the curriculum.

During this phase it is also advisable to create opportunities for teachers to learn from scientists in laboratories. Pretorius (2015) has shown how Johannesburg teachers developed a more nuanced understanding of the nature of science by engaging in activities at the African Centre for DNA Barcoding.

■ **Phase 3: Post-developmental stage**

This is the consolidation phase, or the refreezing phase according to Lewin. The boundary between the second and third phase is very vague since it takes place continuously and alternately. Skills development of levels 3 and 4 of Rogan's profile of implementation can be the goal for future continuous development in the CoP. This refers to the internalisation and recursion stages in Warford's construct of the ZPTD.

Teachers will be encouraged to keep a reflective journal as a hands-on tool to make their development more tangible and concrete, and which can serve as intrinsic motivation and a future reference source.

■ Conclusion

Zsiga and Webster (2007) argue that to change existing curriculum and behavioural patterns in teachers is a massive undertaking. They further state that it will require comprehensive planning, a risk-taking opportunistic attitude, and a commitment to change and improve and simultaneously make adjustments to instructional practices. Indeed this is true; our research also showed that the participating teachers largely taught in a teacher-centred manner. This is in spite of the many advantages that inquiry-based teaching methods hold in the classroom. This current state may, over time, be turned around if all stakeholders become involved to design a thoughtful CPD programme.

Pretorius (2015) has shown what role universities could play in this regard, especially in providing a type of internship for teachers to engage in real research in a research laboratory. Pretorius showed how teachers in the Johannesburg area participated for a week in research at the African Centre for DNA Barcoding at the University of Johannesburg, and how this provided them with a more nuanced understanding of the nature of science. This would hopefully be transferred to the classroom with more inquiry activities. A functional CoP may assist in reaching such a goal, which may ultimately contribute to improve the quality of education in SA.

■ Chapter 9: Summary

Science education globally has been characterised by waves of curriculum transformation that have been echoed in the Life Sciences curriculum in South Africa. The democratisation process in South Africa was accompanied by continuous curriculum reform and development. The Life

Sciences National Curriculum Statement of 1997 emphasised inquiry teaching approaches but encountered challenges in practice. For example, numerous teachers had limited subject content knowledge (SCK) and pedagogical content knowledge (PCK), which are necessary for quality teaching. To understand the situation better we examined the ways in which Life Sciences teachers had been implementing the learner-centred inquiry-based curriculum and the issues they encountered. This ethnographic study revealed that Life Sciences teachers applied mainly teacher-centred transmission mode teaching methods. It also identified factors that might have influenced their agency to apply inquiry approaches, one of which related to non-functional communities of practice (CoP), or pseudo-communities of practice (Whitelaw 2008). This chapter ends with a description of how a functional CoP can be used amongst others as a platform for continuous professional development by using an adapted version of Rogan and Grayson's (2003) framework. We also frame teacher professional development with regard to Warford's (2011) take on the well-known Vygotskyan concept of the ZPD, namely the zone of proximal *teacher* development.

Information and communication technology pedagogical practices of South African Grade 8 Mathematics and Natural Science teachers

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■ Introduction

The World Economic Forum *Global Information Technology Report of 2013* ranks South Africa's Mathematics and Science education as second last in the world, ahead only of Yemen. It further lists the quality of South Africa's education system at 140 out of 144 countries, and Internet access in schools at 111 out of 143 countries (Bilbao-Osorio, Dutta & Lanvin 2013). This is the case despite the South African Department of Basic Education (DBE)'s vision for information and communication technology (ICT) to improve access to a better quality teaching and learning environment (Department of Education 2008). There is evidence that the appropriate use of ICT could raise educational quality and connect learning to real-life situations (Castro Sánchez & Alemán 2011; Lowther *et al.* 2008; Weert & Tatnall 2005). ICT is also considered to be a catalyst for change from traditional pedagogical practices to constructivist pedagogical practices. In addition, ICT may act as a tool to motivate learners to become independent in their learning and facilitate the creation of new knowledge (Anderson 2005). The following section explains the operational meaning of the main concepts used in this study.

■ Operational definitions

□ Information and communication technology (ICT)

Information and communication technology (ICT) refers to data processing and sharing using computers, networks, software and peripherals (Anderson 2005). According to UNESCO (2007) ICT refers to forms of technology used to transmit, process, store, create, display, share or exchange information by electronic means. This broad definition of

ICT thus incorporates radio, television, DVDs, landline and cellular phones, computer hardware, networks, computer software, video conferencing, instant messaging, blogs and email as part of ICT. For the purposes of this study Anderson's definition is chosen as the working definition of ICT.

□ Pedagogy

The word 'pedagogy' is derived from the ancient Greek word *paidagogos*, referring to the slave who guided children to school. Pedagogy is generally considered the *art and science* of teaching. Alexander (1992), as quoted by Cox *et al.* (2003), identifies 'teaching methods' and 'learner organisation' as the two main facets of pedagogy. The above explanations are based on teacher-centred pedagogy. Currently (and for this study) pedagogy represents the processes, experiences, contexts, outcomes and relationships of teaching and learning (Beetham & Sharpe 2007). Unlike in the past, pedagogical practices should now place more emphasis on learning (by the learner and the teacher) and less on teaching (by the teacher alone). Beetham and Sharpe (2007) propose that 'design for learning' should replace 'pedagogy'.

□ ICT pedagogical practice

Developments in ICT provide different learning opportunities for learners. McLoughlin and Oliver (1999) define pedagogical roles for teachers in a technology-supported classroom as setting joint tasks, rotating roles, promoting student self-management, supporting metacognition, fostering multiple perspectives and scaffolding learning. This study uses McLoughlin and Oliver's definition.

□ Learning

Learning can be thought of as a process that may transform and/or create culture; could involve different cultural contexts and standards of competence; and may lead to the formation of theoretical knowledge and concepts (Daniels 2012).

According to Jarvis (2006) learning is the combination of processes whereby the whole person – body (genetic, physical, biological) and mind (knowledge, skills, attitudes, values, emotions, beliefs and senses) – experiences a social situation. The perceived content of this is then transformed cognitively, emotively, or practically (or through any combination of those) and integrated into the person's individual biography, resulting in a changed (or more experienced) person.

For this study learning is defined as any process in living organisms that leads to permanent capacity change and which is not solely due to biological maturation or aging (Illeris 2009).

□ Constructivism

Constructivists view learning as the result of mental construction. Learning takes place when new information is built into and added onto the individual's current structure of knowledge, understanding and skills (Prichard 2009). Constructivist learners are mentally active and create their own individualistic meaning and structure of the world. Knowledge construction involves an integration of individual cognitive and social processes. Knowledge is constructed, rather than discovered, which implies that it is neither independent on human knowing, nor value-free (Gordon 2009).

□ **Conventional role of teachers**

In the conventional role of a teacher all learners receive a ‘one size fits all’ presentation and every learner does the same thing at the same time, such as completing a worksheet or taking a test. Here the activities are teacher-oriented and aimed at helping learners to pass tests and achieve high scores in examinations.

□ **The structured inquiry role of teachers**

In structured inquiry teachers provide learners with a hands-on problem which they have to investigate. Teachers also provide the procedures and materials. This resembles a cookbook activity. Learners conduct previously established procedures in order to discover relationships between variables, such as proving a theorem in Mathematics or verifying a law in Natural Science, or otherwise generalise from data collected. Here, the emphasis is on the ‘processes of science’.

□ **The guided inquiry role of teachers**

In guided inquiry the teacher provides only the problems to investigate and, if needed, requested resources will be supplied. Learners devise their own procedures for solving the problem. Activities involve learners in self-initiated, self-sustained learning activities (Colburn 2000).

■ **Problem statement and aim**

The first question posed by the researchers was whether South African Grade 8 Mathematics and Natural Science teachers used ICT to promote

constructivist learning activities in their learners by providing opportunities for teamwork, problem-solving and product creation. The second question posed was whether or not Grade 8 Mathematics teachers and Natural Science teachers need separate ICT pedagogical training opportunities. Answers to these questions might help stakeholders make more informed decisions regarding the effective use of meagre ICT resources in South African classrooms.

The aim of this chapter is to report on the findings of research with regard to these two research questions. To achieve this aim the remainder of the chapter is structured as follows. Firstly, a conceptual and theoretical framework is outlined, followed by an exposition of the research method applied. The findings are then listed, followed by a discussion thereof in view of the conceptual and theoretical framework. The article concludes with several recommendations.

■ Conceptual-theoretical framework

ICT in education may include any resource or any process that facilitates learning. A teacher can use ICT for quality and clarity in communication. The extent to which ICTs facilitate dialogue is the extent to which they succeed as educational tools (Johnson 2010). ICT can be used as a tool to fit any specific learning style. A learner can also use ICT to suit his or her cognitive style. In addition, ICT can provide stimulus, rewards and feedback, as well as help a learner construct and test mental models. Moreover, ICT can help learners construct new knowledge through social interaction (Lever-Duffy & McDonald 2008). The idea that ICT can be used to foster different pedagogical approaches across different learning contexts can also be explained with regard to activity theory.

Activity theory (Engeström 1987; Engeström 2009; Kaptelinin & Nardi 2009; Ryder 2009; Vygotsky 1978), which formed the conceptual foundation for this study, is a variant of the cultural historical activity theory (CHAT) (Lektorosky 2009); CHAT holds that human beings do not live in a vacuum but that their thinking and activities are mediated through their cultural symbol systems, artefacts (e.g. ICT) and social mediators (Engeström 2009). Activity theory is a framework for studying humans and their use of artefacts (Molenda 2008).

The main constructs of activity theory will now be briefly described in terms of objects, mediating artefacts, subjects, activity, division of labour, community, rules, and outcomes.

■ Objects

Engeström (1999) states:

[T]he object of an activity can best be regarded as a project under construction, moving from potential raw material to a meaningful shape and to a result or outcome. In this sense, the object determines the horizon of possible goals and actions. But it is truly a horizon: as soon as an intermediate goal is reached, the object escapes and must be reconstructed by means of new intermediate goals and actions. (p. 65)

For example, in this investigation ICT pedagogical practices are one of the objects.

■ Mediating artefacts

The relationship between human agents and objects of the environment is mediated by cultural artefacts, i.e. tools and signs. The human mind develops and can only be understood within the context of meaningful, goal-oriented and socially determined interactions between human beings and their material environments (Bannon 1997; Kaptelinin & Nardi 2009;

Ryder 2009). As an individual engages and interacts with the environment, tools are produced. These tools are *exteriorised* forms of mental processes. Because these mental processes manifest in tools, they become more readily accessible and communicable to other people. These tool manifestations of mental processes then become useful for individual and social interaction. Artefacts are present when we are engaged in a certain activity, but they can also become a product of our activity. Artefacts are constantly changed through activities. The Internet and the World Wide Web are perhaps history's largest collective human artefacts (Bannon 1997; Kaptelinin & Nardi 2009; Ryder 2009).

■ Subject

The subject is the bearer of an activity. An individual activity has an individual subject, whilst a collective activity has a collective subject (Lektorosky 2009). In this study teachers, learners, groups of learners and even the government (depending on the context) are regarded as the subjects.

■ Activity

Activity refers to the engagement of a subject towards a certain goal or objective. Activities organise human life. Through activities, humans develop skills, personalities and consciousness. Through activities we transform our social conditions, resolve contradictions, create new tools and create new forms of life and self-actualisation. Activities connect the inner subjective world of consciousness to the outer world of people and things (Lektorosky 2009). Activity is a concept that denotes the basic unit of concrete human life (Sannino, Daniels & Gutierrez 2009). They are carried out automatically by human routines or machines. Activity is the

primary unit of analysis in activity theory. Activity systems travel through zones of proximal development (Engeström 1999). In this study, teaching, learning, facilitation, counselling and guidance constituted (at various times, according to the context) the activities.

■ Division of labour

The term ‘division of labour’ allocates responsibility to the members of the community in relation to the object (Engeström 1987). For example, when learners are involved in problem-solving as a group, one may search and find information, another one may create PowerPoint presentations and a third may present it to the class orally.

■ Community

The community in which the subject is present is called the ‘immediate environment’. This environment includes people and the social artefacts they use. Teachers, group leaders, peers, parents, experts outside the school and the Internet community could all scaffold learning activities, depending on the requirements of the context (University of Tasmania 2009).

■ Rules

Rules can be defined as the norms that regulate the actions carried out by the subject. They are located between the subject and the community and may be explicit, such as printed regulations, standards, policies, and statutes, or implicit, such as cultural beliefs, values and power relations. Learning within schools takes place in an environment surrounded by formal and informal rules, traditions and acceptable practices.

Outcomes

Outcomes specify the results of the activity. For instance, efficient ICT pedagogical practices of teachers could enable learners effectively achieve the South African curriculum goals.

ICT can be considered a cultural artefact (Wertsch 1998). We think with and through artefacts (Säljö 1995). Each artefact has its own affordances and constraints (Gibson 1979). Accordingly, ICT could provide opportunities for optimum facilitation in educational activities. Figure 12 presents the structure of the human activity system.

Engeström reformulated the collective activity system by including rules and collective subjects. He then created a graphical representation of the system, as depicted in Figure 12. Subjects undertake an activity, for example, teachers who participate in an ICT training course. Together with the instructor and the technician, they form the community. They use specific ICT artefacts, such as computers, the Internet, software and the course manual, to mediate the activity between the subjects (teachers) and the object (e.g. the skills and

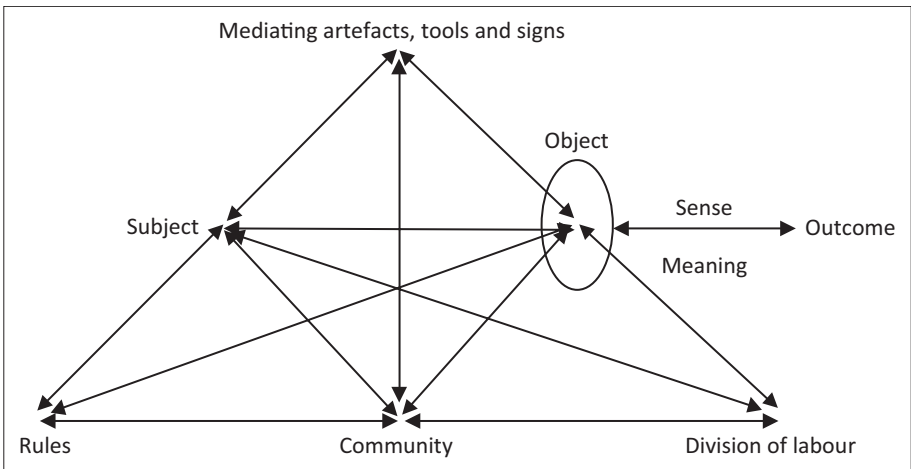


FIGURE 12: The structure of the human activity system [Engeström 1987:78].

knowledge to use ICT in teaching and learning). They work in collaboration with others (the community) according to specific rules (e.g. computer laboratory rules, instructions from the trainers, directions from the course manual and their mutual respect for one another). Within the training community a division of labour exists according to expertise, for example, the instructor presents the course and guides teacher students; the technician solves technical problems, the teacher-students perform specific tasks on the computers, and the teacher students with the most computer competency assist the instructor in transferring skills and knowledge to teacher students with less computer competency. The outcomes of this activity system are ICT-competent teachers that effectively use ICT with confidence for teaching and learning.

The following section presents the research method used in this investigation.

■ Research method

■ Secondary data analysis

The investigation aimed to extract characteristics of the ICT pedagogical practices of Grade 8 Mathematics and Natural Science teachers by using secondary data analysis of the South African data set of the Second International Information Technology in Education Study (SITES) (Brese & Carstens 2009).

The International Association for the Evaluation of Educational Achievement (IEA) made the SITES 2006 international database available to the public to promote secondary data analysis (Brese & Carstens 2009). Owing to the large sample size of 504 schools, the random sampling and the ordinal nature of the data, the parametric statistical analysis was a valid operation that could be conducted (Elliot & Woodward 2007) on the SITES 2006 database.

■ Statistical procedures

The IEA's Independent Database Analyser software enabled the combination of Statistical Program for Social Sciences (SPSS) data files from the IEA SITES 2006 and certain analyses to be conducted. Firstly, a factor analysis (Nicole & Pexman 2000) was conducted on the combined Mathematics and Natural Science teachers' data set (Brese & Carstens 2009) by means of the SPSS (Byrne 1989). The factor analysis was conducted to examine the correlations amongst the variables represented by the questionnaire and to identify the clusters of highly interrelated variables that reflected underlying themes or factors within the combined data set. Secondly, Cronbach's alpha was calculated as a reliability test on identified factors. Cronbach's alpha is a measure of the internal consistency of items on questionnaires. It is used when all or some of the items are intended to measure the same concept (Cramer & Howitt 2004). When the measure is internally consistent, all of the individual questions or items making up that measure should correlate well with others. Thirdly, as SITES 2006 frequency tables represent ordinal variables, Spearman's rank order coefficients were calculated on factors identified during factor analysis in order to reveal the correlations that existed amongst the factors. Spearman's rank order coefficient is a non-parametric measure of statistical dependence between two variables. It benchmarks the monotonic relationship between two variables (Nicole & Pexman 2000). Fourthly, a *t*-test was conducted to establish whether there was any difference between the ICT pedagogical practices of Mathematics and Natural Science teachers.

■ Reliability

Secondary data generally have a pre-established degree of validity and reliability which does not need to be re-examined by researchers reusing the data. SITES 2006 was conducted by the IEA, which is an established, experienced, professional, international research organisation; hence the

SITES 2006 data set used for this research was assumed to have acceptable levels of reliability. In addition, favourable Cronbach's alpha reliability indices were calculated in the current investigation for identified factors.

■ Validity

Validity is the ability of research instruments to measure exactly what they purport to measure. In quantitative data collection data validity might be improved through careful sampling, appropriate instrumentation and the appropriate statistical treatment of the data. Whilst every precaution was taken in this regard, it remains impossible for research to be 100% valid because of standard errors inherent in all measurements (Cohen, Manion & Morrison 2007).

■ Ethical considerations

This research is a secondary data analysis of the SITES 2006; thus ethical issues, if any, were addressed during the original data collection. Appropriate acknowledgement to the IEA was provided and the integrity of the data was respected.

■ Limitations of this study

Secondary data analysis was the reanalysis of previously analysed research data and therefore the scope of this research was limited by the objectives of the original data collection.

■ Results of statistical analysis

Table 18 lists the general factors identified through factor analysis of the Mathematics and Natural Science teachers' responses to the SITES 2006 South African combined data set (Brese & Carstens 2009).

TABLE 18: General factors identified through factor analysis.

Themes	Factors
Roles of the teacher	<ul style="list-style-type: none"> - Conventional role of the teacher - Mediating role of the teacher
Roles of the learners	<ul style="list-style-type: none"> - Conventional role of the learner - Structured inquiry role of the learner - Guided inquiry role of the learner
Assessment practices	<ul style="list-style-type: none"> - Conventional assessment practices - Constructivist assessment practices
Barriers to ICT pedagogical practices	<ul style="list-style-type: none"> - Teacher-level barriers - School-level barriers - Curriculum-level barriers

In the conventional role of the learner (Table 18) all learners simultaneously engage in identical activities. In the structured inquiry role of the learner (Table 18) learners conduct previously established procedures according to this data set. In the guided inquiry role of the learner (Table 18), the teacher only provides the problem and the learners devise their own procedures to solve the problem (Colburn 2000).

Factor analysis of responses to ICT pedagogical practices and barriers

Factor analysis was conducted on selected items of the questionnaire: BTG9, BTG14, BTG15 and BTG23 are the original item numbers. This was done in order to unearth themes of pedagogical practices and barriers present amongst the variables represented by questionnaires. These specific questionnaire items were selected as they fairly represented the teachers’ pedagogical activities (management of learning, assessment activities, and management of learners) and the barriers present in the classroom.

Table 19 presents the results of factor analysis of the responses to items related to teacher roles.

TABLE 19: Teacher roles.

Question number	In your teaching of the target class in this school year, how often do you conduct the following:	Factor analysis		Communalities extracted
		Factor 1: Conventional role	Factor 2: Mediating role	
BTG14G	Use classroom management to ensure an orderly, attentive classroom	0.696	-	0.699
BTG14A	Present information, demonstrations and/or give class instructions	0.693	-	0.548
BTG14E	Assess students' learning through tests or quizzes	0.590	-	0.549
BTG14F	Provide feedback to individuals and/or small groups of students	0.543	-	0.719
BTG14C	Help or advise students in exploratory and inquiry activities	0.528	-	0.591
BTG14B	Provide remedial or enrichment instruction to individual students and/or small groups of students	0.454	-	0.588
BTG14H	Organise, monitor and support team building and collaboration amongst students	0.407	0.405	0.754
BTG14D	Organise, observe or monitor student-led whole-class discussions, demonstrations and presentations	0.406	0.376	0.710
BTG14J	Liaise with collaborators for student collaborative activities	-	0.830	0.627
BTG14I	Organise or mediate communication between students and experts or external mentors	-	0.776	0.709
BTG14K	Provide counselling to individual students	-	0.640	0.719

Table 19 continues on the next page →

TABLE 19 (Continues...): Teacher roles.

Question number	In your teaching of the target class in this school year, how often do you conduct the following:	Factor analysis		Communalities extracted
		Factor 1: Conventional role	Factor 2: Mediating role	
BTG14L	Collaborate with parents/guardians/caretakers in supporting or monitoring students' learning and/or providing counselling	-	0.608	0.587
Cronbach's alpha		0.847	0.814	-
Mean standard deviation		4.434	3.007	-

Variables in question BTG14 fit into two factors representing teacher roles (Table 19). Six variables fit neatly into Factor 1, four fit into Factor 2, and two variables fit weakly into both Factor 1 and Factor 2. Close examination revealed that Factor 1 represents the conventional role of a teacher in the classroom, whereas Factor 2 represents teachers' mediating role of the teacher in the classroom, characteristic of constructivist learning.

Table 20 represents results regarding the factor analysis of responses to questionnaires related to learner roles.

An examination of the factor analysis results (Table 20) indicates that the activities chosen by teachers represent three factors of pedagogical practices. Four variables overlap slightly. Factor 1 mainly represents structured inquiry-based pedagogical orientation. Factor 2 mainly represents a conventional pedagogical orientation. Factor 3 mainly represents the guided inquiry pedagogical orientation (Colburn 2000). Table 21 provides the factor analysis of responses to teacher questionnaire question BTG15 through a representation of the methods of assessing learner performances.

The total variance explained by the extracted factors was 54.57%. An examination of the results of a factor analysis of BTG15 reveals that BTG15A and BTG15B fit neatly into Factor 1 and BTG15C to BTG15H fit

TABLE 20: Learner roles.

Question number	In your teaching of the class in this year, how often is the scheduled learning time of the class used for the following activities?	Factor analysis results			Communalities of extracted values
		Factor 1: Structured inquiry	Factor 2: Conventional practice	Factor 3: Guided inquiry	
BTG9L	Looking up ideas and information	0.760	-	-	0.625
BTG9M	Analysing data	0.656	-	-	0.501
BTG9K	Studying natural phenomena through simulations	0.624	-	-	0.535
BTG9I	Laboratory experiments with clear instructions and well-defined outcomes	0.496	-	-	0.279
BTG9F	Field study activities	0.415	-	0.307	0.396
BTG9H	Exercises to practice skills and procedures	-	0.733	-	0.610
BTG9J	Discovering mathematics principles and concepts	0.403	0.493	-	0.508
BTG9G	Teacher's lectures	-	0.453	-	0.262
BTG9A	Extended projects	-	-	0.639	0.457
BTG9B	Short task project	-	0.214	0.603	0.449
BTG9C	Multimedia product creation	0.245	-	0.550	0.507
BTG9E	Scientific investigation	0.389	-	0.413	0.505
BTG9D	Self-assessed courses and/or learning activities	-	-	0.389	0.388
Cronbach's alpha		0.796	0.682	0.793	-
Mean standard deviation		3.487	2.261	3.198	-

TABLE 21: Methods of assessing learner performance.

Question number	In your teaching of the target class in this school year: [a] How often do you conduct the following? [b] Do you use ICT for these activities?	Factor analysis		Communalities of extracted factors
		Factor 1: Conventional	Factor 2: Constructivist	
BTG15A	Written test or examination	0.933	-	0.862
BTG15B	Written task/exercises	0.938	-	0.853
BTG15C	Individual oral presentation	-	0.656	0.408
BTG15D	Group presentation[oral or written]	-	0.764	0.583
BTG15E	Project report and/or Multimedia products	-	0.603	0.367
BTG15F	Students' peer evaluations	-	0.671	0.439
BTG15G	Portfolio or learning log	0.364	0.323	0.308
BTG15H	Assessment on collaborative tasks	-	0.730	0.545
Cronbach's alpha		0.534	0.738	-
Mean standard deviation		0.406	1.141	-

into Factor 2. BTG15G fit poorly into both Factors 1 and 2. BTG15A and BTG15B represent written tests or examinations and written tasks or exercises respectively. These are conventional assessment practices where all learners take part in identical tasks, exercises, tests and examinations. BTG15C to BTG15H represent constructivist assessment practices such as creating learning products, collaborative tasks and peer assessment.

In Table 22 Spearman rank order correlations were determined between factors identified on the A part (variables) and B part (whether or not ICT was used) on questionnaire items BTG9, BTG14 and BTG15.

Spearman rank order correlations were conducted in order to examine the extent of ICT use in each of the identified factors. The results show that little correlation is found between identified factors and ICT use. This was probably due to teachers' very low level of ICT use (less than 24%).

Factor analysis was also conducted on responses to teacher questionnaire items BTG23A to BTG23L in order to identify common themes in the barriers faced by teachers when using ICT for teaching and learning (Table 23).

TABLE 22: Correlation between identified factors and ICT use (Spearman's rho).

ICT	BTG9 Conventional learning	BTG9 Guided inquiry learning	BTG9 Structured inquiry learning	BTG14 Conventional role of teacher	BTG14 Mediating role of teacher	BTG15 Conventional assessment practices	BTG15 Constructivist assessment practices
ICT used	0.06224	0.11648	0.24259	0.01579	0.16676	0.051315	0.12909

TABLE 23: Pedagogical barriers.

Question number	Do you experience the following obstacles in using ICT in your teaching?	Factor analysis results			Communalities extracted factors
		Factor 1: Teacher-level barriers	Factor 2: School-level barriers	Factor 3: Curriculum-related barriers	
BTG23C	I do not have the required ICT-related skills	0.915	-	-	0.795
BTG23D	I do not have the required ICT-related pedagogical skills	0.748	-	-	0.657
BTG23L	I do not have access to ICT outside school	0.237	-	0.229	0.437
BTG23F	My learners do not possess the required ICT skills	-	0.654	-	0.470
BTG23B	My school does not have the required ICT infrastructure	-	0.644	-	0.383
BTG23J	My school lacks digital learning resources	-	0.640	-	0.416
BTG23G	My school does not have access to the required ICT tools outside of the school premises.	-	0.630	-	0.247
BTG23A	ICT is not considered to be useful in my school	-	0.242	0.231	0.136
BTG23H	I do not have the time necessary to develop and implement the activities	-	-	0.573	0.292
BTG23K	I do not have the flexibility to make my own decisions when planning lessons with ICT	-	-	0.515	0.464
BTG23I	I do not know how to identify which ICT tools will be useful	0.388	-	0.448	0.517
BTG23E	I do not have sufficient confidence to try new approaches alone	0.282	-	0.406	0.333
Cronbach's Alpha		0.724	0.714	0.696	-
Mean standard deviation		1.191	1.526	1.434	-

An examination of the results of the factor analysis (Table 23) indicates that variables under Factor 1 mainly represent teacher-level barriers; variables under Factor 2 mainly represent school-level barriers; and variables under Factor 3, BTG23H and BTG23K specifically, represent barriers related to the curriculum. Four variables fall weakly into two factor groups because they partly share these characteristics. Factor 1 represents teachers' inadequacy in knowledge, skills, confidence and access regarding the use of ICT; Factor 2 represents barriers related to the school and learners; and Factor 3 mainly represents curriculum-related barriers. The common themes represented by these factors are in congruence with the literature regarding barriers faced by teachers when using ICT for teaching and learning (Bingimlas 2009). The following section presents the results of correlation analysis conducted on the factors identified through factor analyses.

■ Correlations found amongst factors identified through factor analyses

Spearman's rank order correlations (r_s) were calculated for the factors identified from teacher questionnaire items BTG9 (Table 20), BTG14 (Table 19), BTG15 (Table 21) and BTG23 (Table 23). The results are presented in Table 24. Only instances of $r_s \geq 0.3$ are presented in the table. Values $0.3 \leq r_s \leq 0.49$ are medium effects, which tend towards practically significant correlations. Values of $r_s \geq 0.5$ are large effects indicative of practically significant correlations. Each of the meaningful correlations in Table 24 is summarised in Table 25.

A large effect size ($r_s = 0.629$) indicative of a practically significant correlation was found between BTG9 (structured inquiry) and BTG9 (guided inquiry). Another large effect size ($r_s = 0.561$), indicative of a

TABLE 24: Spearman rank order correlations ($r_s \geq 0.3$) amongst factors identified through factor analyses of BTG9 (Table 20), BTG14 (Table 19), BTG15 (Table 21), and BTG23 (Table 23).

Factors	BTG9 Structured inquiry	BTG9 Guided inquiry	BTG9 Conventional Pedagogy	BTG14 Conventional teacher's role	BTG14 Mediating teacher's role	BTG15 Conventional assessment	BTG15 Constructivist assessment	BTG23 Teacher level barriers	BTG23 School level barriers	BTG23 Curriculum barriers
BTG9 Structured inquiry		0.629	0.459	0.383	0.448	0.351				
BTG9 Guided inquiry	0.629		0.425	0.390	0.397	0.325				
BTG9 Conventional pedagogy	0.459	0.425		0.359						
BTG14 Conventional teacher's role	0.383	0.390	0.359		0.535					
BTG14 Mediating teacher's role	0.448	0.397		0.535		0.347				
BTG15 Conventional assessment										
BTG15 Constructivist assessment	0.351	0.325		0.347						
BTG23 Teacher level barriers								0.405	0.561	0.350
BTG23 School-level barriers								0.405		
BTG23 Curriculum barriers								0.561	0.350	

TABLE 25: Summary of significant correlations.

Summary	Factor 1	Factor 2	r_s
Large effect sizes indicative of practically significant correlations	BTG 9 Structured inquiry	BTG 9 Guided inquiry	0.629
	BTG23 Teacher-level barrier	BTG9 Curriculum barrier	0.561
	BTG14 Conventional teachers' role	BTG9 Mediating teachers' role	0.535
Medium effect sizes tending towards practically significant correlations	Conventional role of the teacher	Guided inquiry role of the learner	0.390
	Conventional role of the teacher	Structured inquiry role of the learner	0.383
	Conventional role of the teacher	Conventional role of the learner	0.357
	Mediating role of the teacher	Guided inquiry role of the learner	0.397
	Mediating role of the teacher	Structured inquiry role of the learner	0.448
	Mediating role of the teacher	Constructivist assessment practices	0.347
	Constructivist assessment practices	Guided inquiry role of the learner	0.325
	Constructivist assessment practices	Structured inquiry role of the learner	0.351
	Conventional role of the learner	Structured inquiry role of the learner	0.459
	Conventional role of the learner	Guided inquiry role of the learner	0.425
	Teacher-level barriers	School-level barriers	0.405
	School-level barriers	Curriculum barriers	0.351

practically significant correlation, was found between BTG23 (teacher-level barrier) and BTG9 (curriculum barrier). A large effect size ($r_s = 0.535$), indicative of a practically significant correlation, was also found between BTG14 (conventional teachers' role) and BTG9 (mediating teachers' role). The practically significant correlation between structured

TABLE 26: Spearman’s correlations with and without ICT for teachers’ pedagogical practices.

Roles of the teacher (variables)	Correlations without ICT (r_s)	Correlations with ICT (r_s)	Mediating role of teacher, roles of learners, and assessment practices (other variables)
Conventional role of teachers	0.535	0.0876	Mediating role of the teachers
	0.390	0.641	Guided inquiry roles of the learners
	0.359	0.656	Conventional roles of the learners
	0.383	0.673	Structured inquiry roles of learners
	0.232	0.703	Constructivist assessment practices
Mediating role of teachers	0.108	0.687	Conventional assessment practices
	0.397	0.529	Guided inquiry roles of the learners
	0.237	0.552	Conventional roles of the learners
	0.448	0.567	Structured inquiry roles of learners
	0.347	0.605	Constructivist assessment practices
	0.062	0.522	Conventional assessment practices

inquiry and guided inquiry is indicative of the common strategy (of using the processes of discipline as pedagogy) present in both of them. The practically significant correlation between teacher-level barriers and curriculum barriers is understandable, because without removing the curriculum barriers (such as the insufficient use of ICT for assessment in all school subjects), teacher-level barriers (such as a lack of time and insufficient confidence in using ICT for pedagogical purposes) will, in effect, remain. The practically significant correlation between the conventional teachers’ role and the mediating teachers’ role reveals the

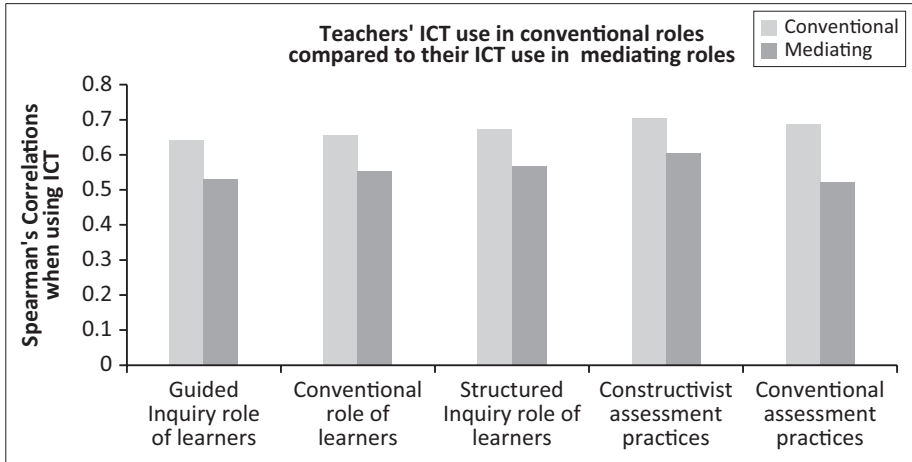


FIGURE 13: Teachers' higher pedagogical use of ICT in their conventional roles.

common role shared between them – the role of a learners' manager. Medium level correlations, which tend towards practical significance, are found between various factors.

Mathematics and Natural Science teachers' preference of the conventional use of ICT

Table 26 presents Spearman's correlations with and without ICT for teachers' pedagogical practices.

Teachers use more ICT in their conventional role than in their mediating role.

This finding indicates that when teachers used ICT, they still used it for conventional pedagogical practices. This is in accordance with literature reviews concerning the teachers' initial pedagogical uses of ICT (Cox *et al.* 2003). Spearman's correlations without ICT did not show any specific trends regarding the conventional and mediating roles of the teacher.

Summary of statistical analysis

Factor analysis revealed 10 general factors from the combined Mathematics and Natural Science teachers' SITES 2006 South African data set (Table 18).

Factor analysis of questionnaires related to teacher roles revealed two roles for the teachers, namely a conventional role and a mediating role (Table 19).

Factor analysis of questionnaires related to learner roles revealed three roles for the learners, viz. structured inquiry, conventional practice and guided inquiry (Table 20).

Factor analysis of questionnaires related to assessing learner performance revealed two methods used by the teachers, i.e. conventional and constructivist methods (Table 21).

Spearman rank order correlations between factors identified on the A part (variables) and B part (whether or not ICT was used) on questionnaire items BTG9, BTG14 and BTG15 showed little correlation between identified factors and ICT use (Table 22).

Factor analysis conducted on responses to teacher questionnaire items BTG23A to BTG23L about barriers faced by teachers when using ICT for teaching and learning revealed teacher-level barriers, school-level barriers, and curriculum-related barriers (Table 23).

Spearman's rank order correlations (r_s) were calculated for the factors identified from teacher questionnaire items BTG9 (Table 20), BTG14 (Table 19), BTG15 (Table 21) and BTG23 (Table 23). Results indicated that teachers' conventional role made more use of ICT than teachers' mediating role.

□ Difference between the responses of Mathematics and Science teachers

A *t*-test to investigate the differences between Mathematics and Science teachers' responses indicated that there was a statistically significant difference between them; however, this was not practically important (effect size < 0.3).

■ Discussion

Activity theory (Figure 12) suggests the possible interactions amongst teachers, computers, the World Wide Web, school community, school curriculum as well as school rules and regulations. Teachers in their conventional role made use of mainly teacher-directed learning activities where there are limited opportunities for involvement of the community and learners, whilst teachers in their mediating role made use of mainly learner-centred activities where there are extended opportunities for involvement of the school community and division of labour (Table 19). Thus, activity theory reveals opportunities for higher levels of interactivity in the learning environment.

Similarly, activity theory supports guided inquiry (Table 20) by providing opportunities for learners to learn by communicating with subject experts and collaborating with peers far away; by seeking help from the community when needed; and by dividing work and cooperating as team members to arrive at mutually agreed outcomes within the confines of the schools' rules and regulations. Likewise, when considering methods of assessing learner performance (Table 21), activity theory exposed opportunities for constructivist learner assessment practices such as group presentations, peer evaluations, multimedia product creation or other

collaborative tasks. Activity theory (Figure 12) explicated the interdependence amongst the pedagogical barriers (Table 23), namely teacher-level barriers, school-level barriers and curriculum-related barriers. Activity theory also suggests holistic and continuous efforts to resolve the entwined barriers.

In the research reported here, activity theory was used to understand the use of computer hardware, software and networks as tools for the activity of teaching and learning in the school community with the rules and regulations and division of labour suggested by the prescribed curriculum. Activities are aimed at meeting the objectives of the school curriculum by achieving the outcomes in the most efficient and effective ways. Activity theory promotes active learning in a caring community where members complement each other's learning. Here, members play different roles, depending on the context. In addition, activity theory suggests that present school rules and routines should be amended so that teachers and learners have more time and easy access to ICT facilities. Further, activity theory highlights the critical role of the teacher. Without the active involvement of competent and dedicated teachers, ICT tools alone are limited in providing quality teaching and learning.

■ Recommendations

The DBE in its *Action Plan to 2019; Towards the Realisation of Schooling 2030*, envisages improvement of the professionalism, teaching skills, subject knowledge and computer literacy of teachers throughout their entire careers (DBE 2015). The DBE also looks forward to advancing the frequency and quality of the monitoring and support services provided to schools by district offices, partly through better use of e-education. In this context, open distance learning using ICT can be one solution, which can

expand access to on the job training, reducing barriers related to time, place, and pace.

The South African DBE should, as soon as possible, holistically resolve the curriculum-level, school-level and teacher-level barriers by a comprehensive revision of the curriculum, which then can clearly demonstrate the facilitation possibilities of ICT, a thorough study of schools' ICT infrastructure at present, and intensive and continuous teacher training in ICT. There is no significant difference between the Mathematics and Natural Science teachers' ICT pedagogical practices, and therefore there is no need to conduct separate training programmes.

■ Conclusion

This investigation used activity theory to explicate the nature of affordances and barriers of ICT-mediated pedagogical practices in South African classrooms. There appears to be an urgent need to address the gaps in teacher competency for the effective use of ICT in pedagogy. ICT has more potential use in the teachers' mediating role when using constructivist pedagogical practices.

This enquiry is based on one of the authors' PhD thesis: *'ICT pedagogic challenges and enablers of Grade 8 Mathematics and Natural Science teachers in South African classrooms'* at North-West University (Varughese 2012).

■ Chapter 10: Summary

Activity theory, which is a framework helpful for understanding the use of artefacts such as information and communication technology (ICT), forms the conceptual basis for this study. Prior to this investigation not much information was available on the characteristics of ICT pedagogical

practices of Grade 8 Mathematics and Natural Science teachers in South Africa. Such information could well be instrumental in enabling stakeholders to make informed decisions regarding the effective and efficient use of the meagre ICT resources available in South African classrooms. For this reason, data of this nature were extracted from the South African data set of the Second International Information Technology in Education Study (SITES). Secondary data analysis was applied to the South African dataset of SITES. The Statistical Program for Social Sciences was used to conduct factor analysis, a *t*-test, the calculation of Cronbach's alpha and Spearman's rank order coefficients. Analyses of the data drawn from a sample of 504 schools with a total of 666 Mathematics teachers and 622 Natural Science teachers revealed that these teachers used ICT mainly to support conventional pedagogical practices and not to provide the differentiated educational affordances available through the successful use of ICT. Continuous and effective teacher training may promote more productive pedagogical uses of ICT in the country's classrooms.

References

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This collected work focuses on themes such as learning readiness, pair programming, peer tutoring, and teaching conceptual change in the physical sciences and environmental learning. It contributes to important issues such as the quality of teacher development programmes by means of open and distance learning mode; perceptual motor skills; and inquiry-based approaches in teacher development. Teaching content and pedagogical knowledge will be greatly enriched if the insights in this book are comprehensively understood and applied effectively at the various educational levels.

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The book attests to a high level of scholarly and critical thinking, both with regard to the reporting and deliberations on the findings. It demonstrates informed knowledge of the current discussions in the respective fields and gives an express indication of the theoretical foundations, research methodologies and methods related to the chapter contributions and their application to empirical scientific research. Empirical illustrations are followed by robust analyses and discussions from which the study findings are derived. The book relates the findings to other scientific findings in the field.

**Professor Pholoho Justice Morojele, Gender & Social Justice Education, Acting Dean of
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The book aims at facilitating teaching and learning in South African education. It represents a collection of possibilities and challenges gleaned from the rich experience and practical observations of academic professional educators from a variety of backgrounds. Significant topics addressed are: the school and learning readiness of Grade R learners; the role of pair programming in enhancing learner capability; postgraduate academic writing; the development of a student peer tutor programme; promoting conceptual change among Physical Science teachers; an environmental learning programme for the understanding of environmental education concepts; work-integrated learning in a distance-learning programme; Grade R teachers' knowledge of perceptual motor skills; the ability of Grade 8 Mathematics and Natural Science educators to use inquiry-based pedagogical practices regarding information and communication technology in the Life Sciences classroom.

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